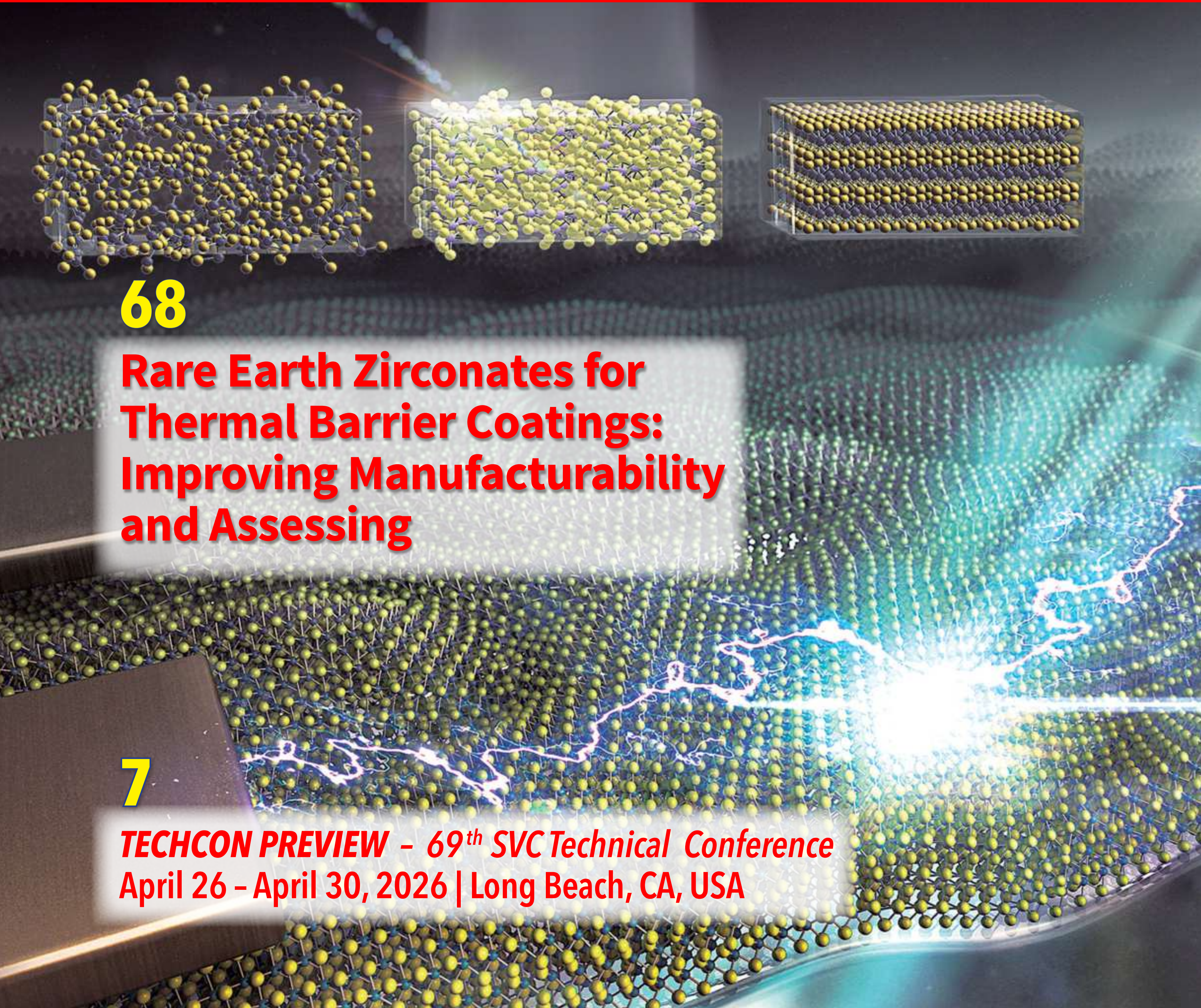
A PUBLICATION FOR THE VACUUM COATING INDUSTRY SPRING 2026

SVC™ SOCIETY of VACUUM COATERS

BULLETIN

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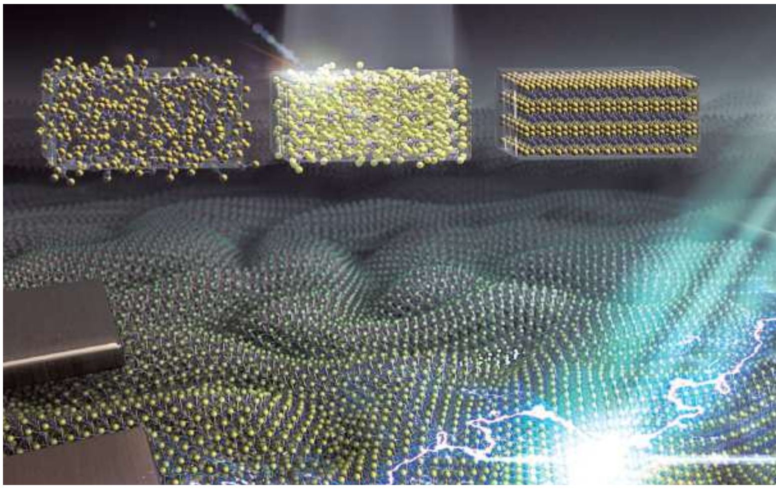

ABOUT THE COVER

Cover image – Lasers, flash lamps, and other highly energetic illumination sources enable rapid thermal processing of surfaces and thin films for scaled, low-cost materials and technologies in areas of high economic, societal and environmental impact. Realization of surface-selective rapid thermal annealing coupled with high-throughput are especially attractive features of photonic materials engineering. This photo represents the use of a flash lamp to convert and synthesis high quality crystalline films. Courtesy of Dr. Christopher Muratore (University of Dayton).

INSIDE THIS ISSUE

FEATURE

7

SVC BULLETIN

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2026 deadlines for ad space reservations & artwork submissions: Summer: 6/17/26 and 7/1/26; Fall: 8/28/26 and 9/5/26; Spring: 2/12/27 and 3/5/27; TechCon Exhibit Guide: 3/12/27 and 3/25/27

BULLETIN SUBSCRIPTION (FREE)
www.svc.org

SVC welcomes contributed original articles.
Find out more by contacting:
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SVC Mission: To promote technical excellence by providing a global forum for networking, educating, and informing the stakeholders, the technical community & the industrial eco-system on all aspects of industrial vacuum coating, surface engineering and related technologies.

SVC Vision: To provide a dynamic global forum for transitioning and commercializing thin film and surface engineering innovation to industry.

The SVC Awards Committee Invites Your Nominations

The SVC Awards Committee is responsible for selecting the recipients of our awards: the **Nathaniel H. Sugerman Award** for distinguished achievement, and the **Fellow-Mentor Award** for significant contributions to the SVC or the vacuum coating industry. We request that nominations be sent to Chris Muratore, University of Dayton, Awards Committee Chair, cmuratore1@udayton.edu, by December 15, 2026. The criteria for the awards and a list of past award recipients can be found on the ***SVC website***.

Nominations should give a brief, thoughtful statement about the individual in light of the criteria for the proposed award. The Sugerman and Mentor Awards can be based on a broad range of possible contributions to the SVC and/or the vacuum coatings industry. Please consider candidates whose contributions are significant but perhaps not as apparent based on more formal mechanisms, i.e., scientific publications.

We encourage you to submit nominations for the 2027 awards now!

Fellow-Mentor Awardees are eligible for the Sugerman Award. Employees and contractors of the SVC and current members of the Awards committee are not eligible.

Awards Committee Members:

Chris Muratore, University of Dayton, *Awards Committee Chair* | cmuratore1@udayton.edu
Ladislav Bardos, Uppsala University, Sweden, *Immediate Past Chair* | ladislav.bardos@angstrom.uu.se
Clark Bright, Bright Thin Film Solutions (3M retired), *Past Chair* | brightcrew@aol.com
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Jolanta Sapieha, Polytechnique Montréal, Canada| jsapieha@polymtl.ca

LETTER
FROM THE PRESIDENT

Liz Josephson
SVC President
INTELLIVATION LLC
ljosephson@intellivation.com

As 2026 kicks off for the Society, we are pleased to report that we are entering the new year with healthy finances and a very impressive schedule for TechCon 2026 in Long Beach. Through the dedicated efforts of the SVC team, along with the Program and Education Committees, this year's conference offers a balance of both technical content and industrial applications and is shaping up to be our strongest TechCon to date. If you are not registered, please use the QR code.

We kickoff our sessions with four exciting keynote presentations discussing Surface Engineering Drivers and Plasma Technologies, as well as Fano-Resonant Optical Coatings and the Quest for Target Parameters. We are honored to have these distinguished speakers and are looking forward to their contributions to the advancement of plasma technology and its applications.

Building on the success of the Colloquium format, six new topics will be introduced this year: Modernization of Coaters for New Demand, Transitioning to Sustainable Surface Engineering, HIPIMS, Coatings for High Power Lasers, Decorative PVD Coatings and R2R Substrate Applications. All these events will include global perspectives and emphasize both technical depth and industrial relevance. I would like to extend our gratitude to all the organizers and presenters and encourage attendees to actively engage with the panelists.

We are also excited to be cohosting a session with the Electrochemical Society (ECS) on integrating vacuum and electrochemical deposition, we are looking forward to their session and new participation engagement. In addition, our extremely successful Technical Forum Breakfasts are expanding to include Technical Forum Sunset meetings. These sessions are consistently well attended, highly interactive and strongly encourage participation.

On Monday morning, the Annual SVC Business meeting will provide a review of the 2025 activities, finances and expectations for 2026. During this meeting, we will also transition the Society leadership, welcoming Lee Howell, incoming President, and David Sanchez, incoming Vice President. This new leadership has already contributed tremendously to new initiatives within SVC, I know their momentum will continue to contribute to the ongoing success and growth of the Society. Please join us during this meeting to welcome our new officers and Board members.

I extend my sincere thanks to the entire SVC team and all the volunteers, including the TAC chairs and their expansive committee members that have been instrumental in developing the 2026 program. I look forward to seeing all of you in Long Beach and encourage you to take advantage of the opportunity to enroll in two Education classes included with a full registration, please ensure you take advantage of this great opportunity.

Thank you all for your support during my Presidency, it has been a privilege to serve the Society and I am truly grateful. Please feel free to contact me if you have any questions or need information on how to contribute to the future of the SVC.

— Liz Josephson
SVC President

SVC™ SOCIETY of VACUUM COATERS

TechCon 2026 Long Beach

Long Beach Convention Center
Long Beach, California, USA

April 26 - April 30, 2026

2026 Focus & Program

Featuring Keynote and Invited Speakers & the 2026 In-Person Tutorial Program

Technical Program: April 27 - April 30, 2026

- Technical Sessions
- Interactive Networking Forums
  + Technology Forum Breakfasts

Education Program: April 26 - April 30, 2026

- Problem-Solving Tutorial Courses

Featuring Sessions on:

Advanced Multifunctional Coatings: Integrating Vacuum and Electrochemical Deposition for Sustainable Energy, Surface Protection, and Biomedical Innovations (Joint Session with The Electrochemical Society - ECS) ***New***
Advances in Thin Film Sensor Technologies: Materials Design and Applications
Atomic Layer Processing
Characterization, Testing and Failure Analysis of Thin Films, Coatings, and Engineered Surfaces ***New***
Coatings and Processes for Biomedical Applications
Coatings for Energy Conversion and Related Processes
Digital Transformation through Artificial Intelligence, Machine Learning, Simulation, and Data Science in the Thin Film Industry
Electron Beam Processes
Emerging and Translational Technologies and Applications
Exhibitor Innovator Showcase
High Power Impulse Magnetron Sputtering (HIPIMS)
Large Area Advanced Packaging and Integrated Photonics ***New***
Large Area Coatings
Optical Coatings
Organic and Perovskite Electronics
Photonically-Induced Transformations of Thin Films and Surfaces ***New***
Plasma Processing and Diagnostics
Process Monitoring, Control, and Automation
Protective, Tribological, and Decorative Coatings
Quantum Computing
Thin Film Contributions for the Hydrogen Economy
WebTech Roll-to-Roll Technologies and Innovation

For more information, contact the SVC at +1-505-897-7743
or CLICK HERE to submit an abstract

www.svc.org

Message from the Program Director

With 2026 comes a new TechCon, and the SVC program team is diligently producing yet another industry-leading event in Long Beach, California. We are excited to be back in a prime venue that many of us remember fondly from past successful TechCons. While the end of April appears far in the future at the time of writing this message, the wheels of staging a successful program are in full motion – after all, TechCon program development is a full-year development cycle that we have refined for efficiency and maximum impact over the years, ensuring we produce the best "product" for you.

The technical program of a TechCon does not magically produce itself. Yes, the SVC has a very small core staff that manages the myriad organizational and logistical details required to run a professional society like the SVC. However, I want to give a big shout-out to a team of over 100 subject matter volunteers that donate significant time, bandwidth, industry insights, and professional connections. They are the ambassadors to the technology & application realms that are relevant to our community, and I am proud to say that this year we have one of the strongest and most engaged teams that ensure the TechCon offers a fresh, relevant, engaging, and attractive program. Their volunteer work enables the broadest ever range of Technology Forum Breakfast/Sunset topics (we are expanding the stage by two afternoon "Sunset" sessions), an unprecedent number of 6 "Colloquia 2.4", and a stellar line-up of Keynote and invited speakers. When I look at our volunteer-based program leadership team, I see many young professionals that are stepping up and taking on new responsibilities, and they rely on the wisdom and mentorship of those that served before them. Nurturing this generational change is critical to keeping our society relevant and current, and I am grateful to those that step up and take the baton from those that are leaving the stage and have helped shape the Society with their dedication and service.

Looking forward to the 2026 TechCon, the program continues to offer core elements that resonate with our multi-faceted constituency – you will find a refreshed line-up of Technology Forum Breakfast / Sunset topics, followed by Keynote talks from industry experts, and session tracks that include invited speakers as well as interactive program elements that we call "Colloquia 2.4" – a podium discussion by experienced professionals that encourages engagement with the audience and has been very well-received over the last few years. The program offers not only the core session line-up that has been refreshed in recent years but also features several new topics – an exciting joint session co-organized with the Electrochemical Society (ECS) on Advanced Multifunctional Coatings, a new session focusing on Characterization, Testing and Failure Analysis, a session on Large-Area Advanced Packaging and Integrated Photonics, and a session on Photonically-Induced Transformations of Thin Films and Surfaces. We add these topics to highlight innovative applications and technological advances in our field in the interest of attendee growth and ensuring topical relevance. The "Exhibitor Innovation Showcase" session provides an attractive podium for the valued contributors to our industry's largest technical exhibit. I also want to point out the benefit of a tutorial

SVC™ Society of Vacuum Coaters

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Our Mission: *To promote technical excellence by providing a global forum for networking, educating, and informing the stakeholders, the technical community, and the industrial eco-system on all aspects of industrial vacuum coating, surface engineering and related technologies.*

Publication Options:

There are two publication options and one video presentation option for work presented during the 2026 Technical Program

WITHOUT PEER REVIEW

Submission Deadline:
September 12, 2026
Publication in PowerPoint OR Manuscript format in Society of Vacuum Coaters Annual Technical Conference Proceedings (ISSN 0737-5921)

PEER REVIEWED

Submission Window Open
May 1 – September 12, 2026
Publication in a special edition of Elsevier's Surface and Coatings Technology Journal (ISSN: 0257-8972)

VIDEO PRESENTATIONS

Submission window open
May 1 – September 12, 2026
Narrated mp4 or PowerPoint video to be posted to the SVC's dedicated YouTube Channel

Message from the Program Director cont'd

seat that is included in a full-conference registration – a great opportunity to extend your TechCon experience beyond just the program segment, and to provide you with access to the impressive educational line-up offered in Nashville for maximum event value.

We are grateful for the experience and many lessons learned over the last few years – and especially the continued support of our SVC community that appreciates experimentation and welcomes innovation in our topic line-up and program format. We are now on "final approach" for the 2026 TechCon in Long Beach. I encourage you as a member of the SVC family and thin film / surface engineering community to register as a presenter for the TechCon, whether it is with a contributed talk or poster that highlights your innovation and achievements, or as an attendee that wants to connect with experts, or just "ask, listen & learn" in the many interactive events and networking opportunities the refreshed TechCon offers.

Only the SVC TechCon offers a premier technical program alongside a best-in-class exhibit and a stellar educational program (remember – your full-conference registration includes access to a tutorial of your choice!). Sharing innovation, learning, networking – all in one attractive location. It does not get better than that, and this Bulletin provides tips and guidance for an optimal TechCon experience.

I look forward to seeing you in a few weeks at the SVC TechCon in Long Beach – we are proud to do it for you, and we also could not do it without you!

— Chris Stoessel, PhD, SVC Program Director
cstoessel@stoesselconsulting.net

SVC and SVC Foundation Travel Support for Students and Young Professionals

Young professionals and students are our future. The SVC and the SVC Foundation recognize that capturing the imagination and the interest of young technicians, engineers, and scientists are essential activites that will perpetuate the technologies and the companies that comprise the SVC. Student education scholarships and sponsorships supporting travel and conference participation are offered annually through programs that encompass a global reach to qualified and deserving individuals.

SVC Student/Young Professional Travel Sponsorship Program

The SVC Travel Sponsorship Program provides travel support and complimentary conference registration to selected full-time students and young professionals (under the age of 35 working in industry) to make an oral technical presentation at the SVC Annual Technical Conference. A limited number of sponsorships will be awarded to the best applicants. Applicants from industry, academic, research, and technical institutions from the United States and around the world are encouraged to apply. The Travel Sponsorship Committee evaluates applications and makes selections based on the quality and relevance of the applicant's project to the interests and mission of the SVC. It will also consider the quality of the application itself (completeness, quality, etc.), potential impact of the oral presentation, its relevance to the specific session, as well as the need for funding.

Requirements for Participation:

The applicant must have a sponsor. The sponsor can be a faculty member or supervisor at the student's institution/place of employment or another academic, technical, or research institution. The sponsor must indicate that he or she understands the nature of the conference and what SVC technical programs are about. The applicant must commit to providing a manuscript based on the content of the oral presentation at the TechCon or the PowerPoint presentation delivered at the TechCon for subsequent publication by the SVC before any financial support is provided.

During the selection process, preference will be given to those applicants who have not already received sponsorship from SVC. The successful candidates should also preferably come from different institutions.

SVC Travel Sponsorship Program Abstract and Application Deadline: October 4, 2026

The SVC Foundation provides scholarships and/or stipends for travel expenses to attend the annual SVC technical conference. Scholarships are open to well-qualitified students planning to enter fields related to vacuum coatings as well as techicians already working in the field practicing the craft. The Society of Vacuum Coaters (SVC), the SVCF's founder, and AIMCAL, an organization committed to advancing vacuum roll-coating technology, and their members, provides support for the Foundation to pursue these goals. Since its inception in 2002, the SVCF has awarded more than 220 scholarships and travel awards totalling over $600,000 to students from more than 28 countries.

Please visit www.svcfoundation.org for more information

Academic Scholarship application deadline: October 18, 2026

Industry Scholarship application deadline: January 23, 2027

Student Travel Sponsorship application deadline: October 4, 2026

Colloquium @ TechCon 2026 Long Beach

The modern SVC era has been the most intense period of innovation, member engagement, event management, and technology focus in the SVC's sixty-nine year history. The SVC is completely focused on our stakeholders, developing an inclusive culture of listening, adopting, refining, and improving approaches that enhance the unique networking and problem solving culture that sets the SVC apart from all other professional organizations. In the spirit of this culture, we are proud to announce, "Colloquium at the TechCon"; a series of focused, technical conversations that address critical industrial needs. This meeting format was first introduced at the 2022 TechCon in Long Beach and based on the extremely positive feedback, we are bringing it back yet again in 2026!

Each topical workshop will be anchored by a technical presentation or series of presentations that will frame a follow-on roundtable discussion. Subject matter experts will be acting as moderators to facilitate discussions and promote interaction and networking between the attendees. As part tutorial, part problem solving, and part networking, the "Colloquium at the TechCon" represents the vanguard of the SVC's efforts to enhance and redefine the technical conference experience. These workshops will be open to all of our conference attendees and exhibitors.

The time and location of all **Colloquium @ TechCon** will be posted in the Final Program; stay tuned!

Monday April 27, 2026 | *Sponsored by the SVC's Large Area Coatings Technical Advisory Committee*

Giving New Life to Old Coaters: Modernization of Coaters for New Demands

Aneliia Wäckerlin

Moderator: **Aneliia Wäckerlin** *(Deputy Head R&D, Glas Trösch)*

Event Description: Retrofitting existing coaters is an attractive approach to upgrade process capabilities to modern standards while avoiding the significant capital expenditure of replacing an entire coater platform. Retrofit projects, however, require careful planning and expertise in order to deliver the expected results.

This interactive event offers a perfect opportunity to learn, discuss and hear perspectives on your specific question. We will start with three concise presentations where our panelists will share their individual perspectives on the following critical topics:

- End user experience on upgrading equipment and considerations for adapting a new coating process
- Running more complex products with higher throughput and uptime on aging coater equipment
- ROI of upgrading hardware based on uptime and throughput

We will then open the discussion to questions and perspectives from the audience. Bring your challenging questions with you, and we will do our best to find the answers together!

Panelists:

— **Kyle Schuberg**
Coating Process Engineering Manager
Gentex Corporation

— **Wilmert De Bosscher**
Chief Technology Officer
Soleras Advanced Coatings BV

— **Ken Nauman**
Director of Global Business Development
Sputtering Components

Kyle Schuberg

Wilmert De Bosscher

Ken Nauman

The Challenge of Transitioning to Sustainable Surface Engineering Practices

Jochen M. Schneider

Moderator: **Jochen M. Schneider** *(Professor of Materials Chemistry, RWTH Aachen University)* research focuses on the quantum-guided design of thin film materials, including sustainability-relevant aspects. He has held academic appointments in Germany, the UK, the USA, and Sweden, and has received numerous awards and fellowships. Throughout his career, he has served in several international advisory roles and supervised more than 40 Ph.D. students.

Event Description: The Sustainable Surface Engineering Colloquium, held as part of TechCon 2026 of the Society of Vacuum Coaters (SVC), will serve as a dedicated forum for researchers, engineers, technologists, and industry leaders to examine and advance the state of the art in environmentally responsible surface technologies. This event aims to highlight not only emerging technical innovations but also the broader systems-level thinking required to make surface engineering processes more resource-efficient, resilient, and aligned with global sustainability goals.

The session will open with an impulse talk by Prof. Christoph Herrmann of Fraunhofer IST, Braunschweig, Germany, whose research focuses on life-cycle engineering and sustainable manufacturing. His presentation will provide a conceptual and analytical foundation for understanding how sustainability metrics, process modeling, and circular-economy principles can be applied within the field of vacuum coating and surface modification.

Following this keynote impulse, four concise pitch presentations will be delivered by distinguished panel members, each representing a different segment of the international surface engineering community:

- **André Anders** (Plasma Engineering LLC, USA)
- **Klaus Böbel** (Oerlikon, Liechtenstein)
- **Tetsuya Takahashi** (Kobelco, Japan)
- **Christoph Schiffers** (CemeCon AG, Germany)

These short pitches will introduce diverse perspectives—from plasma process innovation and industrial coating solutions to equipment design and sustainable production strategies—thereby establishing a multidisciplinary springboard for further discussion.

The subsequent interactive dialogue between the audience and the panel, moderated by Jochen Schneider of RWTH Aachen University, will delve deeply into the opportunities and challenges associated with transitioning toward more sustainable surface engineering practices. Topics will include actionable pathways for reducing energy consumption, strengthening sustainability education across stakeholder groups, integrating circular-economy concepts, and improving the environmental footprint of coating technologies across their full life cycle. Through this collective exchange, the colloquium aims to underline the crucial role of continuous research, cross-sector collaboration, and forward-looking innovation in shaping a more sustainable future for the global surface engineering community.

Panelists:

Christoph Herrmann

— Christoph Herrmann *Fraunhofer Institute for Surface Engineering and Thin Films (IST):* is Director of the Fraunhofer Institute for Surface Engineering and Thin Films (IST) in Braunschweig and a full professor for Sustainable Production & Life Cycle Engineering at the Technische Universität Braunschweig. He leads work on sustainable manufacturing, life-cycle and surface technologies, integrating ecological, economic, and production-engineering perspectives.

André Anders

— André Anders *Plasma Engineering LLC:* investigates plasmas and has developed plasma-based coating processes for many years. He worked in Berlin (Germany), Berkeley (California), was an Institute Director and Professor of Applied Physics in Leipzig (Germany), and he is now again in California as the Founder/CEO of Plasma Engineering LLC. André was elected as one of the Directors of AVS for the 2026/27 period.


Klaus Böbel

— Klaus Böbel *Oerlikon:*
is an R&D Portfolio Manager at Oerlikon, where he drives innovation in surface, plasma, and coating technologies. Prior to joining Oerlikon, he spent more than two decades advancing plasma and PVD/DLC coating solutions in senior R&D roles at Bosch Manufacturing Solutions. His current work integrates sustainability considerations into technology development, contributing to Oerlikon's efforts toward more energy- and resource-efficient surface solutions.


Tetsuya Takahashi

— Tetsuya Takahashi *Kobe Steel, Ltd. (KOBELCO):*
is a senior engineer at Kobe Steel, Ltd. (KOBELCO), Japan, specializing in plasma-based coating technologies and advanced materials. He earned his doctorate in engineering from RWTH Aachen University in Germany. While his main expertise is in hard coatings, he is currently exploring novel applications of vacuum deposition technologies as part of new business creation initiatives.


Christoph Schiffers

— Christoph Schiffers *CemeCon AG:*
has been with CemeCon AG , the pioneer of HiPIMS coatings for cutting tools, for more than 15 years. HiPIMS has become the new standard in the cutting tool world because of the dense coating structure, the super smooth surface, and the enormous flexibility. The tremendous HiPIMS success story in the cutting tools industry suggests that HiPIMS will replace traditional techniques for high value products within a few years. Christoph holds a Dr.-Ing. in mechanical engineering from RWTH Aachen University.

Colloquium 2.4

The Innovation Spiral of HIPIMS Towards Industrialization

***Moderator:* Ton Hurkmans** *(Chief Technology Officer (CTO), IHI Ionbond Group)*

Ton Hurkmans

Event Description: High Power Impulse Magnetron Sputtering (HIPIMS) has emerged as a transformative technology in the field of thin film deposition, driving a dynamic industrial innovation spiral starting from advanced manufacturing tools and expanding into architectural glass, semiconductor and spreading into antimicrobial and sensor applications as more companies and research groups engage with the technology each year. The industrialization of HIPIMS is characterized by iterative advancements in plasma physics, power supply engineering, process control, and design of thin film and coating materials which enabled the realization of dense, adherent coatings with tailored properties, surpassing the limitations of conventional sputtering techniques.

A panel of experts with long track record in plasma science, industrial production and applied research will engage with the audience in an active discourse on current topics ranging from latest academic advances in plasma, process and materials science, and deployment in process development to latest industrial trends and hot topics. We are currently filling the panel seats with renowned experts from academia, applied research, and industry.

Panelists:

— **Ralf Bandorf**
Head of Group, Optical and Electrical Systems
Fraunhofer IST

— **Arutiun Ehiasarian**
Head of National HIPIMS Technology Center
Sheffield Hallam University

— **Uwe Heydenreich**
Key Account Manager
TRUMPF Hüttinger GmbH + Co.

— **Daniel Loch**
Application Engineer
TRUMPF Hüttinger GmbH + Co.

— **Dermot P. Monaghan**
Managing Director
Gencoa Ltd

— **Tetsuhide Shimizu**
Associate Professor
Tokyo Metropolitan University

Ralf Bandorf

Arutiun Ehiasarian

Uwe Heydenreich

Daniel Loch

Dermot P. Monaghan

Tetsuhide Shimizu

Colloquium 2.4

A Manufacturer's Guide to Coatings for High Power Lasers

Moderators: **Jay Anzellotti** *(IDEX, Inc.)*; **Colin Harthcock** (*Lawrence Livermore National Laboratory (LLNL)*); **David Sanchez** *(Materion Electronic Material)*

Event Description: Markets for high LIDT (Laser-Induced Damage Threshold) coatings are expanding rapidly, driven by critical applications in medical lasers, industrial lasers, laser fusion R&D, semiconductor fabrication and metrology, and high-energy defense systems. As these technologies scale, coatings inevitably face damage and require replacement, creating an urgent need for manufacturers to develop methods that extend coating lifetime while managing costs.

Key factory processes will be at the center of our dialogue, including substrate cleaning, cleanroom design and protocol, chamber design and maintenance, deposition dynamics, and post-coating handling and packaging. Each of these steps plays a vital role in achieving coatings that withstand high-energy environments and deliver consistent performance over time.

We invite you to join us and share your challenges in meeting technical specifications and scaling production. This colloquium will bring together experts, innovators, and manufacturers to discuss these challenges in an open forum. The event will consist of several short presentations by a team of experts, followed by a facilitated round-table discussion.

Moderators:

— **Jay Anzellotti** spent his early career as a hands-on engineer depositing optical coatings for high power lasers. He then held coating development roles in various areas including industrial lighting, optical communications, fluorescence instrumentation, and semiconductor inspection tools. Jay is currently the Director of Filter Design and Coating Engineering in the Optical Filters business at IDEX, Inc. Jay has a BS from the University of Rochester.

Jay Anzellotti

— **Colin Harthcock** is currently a group lead at Lawrence Livermore National Laboratory (LLNL). He previously served as a staff scientist and before that a postdoctoral fellow. Colin's work has focused on understanding defect causes in coatings and optical materials for the NIF program, which is pushing the boundaries of laser power to achieve nuclear fusion. Colin has a PhD in chemical physics at Oregon State University.

Colin Harthcock

— **David Sanchez** has been Chemical Engineer and Materials Scientist for 29 years. He was motivated by firsthand use of advanced thin film optics and technologies in the US Marine Corps. He completed his dual BS degree in California and went to work at OCLI/Flex in 1996 as a Process Engineer. He was classically trained in thin film technology from the best in the emerging field. David has leveraged his experience and built a wide range of skills as a materials and applications scientist and engineer. For more than 28 years he has led many efforts to develop key materials and now supports the complete line of specialty inorganic materials, precious metals, and rare metals for Materion Electronic Material's PVD, energy and semiconductor customers.

David Sanchez

Colloquium 2.4

Decorative PVD Coatings - Trends and Challenges


Martin Engels

Moderator: **Dr.-Ing. Martin Engels** *(Global Process Engineer Deco & Sports, IHI Ionbond Group)*

Event Description: Decorative Physical Vapor Deposition (PVD) coatings have been a growing market for decades and the number of applications, as well as the request for new colors, are still growing. The markets which are being addressed range from sanitary parts to automotive interior/exterior or luxury articles like watches or golf clubs, and of course numerous other articles which can be coated.

The application of a decorative PVD coating not only gives parts a special appearance but also improves the wear resistance and therefore durability significantly. In the past, interest and availability were mainly focused on grey scale colors ranging from light silver to deep black or bright colors in the range of light gold to copper or brass. Nowadays, additional to the classic features of decorative PVD coatings, the interest of customers is expanding to more special colors like blue, green, dark brown, etc. Other than that, there is a significantly rising demand for additional properties like corrosion protection as well as easy-to-clean or anti-fingerprint behavior. However, new colors and coating properties are also arising with new challenges for the production of a decorative PVD coating. These might range from the need for novel process technology like HiPIMS to additional process steps.

In order to give the TechCon participants a deeper insight into the unique world of decorative coatings and their trends and challenges as well as ideas to address them, we have gathered a team of experts, who will cover a range from coating machine manufacturers, process simulation, and job coaters. Our panelists will start with a brief introduction of themselves and their companies. This will be followed by insights on the history of decorative PVD, the present state of the art and their vision about the future of decorative coatings. The audience is highly welcome to interactively discuss questions and to share experiences with our panelists and will have the unique opportunity to connect with the experts for further cooperations and knowledge exchange.

Panelists:

— **M.Sc. Bryce Anton** (Director of Technology) *Vapor Technologies, Inc.*
26 years of experience in PVD thin film development, primarily in decorative coatings for various consumer product industries (home products, automotive, sporting goods, etc.). Currently holds 11 patents in this field.


Brian T. Nevill


Bryce Anton

— **Dr. Ton Hurkmans** (Chief Technology Officer - CTO) *IHI Ionbond Group*
Key person in the use of PVD coatings for decorative applications since mid-90's. From pioneering to first applications and the full integration of new PVD production lines at in-house coating facilities. Currently responsible for all coating innovations across all business segments.


Adam Obrusnik


Ton Hurkmans

— **Brian T. Nevill** (President & Owner) *West Coast PVD, Inc.*
40 years experience in the vacuum coating industry including IVD and PVD technology for decorative & functional applications. Owner and operator of PVD coating centers for 25 years.

— **Adam Obrusnik, PhD** (CEO, head of consulting, co-founder) *PlasmaSolve s.r.o.*
More than 10 years of experience in plasma-based processes, especially PVD, as well as plasma simulation and diagnostics. Worked as independent consultant before co-founding PlasmaSolve company, which amongst others focusses on simulation of decorative PVD processes.


Chinmay Trivedi

— **M.Sc. Chinmay Trivedi** (Process Technology Manager) *IHI Hauzer Techno Coating B.V.*
Over a decade of experience in decorative applications with a strong understanding of the essential steps for successful technology integration, including conventional sputtering, Arc, PACV and HiPIMS processes.

Colloquium 2.4

Rigidly Flexible - Exploring the Middle Ground in R2R Substrate Applications

Moderator: **Liz Josephson** *(VP of Commercial Operations, INTELLIVATION LLC)*

Liz Josephson

Event Description: Roll-to-Roll (R2R) coating promises "economy of scale" for a myriad of high-volume applications, whether it is barrier layers for food packaging or flexible electronics. In many cases, the end use does not actually require "flexibility" – think of displays – nor a start-to-finish roll-to-roll process – think of sheet-based chip attached for hybrid electronics – to still make R2R a convincing manufacturing approach. However, experience and detailed knowledge is required to avoid costly failures and reap the full benefits of this powerful yet sometimes "mysterious" manufacturing methodology.

This Colloquium will examine the opportunities and challenges of R2R manufacturing processes, and will touch on substrate considerations, coating material options (vacuum- or wet-coating), issues like multi-pass, lamination and singulation operations and other critical topics that are crucial to successful production.

The interactive nature of this moderated panel discussion welcomes questions from the audience that may be addressed by a panel of subject matter experts, or in discussion with other practitioners in the audience.

We invite you to bring your questions, challenges or success stories that help take the "mystery" out of this powerful high-volume manufacturing methodology!

Panelists:

— **Andy Jack**
Sales Director
Emerson & Renwick Ltd

— **Joe Papalia**
President
DTI Films

— **Mike Simmons**
President & CEO
INTELLIVATION LLC

— **Chris Stoessel**
Innovation Counsultant and Partner
Stoessel Consulting/SputterTek LLC

Andy Jack

Joe Papalia

Mike Simmons

Chris Stoessel

Sustainability and Life Cycle Thinking as Innovation Drivers for Surface Engineerings

Christoph Herrmann
Fraunhofer Institute for Surface Engineering and Thin Films IST and TU Braunschweig, Braunschweig, Germany

Surface technologies are fundamental to a wide range of industrial applications and are typically integrated within comprehensive process chains comprising both upstream and downstream activities. Achieving sustainable development demands that engineered solutions operate within the Earth's biophysical limits and adhere to established environmental boundaries. This necessitates the identification of challenges throughout circular value chains and emphasizes the importance of practical, application-oriented research into sustainable product and process innovations. Concurrently, it is crucial to ensure that micro-level engineering decisions are consistent with macro-level sustainability frameworks, such as planetary boundaries, which recognize the finite capacities of global climate and ecosystems. This presentation will outline a systematic methodology designed to identify and prioritize mitigation strategies, thereby providing valuable insights for engineering initiatives. Relevant case studies from the field of surface engineering will illustrate the effective implementation of this approach..

Prof. Dr.-Ing. Christoph Herrmann is university professor for Sustainable Manufacturing & Life Cycle Engineering and co-director of IWF, Institute of Machine Tools and Production Technology, Technische Universität Braunschweig as well as director of the Fraunhofer Institute for Surface Engineering and Thin Films IST since November 2018. Prof. Herrmann serves on different boards, including the Open Hybrid LabFactory (Wolfsburg), the Hydrogen Campus Salzgitter, and the Battery LabFactory Braunschweig. He currently acts as the Spokesperson of the Fraunhofer Center for Energy Storage and Systems (ZESS) in Braunschweig. Since July 2025, he is also the chairman of the Fraunhofer Group for Production. Prof. Herrmann has conducted various industry and research projects in the context of life cycle engineering and sustainable manufacturing on national and international level. He has published more than 500 papers and book publications as author, co-other and editor. Prof. Herrmann is member of the German Academic Association for Production Technology (WGP) and the International Academy for Production Engineering (CIRP).

Plasma Technologies for Precision and Large-Scale Surface Engineering

Elizabeth von Hauff
Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technologies FEP and TU Dresden, Dresden, Germany

Fraunhofer Society's mission is to bridge the gap between fundamental and applied research by partnering with industry to translate laboratory results into real-world applications. Fraunhofer FEP in Dresden specializes in electron-beam and plasma technologies for large-scale and precision coatings, alongside advanced surface engineering. By integrating process and hardware development, we deliver technical solutions across a broad range of fields, including energy technologies, architectural glazing, semiconductors, optics, sustainable packaging, and environmental and biomedical applications. Our collaboration models span from feasibility studies to pilot-scale production, accelerating knowledge transfer and reducing risk for industry, with a focus on overcoming bottlenecks in cost, reliability, and performance to deliver scalable, robust solutions. In this talk, I present our latest results in precision coatings for optics and power electronics, and in large-scale, flexible coatings for photovoltaic and battery technologies. We also highlight advances in plasma-chemical processes and discuss how tailored hardware platforms and integrated process chains can reduce material usage, lower energy consumption, and eliminate toxic precursors, without compromising performance. The focus is on strategies that combine process design, equipment engineering, and system integration to enable cleaner, more efficient solutions.

Elizabeth von Hauff studied Physics at the University of Alberta in Edmonton, Canada. Her PhD and Habilitation work was performed at the University of Oldenburg, Germany in experimental physics. In 2011 Elizabeth accepted a joint appointment between the Institute of Physics, University of Freiburg and the Fraunhofer Institute for Solar Energy Systems (ISE). From 2013 – 2021 Elizabeth was an Associate Professor in Physics at the VU Amsterdam. In 2020 she was appointed as a special Chair in Chemistry at the University of Amsterdam. In 2021, she accepted an appointment as director of the Fraunhofer FEP and Professor in Electrical Engineering at the TU Dresden. Her research interests lie in fundamental questions in physics and chemistry within the context of real applications.

Speakers for the 2026 TechCon

Fano-Resonant Optical Coatings and Applications

Chunlei Guo
University of Rochester, Rochester, NY

Despite being a century-old technology, optical coating comprises only a handful of types. Here, I introduce a new class of optical coatings exhibiting photonic Fano resonance, termed Fano-resonant optical coatings (FROCs). FROCs consist of just four thin layers, yet they outperform coatings that require orders of magnitude more layers and thickness. I will also discuss a range of applications enabled by FROCs' superior properties, including beam splitter filters that transmit and reflect the same color, full-gamut high-purity structural colors, and efficient solar energy harvesting systems.

Chunlei Guo is a Professor in The Institute of Optics and Physics at University of Rochester, where his research spans femtosecond laser-matter interactions to nanophotonics. His work at Rochester led to the discovery of a range of highly functionalized materials, including the so-called black and colored metals, super-hydrophillic/-hydrophobic surfaces, and advanced coatings. These discoveries have gained extensive public interest, including 4 features in The New York Times. He is a Fellow of the American Physical Society, Optica, and Int'l Academy of Photonics and Laser Engineering. He served as the Editor-in-Chief for the recently released 2nd edition of the CRC Handbook of Laser Technology and Applications, which serves as the most comprehensive handbook in the field of lasers to date.

From Poisoned Targets to Healthy Models: The Quest for Parameters

Diederik Depla
Ghent University, Gent, Belgium

The conceptual simplicity of reactive magnetron sputtering facilitates the description of global trends in process curves characteristic of reactive magnetron sputtering. However, achieving a quantitative description of these trends through simulations remains far more challenging, as the critical bottleneck of every modelling effort lies in the determination of accurate input parameters. Following a brief introduction to the RSD model, this paper provides an overview of several experimental methodologies designed to extract the parameters essential for its implementation. A central parameter in any thin-film deposition technique is the deposition rate. While its determination in metallic mode is relatively straightforward, the task becomes substantially more complex in poisoned mode due to the limited availability of sputter yield data for oxides. Our experiments reveal that in poisoned mode sputter yields exhibit a pronounced dependence on process conditions. Monte Carlo simulations, moreover, uncover a remarkable material-independent correlation between reported partial yields for oxides and experimentally measured yields in poisoned mode. Another crucial quantity, the ion-induced electron yield, can only be reliably determined experimentally, even for metals. By employing empirical scaling laws, however, it becomes feasible to estimate these yields under poisoned-mode conditions. The strong influence of chemisorption on the electron yield explains the discharge voltage behaviour in metallic mode. The influence of chemisorption on target poisoning emerges as the next major challenge, particularly as a novel strategy to control the reactive sputtering process exposes discrepancies between the current formulation of the model and experimental observations. Nevertheless, this measuring strategy provides compelling evidence that the RSD model's prediction of double hysteresis behaviour is fundamentally correct.

Diederik Depla has received his Master Degree in Chemistry in 1991 at Ghent University (Belgium). In 1996 he promoted with a PhD thesis in Solid State Chemistry on spray drying of precursors for superconductors. After a short period as senior scientist in the Department of Solid State Sciences, in 1999 he became assistant professor. As full professor, he is now head of the research group "Dedicated research on advanced films and targets(DRAFT)" in the same physics department. Two fundamental research questions has driven his research up until now. The first question is how deposition conditions influence film growth, while the second question probes for the impact of reactive gas addition on the magnetron process. Under his guidance, the research group has distinguished itself from the traditional, technological approach, and has set an own course seeking for answers on the two above mentioned fundamental questions, translated in the mission statement of the group: "At DRAFT we want to become the recognized leader in the understanding of thin film growth by reactive magnetron sputtering, and to enjoy research by experiments and simulations." This "target on growth" approach has resulted in several publications in peer reviewed papers. He authored the book "Magnetrons, reactive gases and sputtering." He co-initiated in 2000 the successful RSD conference series. He received the Bill Sproul Award from AVS for "his persistence to unravel the fundamental processes during reactive magnetron sputtering." More details on his research can be found on www.draft.ugent.be.

Advanced Multifunctional Coatings: Integrating Vacuum and Electrochemical Deposition for Sustainable Energy, Surface Protection, and Biomedical Innovations (*Joint Session with The Electrochemical Society*)

Thin-film coatings are at the heart of materials innovation, playing a transformative role in energy systems, corrosion resistance, surface protection, and biomedical applications. This session will bridge expertise from the Society of Vacuum Coaters (SVC) and the Electrochemical Society (ECS) by exploring the synergy between vacuum-based deposition techniques and electrochemical processes, focusing on their combined potential for enhancing specific applications. Whether by integrating vapor-phase deposition methods with electrochemical techniques or applying vacuum-deposited thin films directly to electrochemical devices such as batteries, fuel cells, and sensors, the session will highlight how these approaches can drive the development of high-performance, multifunctional materials for a range of applications.

Vapor-phase methods such as physical vapor deposition (PVD), chemical vapor deposition (CVD), and atomic layer deposition (ALD) enable the deposition of high-purity, conformal coatings with precise microstructural control. These techniques are becoming crucial for the fabrication of next-generation energy devices, corrosion and wear-resistant surfaces, and bioactive films. This session aims to explore the dynamic intersection of vacuum-based deposited thin films materials and electrochemical technology applications. By bridging surface engineering with electrochemical performance, the session seeks to promote cross-disciplinary dialogue and drive innovation across both fields. Discussions will focus on how advanced thin films, coatings, and nanostructures fabricated through vacuum processes can transform electrochemical devices such as batteries, fuel cells, sensors, and beyond.

The Session welcomes papers in the following areas:

- Innovations in PVD, CVD, and emerging vacuum methods for fabricating high-performance electrochemical components,
- Integration of vacuum deposition (PVD/CVD) with electrochemical methods (electrodeposition, electroless plating) for multifunctional and durable coatings,
- Design and development of thin film electrodes for batteries, supercapacitors, and fuel cells to enhance energy storage and conversion efficiency,
- Surface modification using vacuum-based techniques to improve interfacial stability, conductivity, and overall electrochemical performance,
- Advances in scalable vacuum deposition processes tailored for mass production of electrochemical energy storage and conversion devices,
- Vacuum-deposited coatings for next-generation batteries, fuel cells, supercapacitors, and hydrogen storage systems, and
- Novel vacuum deposition approaches to enhance corrosion resistance and extend the service life of components in aerospace, marine, and harsh environments.

Advanced Active and Inactive Coating Technologies to Improve Life and Safety of Lithium-Ion Batteries for Automotive and Grid Applications

Khalil Amine

Argonne National Laboratory, Argonne, IL

To enable mass electrification of vehicles, there is an urgent need of developing high-energy density batteries that offer 15 years calendar life and meet all the abuse tolerance needed to demonstrate excellent safety performance. These challenging requirements make it difficult for conventional battery systems to be adopted in EVs or smart grid application. In this talk, we will present different advanced coating technologies that can stabilize the interface between electrodes and electrolyte leading to significant improvement of both cycle and calendar life as well as battery safety. The protective coating can be done either at the electrode level or at the particle level. We will disclose both inactive coating by spraying nano particle of stable metal oxide, fluoride or phosphate on the secondary particle of the active cathode particles or polymerising a PEDOT conductive polymer to fully protect the secondary and primary particle of the cathode. We will also disclose an active coating using a dual mode gradient approach where we put a stable structure at the surface of the cathode particle to eliminate any Oxygen release responsible for surface parasitic reaction and oxidation of electrolyte causing a thermal runaway. Another alternative is to use functional electrolyte additives to form a robust coating film on the electrode by either reduction, oxidation or polymerization of the additive to form a passivation film that can prevent any side reaction between electrodes and electrolyte at both high voltage and high temperature. These coating technologies have proven to be very effective low-cost approach to enhance battery safety and performance and can enable low cost long range electric vehicles and smart grid.

Powder Atomic Layer Deposition at the Commercial Scale for Batteries and Other Applications

Christopher Gump

Forge Nano, Thornton, CO

While atomic layer deposition (ALD) has found extensive use in the semiconductor industry, it has been generally regarded as too slow or expensive for powder coating applications, even though the precise and nanoscale films could be incredibly useful across many industries. Even so, the number of research publications on the benefits of ALD onto powders has continued to grow over the last 25 years. Fundamentally, ALD on powders is the same as on flat surfaces like silicon wafers. However, much higher mass transfer rates for precursors and reactions products to and from the substrate surface are required. Substrate handling can also be more challenging.

Much of the powder ALD work has been reported in the lithium-ion battery space, where ALD films have been demonstrated to be an effective way of achieving the higher energy densities and charge/discharge rates necessary to speed the commercial adoption of electric vehicles. For these research findings to benefit industry, processes capable of coating large quantities of high-surface area substrates must be developed. To that end, Forge Nano has designed and built commercial-scale tools capable of coating tons of cathode and anode powders in order to standup a robust supply chain for these applications. This talk will highlight the science and engineering for both our semi-batch rotary tool, capable of coating hundreds of kilograms of material with the hundreds of grams of trimethylaluminum and water precursor required per ALD cycle, and our fully continuous vibrating bed tool, capable of coating tens to hundreds of kilograms of material per hour. Products from these tools have been tested in battery cells and shown to have the same performance improvements seen in materials coated at much smaller scale. Results for ALD coatings on Ti64 additive manufacturing feedstocks will also be shared.

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Advances in Thin Film Sensor Technologies: Materials Design and Applications

This technical session highlights cutting-edge developments in thin film sensor technologies, with a focus on the interplay between novel functioning materials, innovative design strategies, and impactful real-world applications. As sensing demands grow across diverse sectors—from healthcare and environmental monitoring to industrial automation and wearable electronics—thin film-based sensors have emerged as a powerful platform for achieving high sensitivity, selectivity, and integration in compact form factors.

Contributions to this session will explore advances in functional thin film materials, including nanostructured, hybrid, and two-dimensional systems; breakthroughs in deposition techniques and micro/nanofabrication; and the engineering of sensor architectures optimized for performance and reliability. Particular emphasis is placed on interdisciplinary approaches that combine materials science, nano-photonics, optoelectronics, electronics, and data-driven techniques to push the limits of sensing performance. Researchers and technologists from academia, industry, and government are encouraged to share innovations, challenges, and future directions in this rapidly evolving field.

The session will welcome contributions on, but not limited to, the following topics:

- Advanced Sensing Materials: Novel nanostructured, hybrid, and 2D thin films,
- Deposition and Fabrication: Innovations in thin film growth and micro/nano-processing,
- Sensor Design and Integration: Compact, robust, and multifunctional architectures,
- Interdisciplinary Approaches: Merging materials, photonics, and electronics,
- Smart Sensing Systems: AI/ML-enhanced data processing and analytics, and
- Application Highlights: Use cases in health, environment, industry, and wearables.

Self-Assembled Oxide-Metal and Nitride-Metal Nanocomposite Thin Films for Metamaterials and Optical Sensing Applications

Di Zhang

University of Texas at Arlington, Arlington, TX

Integration of nanocomposites and heterostructures can create extraordinary properties that cannot be achieved in single phase materials. Beyond oxide-oxide functional nanocomposite films which have been widely explored in the past two decades of this century, oxide-metal nanocomposites films have attracted increasing interests in recent years owing to their wide range of functionalities, such as metamaterials with plasmonic and hyperbolic optical properties, and ferroelectric, ferromagnetic and multiferroic behaviors. In this talk, I will focus on introducing the recently explored oxide-metal and nitride-metal vertically aligned nanocomposite (VAN) thin films showing exotic optical and magnetic-optic coupling effect. Detailed transmission electron microscopy (TEM) and X-ray diffraction (XRD) characterization work revealed the film epitaxy and crystallographic lattice matching relation at metal/oxide (nitride) interfaces. The structure anisotropy of the nanocomposite films results in the corresponding anisotropic optical properties such as angular-dependent transmission and reflectivity, and plasmonic hyperbolic dispersion in the UV-Vis-NIR wavelength regimes. The novel physical properties and coupled functionalities render the VAN thin films to have great potentials in nanophotonic and optical sensing applications.

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Atomic Layer Processing (ALP)

Over the last few years, atomic layer processes (ALPs), such as atomic layer deposition (ALD), atomic layer etching (ALE), molecular layer deposition (MLD), and atomic layer epitaxy (ALEp) have increased in importance, enabling many new products and applications. With excellent uniformity, nanoscale precision, and high versatility, ALPs have applications in sensing, optical coatings, energy storage, and microelectronics. Recent advances in low temperature processing make ALP methods attractive to the processing polymers, biomaterials, and other applications with low thermal budgets.

Sequential Infiltration Synthesis (SIS), alternatively called also Vapor Phase Infiltration (VPI) complements the above-mentioned layer-by-layer technologies by its ability to form 3D nanostructures by a bulk diffusion and selective chemical reactions of precursor with functional groups in polymers or block co-polymers (BCP). Highly selective reactions of precursors with e.g., carbonyl groups (C=O) in the polymer bulk allows integration of inorganic materials into the organic matrix, resulting in a hybrid material. A self-organized BCP film after the SIS will form 3D nanostructures.

The common feature of all those methods is the use of self-limiting reactions that can provide atomic-scale resolution in both vertical and horizontal directions: this property can also be complemented by selectivity in etching or deposition. Selectivity in deposition or etching may solve some of the processing challenges in the technology of nano-devices, e.g., alignment of nanometer-sized features. A high degree of control makes the selective atomic scale processes attractive for future nano-fabrication methods.

We are soliciting oral and poster contributions in areas including both established technologies and creative new developments. Advanced technologies which successfully cross over from early-stage feasibility studying to commercially viable industrial solutions are of particular interest.

Session topics will include:

- Innovations in methods for upscaling ALPs towards high-volume industrial applications,
- New business concepts or market perspectives that accelerate transfer of ALPs and selective atomic processes from the lab to commercial viability,
- Current commercial products using ALPs,
- Precursor synthesis,
- Fundamental aspects of ALP,
- Process development,
- Plasma enhanced processes,
- Challenges and applications of ALPs and selective atomic processes,
- Novel concepts for ALP process control, characterization, and monitoring,
- Applications of selective atomic processes, and
- Selective atomic processes in micro- and nanoelectronics.

Directional Atomic Layer Etching of Lithium Niobate Using Bromine Plasma Chemistry

Austin Minnich
California Institute of Technology, Pasadena, CA

Lithium niobate ($LiNbO_3$, LN) is a ferroelectric crystal of interest for integrated photonics owing to its large second-order optical nonlinearity and the ability to impart periodic poling via an external electric field. However, on-chip device performance based on thin-film lithium niobate (TFLN) is presently limited by propagation losses arising from surface roughness and corrugations. Atomic layer etching (ALE) could potentially smooth these features and thereby increase photonic performance. Previously, our group has reported the first isotropic ALE processes for lithium niobate. Here, we report a directional ALE process for x-cut MgO-doped LN using an HBr-containing plasma. At 0 degrees Celsius we report an 85% synergy ALE recipe with etch rate of 1.04 nm/cycle and surface roughening. At 200 degrees Celsius we report a reduced synergy at 30%, with an etch rate of 1.24 nm/cycle and no evidence of surface roughening. We also compare the surface roughness result of the HBr containing process with a chlorine-only process. Our ALE process could be to fabricate waveguide structures with nanometer precision without surface roughening or redeposition, thereby increasing the performance of TFLN nanophotonic devices and enabling new integrated photonic device capabilities.

Hydrazine-Enabled Atomic Layer Deposition of TiN for High Performance DRAM Electrodes

***Walter Hernandez*[1]**, Adrian Alvarez[1], Lorenzo Diaz[1], Amy Ross[2], Andrew Kummel[2]
[1]RASIRC, Inc., San Diego, CA
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This presentation outlines a thermal Atomic Layer Deposition (ALD) process for titanium nitride (TiN) that leverages anhydrous hydrazine (N_2H_4) as a nitrogen source to achieve low-resistivity, conformal films suitable for advanced semiconductor applications. Unlike conventional ammonia-based processes, hydrazine enables deposition at lower temperatures while maintaining excellent film quality and uniformity in high aspect ratio structures.

The process uses hydrazine in combination with $TiCl_4$ and TEMATi (tetrakis(ethylmethylamino)titanium) in a plasma-free, halogen-free configuration, producing TiN films with reduced impurity levels and enhanced electrical performance. Experimental results demonstrate successful coating of high aspect ratio horizontal vias, with hydrazine contributing to improved conformality and reduced carbon contamination.

We also address safety and delivery challenges traditionally associated with hydrazine, highlighting recent innovations in purification and vapor-phase transport systems. Collaborative work with academic and industrial partners has validated hydrazine's effectiveness across a range of substrates and deposition conditions.

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Characterization, Testing, and Failure Analysis of Thin Films, Coatings, and Engineered Surfaces

In support of innovations and continuous R&D, product and process improvements across SVC society stake holders and industries, a new session for the SVC TechCon has been added to this year's program. This new session focuses on thin film, coating, and engineered surface characterization, evaluation and failure analysis. The goal of the session is to provide a forum for attendees to present and exchange technical information related to characterization and evaluation of thin films, coatings and engineered surfaces made through vacuum coating processes. The importance and significance of this session are obvious. First, the various properties of thin films and coatings depend on several factors during preparation. Proper characterization is critical for understanding and further optimization. Second, characterization and testing are essential for intended applications, for meeting product-design specifications, and for ensuring desired interactions with service environments. Third, the lifetime estimates, and failure analysis of thin films and coatings are crucial for avoiding unexpected situations and for identifying root causes of failures.

There are a variety of techniques for analysis, characterization and testing of materials. This session will focus on techniques and applications suitable for thin films, coating and engineered surfaces, with an emphasis on the recent development of the new in-situ and

ex-situ capabilities, multi-technique approaches, automation, and AI assistance.

Presentation submissions in the following areas and topics are encouraged:

- Biological compatibility, toxicity, antimicrobial properties,
- Chemical composition, stability and interactions with environments,
- Lifetime estimation and life cycle assessment,
- Mechanical properties, super-hardness and stress evolution,
- Electric and magnetic properties,
- Microstructure, crystallinity, phase composition and porosity
- Nano/microscale phenomena, organized structures and nanocomposites,
- Optical properties, colors and emissivity,
- Surface and interfacial properties,
- Thermal properties, heat transfer and thermal stability, and
- Tribological properties, wear and adhesion.

This session, through a series of invited talks and contributed presentations, aims to address common questions and challenges faced by researchers, practitioners, and professionals who are in the SVC associated fields. It will provide new insights into the analysis, characterization and testing methods currently available, recently developed and under development for thin films, coatings and engineered surfaces.

New Developments in Spectroscopic Ellipsometry

James N. Hilfiker, Nina Hong, Rafał Korlacki, Jeffrey S. Hale, Joel Mohrmann, Jeremy Van Derslice

J.A. Woollam Company, Lincoln, NE

For decades, spectroscopic ellipsometry (SE) has been a prominent technique for non-destructive and accurate measurement of thin film thicknesses and optical constants. To understand recent advances, we first need to consider the conventional SE measurement technology. Most SE tools probe the sample of interest using light with wavelengths from the ultraviolet (UV) to the near-infrared (NIR) or even the mid-infrared (IR). SE data are often collected in seconds. The data analysis has become routine for the thickness and refractive index of single-layer coatings, and with some effort, can be extended to more complex structures. Now, let's examine several new advances in instrumentation and software that are enhancing SE capabilities.

While SE performed at UV to NIR wavelengths is fast, SE measurements in the mid-IR can take hours to achieve an adequate signal-to-noise ratio. Recently, quantum cascade lasers (QCL), with many orders of magnitude more brightness than standard blackbody radiation sources, have been integrated into IR-SE. The extra light allows much faster measurements, which is particularly useful for dynamic data collection, anisotropic characterization requiring multiple sample orientations, and uniformity mapping.

Standard SE measurements describe the transformation of polarized light by the sample. A more complete description of light is considered by the Stokes-Mueller formalism. With this capability, both the cross-polarization and depolarization of light can be quantified. One such example is $LiNbO_3$, used in photonic applications, where the uniaxially anisotropic refractive index can be determined via sample-rotated Mueller matrix (MM) SE measurements. MM-SE is also used for chiral materials and non-symmetric crystal materials. MM-SE measurements have even found applications in many semiconductor processing steps, where critical dimensions (CD) can be determined via the specular scatter measured by MM-SE for 3D memory and logic device structures.

Finally, we will examine how machine learning is transforming the approach to SE data analysis. Will computers put us out of a job? Only time will tell, but maybe we had better start saving for an early retirement.

Surface Coating, Treatment, and Analysis of Materials for Medical Devices

Bernard Li

Medtronic Neuromodulation, Minneapolis, MN

Surface coating and treatment on medical device components are critical to enhance the performance of medical devices. Surface coatings and treatments have been used in medical devices for different functions, such as insulation, low friction, wear resistance, antimicrobials, etc. All coatings and surface treatments need to undergo surface characterization in order to understand their properties. This study investigates the application of Diamond-Like Carbon (DLC) and Tungsten Carbide-Carbon (WC-C) coatings for the Sychro-Med Infusion (SMII) drug pump, as well as Titanium Oxide (TiOx) coatings for a piston pump application. Advanced surface analysis techniques, including microscopy, nanoindentation and scratch tests, were employed to evaluate coating properties, adhesion, and surface morphology. These analyses, combined with wear resistance testing, demonstrate the effectiveness of the coatings to mitigate surface degradation and to extend the functional lifespan of critical components under demanding operational conditions. The study confirms that the coatings not only improve wear resistance, but they also offer significant improvement for the durability and reliability of medical devices.

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Coatings and Processes for Biomedical Applications

Coatings and surface treatments are essential to the advancement of both established and emerging biomedical technologies. Recent progress in the understanding of biological systems has accelerated the development of innovative coatings and surface engineering approaches. These technologies aim to improve osseointegration, enable neural interfaces, extend the operational lifespan of implanted devices, enhance biocompatibility, and reduce costs. These advances are not limited to implantable devices; they also support a wide range of applications such as energy harvesting for wearable health-monitoring systems, where flexibility and biocompatibility are essential.

To support continued innovation and address technical challenges in this rapidly evolving field, the Coatings and Processes for Biomedical Applications Technical Advisory Committee (TAC) welcomes paper submissions focused on coatings and surface modifications for biomedical applications. Submissions may cover material development, surface engineering techniques, characterization methods, performance evaluation, regulatory pathways, or emerging applications in the biomedical space.

Topics of interest include, but are not limited to:

- Orthopedic coatings and osseointegration,
- Cardiac rhythm management,
- Neurostimulation technologies,
- Cardiovascular interventions,
- Bio-corrosion resistance,
- Flexible and stretchable electronics,
- Biosensors, bioelectronics, and biochips,
- Antimicrobial surface treatments,
- Novel surface modification techniques (e.g., laser processing),
- High-throughput materials development,
- High-throughput and advanced characterization techniques,
- Regulatory approval strategies,
- Navigating evolving funding landscapes, and
- Market analysis and projections.

Submissions addressing other biomedically relevant topics related to coatings and surface engineering are also encouraged.

INVITED SPEAKER:

From Telecom to Biotech–Closing the Loop with Thin Films

Matthias Wagner

Cambridge, MA

As medicines shift from small molecules to proteins to cells, manufacturing challenges are mounting in biotech and pharma. Critically, the coming wave of regenerative cell and tissue therapies currently rely almost entirely on manual cell culture processes in dedicated clean rooms. Cellino Bio is building a scalable platform for autonomous manufacturing of personalized regenerative medicines. At the core of the platform is a laser-film interaction that enables precise closed-loop control of biology. Nanosecond laser pulses are partially absorbed by the thin film and cause rapid microbubble expansion and collapse, providing a tunable mechanical force on cells that are cultured on the surface. These forces may be used to temporarily porate cells for intracellular delivery, or to irreversibly porate them for destruction and removal from the cell culture. The thin film itself is subject to a set of stringent requirements including biological, environmental, optical, thermal, and regulatory. A significant number of iterations was required from the initial university laboratory proof-of-concept up to the clinical-ready film. Ultimately, work with an external expert and vendor capable of scaling manufacturing was required for repeatable, reliable results. Previous background in other thin film structures, notably ones for optical communications, served as a guide but also a contrast from a requirements standpoint. Finally, the effort required a significant amount of venture financing as well as government backing, which will be described in the talk, together with the productization path for the film and system.

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Coatings for Energy Conversion and Related Processes

This session provides a comprehensive forum for experts and researchers to discuss the latest developments and technologies in the field of energy conversion coatings. These talks cover a wide area of applications, however with a core focus on energy conversion, storage, and management. This session brings industry, research, and academics together in order to facilitate the transfer of technology and share new and upcoming ideas and technologies for the improvement of sustainable living.

The Technical Advisory Committee (TAC) welcomes papers in the following areas:

Solar and Ambient Light Energy Conversion:

- Thin-film and thin wafer as well as perovskite silicon tandem photovoltaics for space and terrestrial applications,
- Organic flexible photovoltaics (OPV),
- Semi-transparent photovoltaics, and
- Coatings for improved performance.

Energy Harvesting:

- RF harvesting,
- Piezoelectrics, and
- Kinetic harvesting through body movement.

Energy Storage:

- Thin flexible batteries,
- Flow batteries,
- Powder surface treatment (PVD, CVD, ALD) for Li-ion batteries, Na-batteries, or solid-state batteries (or other types),

- Super capacitors,
- Coatings for improved stability, graphene and carbon nanotubes, and
- Protective coatings for the prevention of e.g., hydrogen embrittlement.

Efficient Functional Coatings:

- Radiative cooling,
- Hydrophobic and hydrophilic,
- Self-cleaning catalytic coatings,
- Development of coatings for reduction of precious metal, and
- Anticorrosive coatings.

Other Traditional Subjects:

- Smart windows,
- Selective radiators,
- Fuel cells and electrolyzers (low temperature, high temperature, advanced types), and
- Large-scale energy conversion and storage.

Yttrium Oxyhydride-Based Photochromic Coatings for Window Applications: From Lab Scale Films to Large Scale Roll-to-Roll Production

S. Zh. Karazhanov

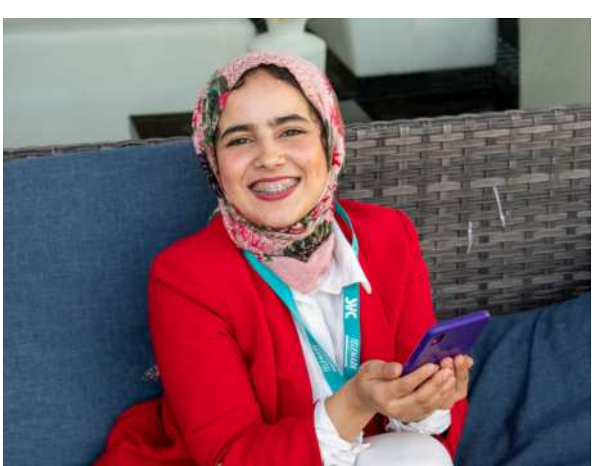
Institute for Energy Technology, Kjeller, Norway and University of Latvia, Riga, Latvia

Yttrium oxyhydride ($YH_{3-2x}O_x$, YHO) belongs to the emerging class of mixed anion systems—materials incorporating multiple anion species, potentially enabling unique properties not found in single-anion counterparts. First discovered in 2011, YHO is synthesized via reactive magnetron sputtering to deposit $YH_{2-\delta}$, followed by oxidation in air. It exhibits photochromic behaviour under ambient conditions, transitioning from a transparent state (transmittance $T > 85\%$) to a dark state ($T \approx 20\%$) upon exposure to sunlight, with nearly uniform absorption across all wavelengths.

YHO has strong potential for various technological applications, including smart windows, protective eyewear, helmet visors, and automotive roof glass. The commercialization of roll-to-roll deposited photochromic YHO has already begun through the SME Sunphade. Today, the study of YHO and other rare-earth metal oxyhydrides is an increasingly attractive research field.

This talk will highlight key research findings on YHO, focusing on its physical and optical properties, including photochromic behavior under visible and ultraviolet light exposure, tunable transparency, and high optical stability with minimal degradation over multiple cycles. The temperature-dependent dynamics of YHO's transition between transparent and opaque states will also be discussed. Additionally, the presentation will cover ongoing studies related to durability and chemical stability, ensuring long-term reliability in practical applications, as well as efforts to enhance response times, cycling stability, and energy efficiency for large-scale implementation.

Theoretical advancements will be explored, including predictions of crystal structures for oxidized yttrium hydride, hydrogen-induced band structure modifications that explain its distinctive optical effects, and phenomena such as light-induced lattice breathing and lattice contraction/expansion. Furthermore, deposition techniques for small- and large-area glass and flexible substrates, prototype development, and functionality assessments in both laboratory and outdoor environments will be presented, along with insights from roll-to-roll deposition studies.



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Digital Transformation through Artificial Intelligence, Machine Learning, Simulation, and Data Science in the Thin Film Industry

This session explores the transformative role of digital technologies in the domain of industrial thin film deposition, particularly within vacuum-based coating technologies. The focus is on leveraging physics-informed simulation, artificial intelligence, and data-driven methods to enhance process understanding, optimization, and control.

The session will include, but is not limited to, the following topics:

- ***Physics and Chemistry Simulations:*** Use of high-fidelity, multi-physics models to predict key process parameters like erosion and deposition profiles, film composition, ion bombardment, gas and plasma distributions, and substrate heating.
- ***Digital Twin Models:*** Real-time capable simulations that integrate equipment layout and operating parameters to forecast coating performance and variability.
- ***Machine Learning and Hybrid Approaches:*** Applications of AI for predictive maintenance, parameter tuning, and anomaly detection. Emphasis on combining limited experimental data with

physical modeling for higher generalizability (greybox models).

- ***Data Infrastructure and Process Mining:*** Tools and methods for systematic data acquisition, storage, accessibility, and intelligent analysis across the coating process chain.

This session is intended for all stakeholders involved in the digital transformation: OEMs and system integrators in the vacuum coating sector, coating service providers and production engineers, developers of coater components and diagnostic tools, as well as providers of simulation software and digital services, and data mining platform providers.

Navigating Digital Transformation in an Established Industrial Environment: Data, Simulation, and the Strategic Road Ahead

Alexander Ebner, *Stephan Trassl, Martin Egginger*

Hueck Folien GmbH, Baumgartenberg, Austria

In this presentation, we emphasize the importance of comprehensive data acquisition across an entire production site and demonstrate how advanced data analytics, in combination with physical simulations, can unlock significant efficiency gains. To this end, we provide insight into our company's technological evolution, outlining our digitalization roadmap along with the concrete implementation steps undertaken to put it into practice.

Our long-term objective is guided by the vision of a fully realized digital twin, which serves as both our strategic goal and design principle. We illustrate how this vision is being pursued through a series of targeted pilot projects, each designed to implement early digitalization elements while keeping the broader transformation in focus.

We then examine our current stage along this transformation path, exemplified by a pilot project aimed at optimizing a particular electron beam physical vapor deposition (EB-PVD) process. This case study demonstrates the synergistic use of data-driven analysis and physical simulation to deepen process understanding and enhance performance.

A variety of methodological approaches and practical examples from both domains are discussed in detail. These include the deployment of an advanced data acquisition system and the corresponding analytics, as well as reverse-engineered simulations to improve film homogeneity and particle-based modelling for process insight and optimization.

Finally, we offer a forward-looking perspective on the scalability of our approach and reflect on the potential challenges and opportunities ahead.

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Electron Beam Processes

The Electron Beam Processes Technical Advisory Committee (TAC) is a spin-off from the International Conference on High-Powered Electron Beam Technology, originally founded by Dr. Robert Bakish in 1983. Today, high-power electron beam technology is well established for coating, melting, and welding. The EB TAC focus is the development of new coatings and coating processes using electron beam technology as well as new ebeam components, such as power supplies and beam control systems to enhance material properties. Of particular interest are improvements to equipment that enable new applications such as additive manufacturing of turbine engine components and medical implants.

The TAC supports the technical and technological exchange of knowledge to promote electron beam technology especially for industrial applications and is looking for papers on the topics listed below:

- Advances in high-rate PVD by electron beam evaporation (EB-PVD), such as for thermal barrier coatings,
- Electron beam processes for the production of novel materials,
- Additive manufacturing with electron beam,
- Thermal processes (welding, hardening, refining, drilling),
- Non-thermal processes (curing, sterilization, crosslinking, gas conversion),
- New applications for PVD by electron beam evaporation for photovoltaics, concentrated solar, energy production (fuel cells), energy storage (batteries), and high efficiency lighting,
- Modelling of electron beam sources, processes, and systems,
- New components in electron beam technology (guns, power supplies, vacuum systems, plasma assist),
- Emerging technologies (electron generation, beam guidance, etc.), and
- Related and new applications of electron beam processes.

Vacuum Barrier Coatings for Mono-Material Films: Developments in Equipment and Process Technology for SiO_x and AlO_x

Markus Piwko, *Jörg Faber, Carsten Deus, Andreas Steinbach*

VON ARDENNE GmbH, Dresden, Germany

Recyclable mono-materials are essential for enhancing sustainability in the packaging industry, making vacuum-coated barrier layers with minimal thickness increasingly significant. Among the various deposition technologies, Electron Beam - Physical Vapor Deposition (EB-PVD) stands out alongside thermal evaporation methods, providing complementary advantages for the deposition of SiO_x barrier layers at a high-volume, cost-effective scale. These SiO_x coatings are anticipated to facilitate new applications, such as retort and hot filling, due to their superior resistance to mechanical elongation and humidity.

Advanced and reliable vacuum equipment, combined with appropriate process development and control, is crucial for achieving specific layer properties while ensuring techno-economic benefits, requirements best met by experienced equipment manufacturers. This presentation will elucidate the distinctions and synergies between electron beam and thermal boat evaporation for SiO_x and AlO_x coatings, while also introducing key performance indicators for the resulting mono-material films. Moreover, insights into new developments in equipment and process technology, along with a techno-economic analysis, will be shared. This information will empower film makers, converters, and brand owners to better understand the opportunities and limitations of barrier coatings deposited via electron beam compared to thermal evaporation techniques.

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Emerging and Translational Technologies and Applications

This session welcomes presentations related to deposition and surface engineering technologies and applications that do not readily align with the classic session topics of the SVC TechCon program.

Modern market needs and application requirements continuously trigger innovation in the production and development of thin films and coatings. There are two trajectories that historically advance the field: (a) adjacent markets and applications expand by taking advantage of innovation in traditional technologies, and on the other side (b) established markets and applications that benefit from technical innovation in fields that previously were restricted to exterior "heritage" domains.

This session seeks to highlight new applications and markets that are enabled by advances in thin film and coating deposition, interface engineering, and surface processing. Contributed presentations may emphasize applications and markets, describe the role of enabling or cross-over technologies, as well as business topics such as market opportunity overviews, or new business and engineering concepts.

Market- and business-focused talks should generally relate to technology innovation within the SVC domain, and technology-focused talks should relate to a new market or application arena that SVC stakeholders should pay attention to.

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High Power Impulse Magnetron Sputtering – HIPIMS

High power impulse magnetron sputtering (HIPIMS) has moved from lab scale to industry. Today, a significant number of industrial-scale HIPIMS processes exist as well as some commercial processes and products. Both fundamental understanding and application-oriented development are essential for exploiting the full potential of this technology.

The latest results from fundamental research, new and advanced approaches for simulation and modeling, and the combination of applied research from lab scale to industrial size cathodes and machines are the focus of this TAC. The session aims to provide a forum linking scientists, technologists, and industrialists to discuss all aspects of the HIPIMS technology.

Papers are solicited from, but not limited to, the following areas:

- Fundamental research on plasma, discharge, and coatings,
- Simulation and modeling of HIPIMS,
- New plasma sources and process modifications,
- Recent development in pulse generation and process and plasma diagnostics,
- Application oriented results: tribological, optical, medical, etc., and
- New coatings and products.

Beyond Traditional High Power Impulse Magnetron Sputtering

U. Heydenreich[1], *D. A. L. Loch*[1], *A. W. Oniszczuk*[2], *R. Bandorf*[3], *A.P. Ehiasarian*[4], *W. Gajewski*[2]

[1]Trumpf Hüttinger GmbH + Co. K.G, Freiburg, Germany
[2]Trumpf Huettinger Sp. z.o.o., Warszawa, Poland
[3]Fraunhofer Institute for Surface Engineering and Thin Films IST, Braunschweig, Germany
[4]Sheffield Hallam University, Sheffield, United Kingdom

Over the last 20 years, high power impulse magnetron sputtering (HIPIMS) has developed into a key PVD technology. It is primarily used in sputtering processes where customers' demands for film quality and characteristics cannot be met by any other means. HIPIMS has established itself as the state-of-the-art coating technology for smooth, highly resistant hard coatings on conductive substrates.

However, applications outside of hard and decorative coatings have only been able to establish themselves to a limited extent. There is a strong, growing trend towards using HIPIMS in more specialized areas, such as semiconductors and electronic packaging.

The pulsed generation of ionized species presents opportunities, but also challenges. In addition to generating ions, controlling them is also challenging. The quest for the ideal substrate bias is complicated by diverse ion-neutral ratios and higher ionized states in the metallic flux, especially given the changing HIPIMS process parameters. Nevertheless, there are various solutions available for generating the desired substrate bias, such as different pulse shapes and patterns, as well as their combination with other excitation methods, such as DC or RF.

Applications in the semiconductor industry present particular challenges. Similar process modules must ensure consistent process quality throughout the entire target life. Special consideration must be given to the requirements regarding particle prevention. This discussion will present possible solutions to these challenges. The requirements for process qualification will also be addressed. Measurement technology is generally only used for process development. However, new requirements are also emerging for measurement technology. Any possible changes, for example due to target erosion or changes in ionization conditions, must be adequately compensated for.

In order to meet these special requirements, a deep understanding of the processes involved in coating three-dimensional structures, as well as their modelling and simulation, is necessary. Verifying stability over the entire target lifetime during development is very time-consuming. Qualifying the product is even more costly. Therefore, digital twins must be developed to shorten the qualification process.

Towards Reactive-Gas-Less Sputtering of Functional Nitrides – The Role of Metal Ions in Plasma-Activated Reactive Environments

Tetsuhide Shimizu[1], *Caroline Hain*[2,3], *Yuji Oshida*[1,2], *Eva Vogt*[2], *Thomas Nelis*[2,3], *Johann Michler*[2]

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[2]Swiss Federal Laboratories for Materials Science and Technology, Thun, Switzerland
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Nitride thin films are indispensable materials across diverse industrial sectors, including hard coatings, semiconductors, and optical devices, typically fabricated by reactive sputtering with nitrogen (N_2). Film stoichiometry and crystallinity are strongly governed by the N_2 partial pressure, but less attention has been given to the actual incorporation efficiency of nitrogen into the growing film. In particular, dissociation of N_2 molecules into atomic nitrogen within the plasma is expected to critically influence surface reaction kinetics. This study investigates the role of highly ionized metal ions of high-power impulse magnetron sputtering (HiPIMS) in the discharge with activated nitrogen species during nitride film growth, with a focus on AlN deposition by microwave (MW)-assisted reactive HiPIMS. In this approach, AlN thin films were synthesized at very low N_2 flow rates within the metallic regime, where enhanced deposition rates and improved process stability are advantageous for industrial application. To analyze discharge characteristics during the reactive mode transition, energy- and time-resolved mass spectrometry was performed using a time-of-flight mass spectrometer (E-ToFMS), enabling detailed analysis of ion dynamics under varying reactive gas conditions. The results demonstrate that highly crystallized, (0002)-oriented AlN films can be deposited at very low N_2 flow rates when MW plasma assistance is applied, whereas conventional HiPIMS under the same conditions yielded metallic Al films. Mass spectrometry revealed that even at reduced N_2 flows, high fluxes of atomic and molecular nitrogen ions were present, particularly during the pulse-off time, highlighting their decisive role in sustaining film-forming reactions. These findings clarify the mechanism of AlN growth under low N_2 pressures and emphasize the importance of dissociated nitrogen species to improve the incorporation efficiency of nitrogen duruing reactive sputtering. The insights gained not only improve process control for AlN but also provide broader implications for the synthesis of other transition metal nitrides by HiPIMS in industrially relevant conditions.

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Large Area Advanced Packaging and Integrated Photonics

The growing demand for high-performance computing, artificial intelligence, augmented/virtual reality, and advanced communication systems is driving unprecedented innovation in both large-area advanced packaging and integrated photonics. As the limits in transistor size and speed approach, the logical next steps to increase performance involve advancements in parallel computation and optimized communication between integrated components. To increase throughput, yields, thermal performance, and reduce cost, substantial focus and development effort have been put into large-area advanced packaging. As a foundational technology for these advancements, thin film deposition, a core area of expertise within the SVC community, plays a critical role in enabling the next generation of devices.

This session will explore the cutting-edge intersection of large-area manufacturing techniques for advanced packaging and integrated photonics. We encourage submissions that address challenges, present novel solutions, and showcase recent advancements in manufacturing equipment, processes, materials, and architectures.

Topics of Interest Include, but are not limited to:

Large Area Advanced Packaging:
- New process, equipment, performance, and yield requirements for advanced packaging,
- Large area packaging challenges and solutions,
- Wafer-level and panel-level packaging for integrated photonics,
- Advanced interconnects (e.g., through-silicon vias (TSVs) and through-glass vias (TGVs)), and
- Substrate technologies and interposer solutions for large-area integration.

Thin Film Deposition for Photonic Integration:
- Challenges and opportunities in scaling up integrated photonics manufacturing,
- Silicon photonics and other material platforms for integrated optics,
- Advanced dielectric and optical coatings for waveguides, filters, and resonators,
- Deposition of active photonic materials,
- The role of atomic layer deposition (ALD) and precise film control, and
- Large area physical vapor deposition (PVD) techniques for metallization and optical layers.

Manufacturing and Process Control:
- High-throughput manufacturing methods,
- Process control and in-situ monitoring for thin film deposition, and
- Yield enhancement and cost reduction strategies for large area integration.

We encourage submissions from academic and industrial researchers, engineers, and scientists working on all aspects of large area advanced packaging and integrated photonics, especially those with a focus on the underlying thin film and deposition processes. Join us to discuss the latest breakthroughs and future directions in this rapidly evolving field.

PVD Driven Innovations in Advanced Packaging: Enabling Next Generation Heterogeneous Integration

Manuela Junghähnel
Fraunhofer IZM-ASSID, Moritzburg, Germany

As semiconductor devices push beyond the limits of traditional scaling, advanced packaging has emerged as a decisive enabler for next generation performance, functionality, and system integration. Heterogeneous Integration combining chiplets, high density interconnects, and diverse materials within a unified package demands manufacturing technologies that deliver exceptional precision, scalability, and material flexibility. PVD has become a cornerstone in this landscape, providing critical thin film layers that define electrical performance, reliability, and thermal behavior in "state of the art" packaging architectures.

This presentation highlights how innovations in PVD process engineering are accelerating the evolution of advanced packaging. Key focus areas include high-density redistribution layers (RDL), advanced UBM and seed layers for fine-pitch interconnects, diffusion barriers for copper metallization, and conformal coatings required for through-silicon vias (TSVs). Emerging requirements such as larger panel formats, ultra-low-defect metallization, and tight uniformity control across increasingly complex topographies are driving the development of new plasma-enhanced, reactive, and high-throughput PVD approaches.

Moreover, the role of PVD in enabling large-area advanced packaging and integrated photonics will explore, where film stress control, adhesion engineering, and optical-grade metal deposition are critical. As AI, high-performance computing, and edge devices demand unprecedented integration density, PVD-based materials and process innovations are becoming essential to building chip and chiplet systems of the future. The presentation gives insight into current challenges, industrial trends, and forward-looking process strategies that position PVD as a key technology for enabling the next era of heterogeneous integration.

Optical Engines and Thin Film Nanophotonics

Mohamed ElKabbash

University of Arizona, Tucson, AZ

The exponential growth of artificial intelligence (AI) workloads has driven a paradigm shift in how information is moved and processed at scale. A central development in this domain is the rise of optical engines, which integrate light sources, modulators, and detectors to overcome the electronic SerDes bottleneck in data movement. I will discuss the motivation behind the push toward co-packaged optics, where photonic components are placed in close proximity to electronics to reduce energy consumption and increase bandwidth density. Particular emphasis will be placed on the challenges that hinder practical deployment, including the temperature sensitivity of semiconductor lasers and electro-optic modulators, the complexity of chip–fiber coupling at high channel counts, and the trade-offs between density, stability, and bit-error rate. Potential solutions such as temperature-stable integrated sources, efficient chip-coupling strategies, and athermal photonic designs will be highlighted.

The second part of the talk turns to thin-film nanophotonics, an emerging area that extends the traditional role of optical coatings beyond interference filters and structural coloring. By exploiting resonant and interference phenomena in multilayer stacks, thin-film coatings can mimic atomic-physics-like effects such as Fano resonances and be engineered for advanced energy applications, precision sensing, and photonic information processing. I will present our efforts on thin-film photonic computing architectures, where diffractive layers establish non-trivial spatial correlations for low-latency matrix operations, as well as photonic memory and edge sensing under low signal-to-noise conditions. Finally, I will discuss our ongoing work toward realizing transmissive extreme ultraviolet (EUV) lenses at 13.5 nm using Si/Mo multilayers, a long-standing challenge in nanolithography and imaging. Together, these directions illustrate how optical engines and thin-film nanophotonics are reshaping the future of information technologies and beyond.

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Large Area Coatings

Scaling up to high volume manufacturing (HVM) has enabled tremendous cost reduction in the production of architectural and automotive glass, flat panel displays, solar cells, and roll-to-roll. Scalability comes with unique challenges. To operate a plant at HVM scales, the selected deposition method and related processes must be stable and reproducible over long operation time. Chemical and physical layer properties at the nanoscale must be precisely controlled across the meter scale. The obtained layers serve later as optical interference stacks, diffusion barriers, hard or lubricating coating for scratch resistance, transparent conductors, decorative coatings, solid electrodes or electrolytes.

The Large Area Coating Session gives you an opportunity to meet with and to learn from leading industry and academic experts in the field, present and discuss cutting edge developments in the broad field of coating applications, highlight the newest materials, methods, processes, review required equipment and software, and also discuss market trends. Session topics will cover:

- Understanding and controlling process at nanoscale with homogeneity up to meter-scale: physics and chemistry of thin films and their interfaces, analytical equipment in-/ex-situ, in-/off-line,
- Human-assisting technologies: predicting and correcting materials and processes by physical simulations and machine learning,
- 2D and 3D coatings, processes, equipment, market trends and regulations for architectural, automotive, aerospace, and display applications,
- Manufacturing methods including surface preparation, etching, sputtering (magnetron, ion beam assisted), high power impulse sputtering (HiPIMS), evaporation, chemical vapor deposition (CVD), plasma enhanced CVD (PECVD), atomic layer deposition (ALD), plasma enhanced ALD (PEALD/PAALD), pulsed layer deposition (PLD), and
- Best practices: process engineering and transfer, quality control, upgrade of equipment, predictive maintenance, metrology, sustainability, testing and introducing new technologies, scale-up.

Mass Production of Inorganic and Organic Coatings for Display Cover Glass

Brian S. Holsclaw

Corning, Inc., Corning, NY

As automotive displays become central to modern vehicle design, it is critical for cover glass coatings to meet certain optical performance, durability, and manufacturability requirements. This presentation will discuss anti-reflective (AR) and organic coatings designed for mass production processes. AR coatings will be discussed that have specific optical attributes for automotive displays including low reflectivity, high transmission, neutral color, and minimal color shift at high-viewing angles. These AR coatings must be scalable to a large-area process and manufacturable with precision.

Durability requirements must also be considered for real-world use cases for such AR coatings. From a production point of view, cost of manufacturing will depend on effective integration of an appropriate coating system within a streamlined factory flow with best-practice processing and manufacturing improvements. Such a flexible and forward-looking manufacturing strategy will allow new products and coatings to be efficiently mass produced.

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Optical Coatings

Exciting developments in optical coatings are stimulated by the latest trends in optics, optoelectronics, photonics, optical data processing, mobile devices, displays, biomedical, sensors, energy and photovoltaics, architectural, aerospace, astronomical, and other technologies. The optical coatings session will bring together these different aspects for technical interchange in the field of optical interference coatings.

To build a well-rounded optical coatings session, abstracts are solicited to cover topics including coating design, development of practical manufacturing techniques, characterization methods, and a wide range of applications.

Specific areas may include:

- Novel optical coating materials, including metamaterials and metasurfaces,
- New fabrication processes for optical coatings,
- Novel optical interference design software and design techniques,
- Production issues common to the industry – including lessons learned or serendipitous discoveries that came from problems or disasters,
- Metrology of optical films (new instrumentation and software developments, inline or in-situ approaches, etc.),
- Real-time process monitoring and control with optical coating processes,
- Industrial scale-up,
- Preconditioning and cleaning issues; refurbishment approaches for optical coatings,
- Coatings on sapphire, polymers or other special substrate materials, coatings for complex 3-D optical devices,
- Applications in non-traditional wavelengths, from EUV to IR (e.g., IR thermal imaging),
- Optical coatings for mobile electronics (e.g., fingerprint sensors, cameras, displays, touchscreens, etc.),
- Optical coatings for wearable technology, including AR/VR,
- Coatings for LIDAR/driverless vehicles,
- Optical coatings for biomedical applications,
- Optical coatings for energy control and solar power,
- Optical coatings for laser applications, including femto-second lasers,
- Optical coatings for display and integrated photonic device applications,
- Optical coatings for astronomy and aerospace, and
- Optical coatings for quantum optics.

State of the Art of Amorphous IBS Coatings Improvements for the Gravitational Wave Detectors and Other Applications

L. Pinard, *C. Michel, B. Sassolas, J. DeGallaix, D. Forest, M. Granata, L. Mereni, J. Teillon*

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For the first time in September 2015, a direct detection of gravitational wave occurred in the LIGO interferometers. These advanced detectors need large fused silica mirrors (34-35 cm diameter, 20 cm thick) having optical and mechanical properties never reached up to now. LMA has developed and optimized these IBS (Ion Beam Sputtering) coatings on the mirrors of the Fabry-Perot arm cavities of the LIGO or Virgo gravitational wave detectors to get:

- the lowest optical losses (0.3 ppm absorption at 1064 nm, around 5 ppm of scattering)
- the lowest mechanical losses (thermal noise reduced by the use of $Ti{:}Ta_2O_5$ as high index layer)
- the best coating uniformity (<0.1 % on 150 mm diameter).

To improve the detector sensitivity, the laser power has increased during the following scientific runs and a problem appeared in the high reflective coating: some very high absorbing points (several hundreds of ppm) can be present. Some investigations were done to understand and find their origin, and a solution was found to suppress them. This optimization was helpful for other projects using high finesse cavities.

The other noise limiting the detector performances in the 100 Hz region is the coating thermal noise, coming from the high index layer. Some R&Ds started at LMA (Working Group between LIGO and Virgo) to find a new material able to reduce this noise by a factor of 2. The best candidate is the $Ti{:}GeO_2$. Some final results will be presented.

Recent Innovations in Optical Coating Design Software

Michael Trubetskov[1,2]

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[2]Max Planck Institute of Quantum Optics, Garching, Germany

Modern software packages in the field of multilayer optical coatings cover many classes of different problems, including analysis and synthesis of multilayers, characterization of monolayers, reverse-engineering of produced multilayer coatings, real-time control of deposition processes using broadband or quasi-monochromatic optical monitoring, and computer simulation of multilayer production. This wide coverage of various classes of problems is essential to achieve high-quality multilayer coatings, addressing new challenges in science and technology.

Various aspects of innovative software support are considered, including efficient ways to solve direct problems of multilayer coating evaluation involving vectorization and parallelization of computations. Efficient methods of solving synthesis problems are discussed, including classic and deep search needle synthesis, gradual evolution, and multi-start optimization. The choice and correct specification of targets—ranging from spectral and integral values, absorptance, and electric field to stress and thickness—are critical. For ultrafast optics, specialized targets include group delay (GD) and group delay dispersion (GDD), and multi-coating configurations for dispersive mirror compressors are involved.

Recent innovations integrate deep search methods able to provide solutions with excellent performance on the one hand and production-friendly tools, such as design cleaner, bound-trap, thick layer reduction, and robust synthesis.

Characterization determines optical parameters of substrates and layer materials, while reverse engineering identifies and compensates for repeatable production errors. Special adaptations support large area manufacturing in automotive, architectural, and wafer applications. Real-time characterization and re-optimization mitigate non-repeatable deposition errors.

Insights from recent Optical Interference Coatings (OIC) design challenges underscore the progress and creativity in tackling these complex problems, illustrating the interplay between theory, computation, and manufacturing realities in modern multilayer optical coating technology.

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Organic and Perovskite Electronics

Organic and organometal-halide perovskite materials have emerged in recent years as important alternatives to traditional inorganic materials for optoelectronic devices. These novel materials provide huge potential benefits such as reduced-cost processing, compatibility with nonconforming and flexible substrates, and tunable color properties, allowing for a range of interesting applications. Organic light-emitting diodes (OLEDs) have become widespread commercially in displays, with improvements in brightness and contrast ratios, as well as interesting form factors such as thin and flexible devices. Perovskite-based photovoltaic devices are attracting considerable interest as a potentially disruptive energy technology, with power conversion efficiencies similar to or in excess of those seen in current panels but with simpler processing requirements.

Like any interesting and fast-growing field of technology, the achievements and benefits in the field of organic/organometallic electronics and optoelectronics don't come without their own challenges. The inherent properties of these materials make them challenging to deposit using a vapor-phase technology:

- The materials are typically prone to decomposition at relatively lower temperatures which has led to development and use of evaporation sources with a complex set of features and temperature control mechanisms.
- Additionally, some of the active films in the device architecture require precise rate control algorithms to achieve the required host-dopant compositions, which in turn also require critical hardware considerations.
- Materials are mostly sensitive to moisture and oxygen, so the protection from these elements during and post-fabrication is critical.

These factors require a deep understanding of material properties, study and treatment of substrates and interfacial properties of layers, considerations of the bottlenecks towards device fabrication, encapsulation techniques and thin-film deposition system solutions, and combined they result in an exciting process in this field of study.

This session welcomes papers addressing materials and processing challenges related to these technologies involving vacuum and vapor-based techniques such as evaporation, sputtering and ALD. We encourage submissions on practical approach towards fabrication of organic devices and emphasizing key parameters to consider during the design and building steps. Discussion on challenges and opportunities in scaling up processes for industrial production will be integral to the session.

The session will include discussions on research on the following device types:

- Organic and perovskite light-emitting diodes (OLEDs and PLEDs),
- Organic and perovskite photovoltaics (OPV and perovskite PV),
- Hybrid inorganic/perovskite tandem photovoltaics,
- Organic thin film transistors (OTFTs and OFETs),
- Organic memory devices and spintronics,
- Organic sensors,
- Flexible and wearable electronics, and
- Building-integrated photovoltaics (BIPV).

Achieving Compositional Tunability in Perovskite Thin Filmsby Physical Vapour Deposition

Jay B. Patel

King's College London, London, United Kingdom

Metal halide perovskites have rapidly emerged as a highly adaptable class of optoelectronic materials, recognised for their defect tolerance, straightforward processing, and impressive performance in photovoltaic and light emitting applications. A major strength of these materials is their intrinsic bandgap tunability, which comes from the ease of substituting halides or metal cations within the ABX_3 lattice. This compositional freedom enables smooth and continuous tuning of optical and electronic properties across the visible spectrum, something that is far more accessible in perovskites than in most conventional semiconductors.

Physical vapour deposition, PVD, offers several advantages for perovskite thin film growth, including excellent uniformity, compatibility with industrial vacuum systems, and tight control over film purity. However, achieving reliable bandgap tuning using PVD is challenging because controlling the fluxes of the different precursors is not straightforward. Variations in vapour pressure, thermal stability, and evaporation behaviour can restrict the accessible composition range or make growth conditions unstable. This has limited how effectively PVD can be used to tune perovskite composition.

In this talk, I will show how we overcome these limitations and achieve the full compositional range of mixed halide perovskites using PVD. I will discuss the resulting structural, optical, and electronic properties of the films, and demonstrate how precise compositional control leads to predictable bandgap shifts, phase stability, and strong optoelectronic performance. These results highlight PVD as a fully tunable and industrially relevant route for high quality perovskite thin films.

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Photonically-Induced Transformations of Thin Films and Surfaces

Lasers, flash lamps, and other highly energetic illumination sources enable rapid thermal processing of surfaces and thin films for scaled, low-cost materials and technologies in areas of high economic, societal and environmental impact. Realization of surface-selective rapid thermal annealing coupled with high-throughput are especially attractive features of photonic materials engineering.

This session provides a forum to discuss pioneering technological applications bound by the common thread of photonically-based methods for surface and thin film annealing, materials synthesis and surface patterning.

We welcome submissions addressing the following key areas:

- Surface selective annealing of bulk materials and thin films with light typically in the <100 ms range,
- Wafer based and large area in-line applications,
- Laser and flash-lamp-based conversion and synthesis of high quality, crystalline materials (transparent and conductive layers, energy harvesting, sensor material, low-power computing, multi-functional 'More than Moore' electronic device technology, large area photocatalysts and smart materials for window applications),
- Rapid patterning of microelectronic devices without photolithography (sensors, medical implants, and hardware for experiments and IoT devices),
- Control of nano-micro scale surface morphology (cell adhesion, directed fluid flow),
- Photonically-induced chemical activation of surfaces for antipathogenic, anti-smudge, (de)wetting properties, and
- Novel photonic illumination processes and devices.

Laser Spike Annealing of Thin Films for Neuromorphic Device Applications

Drake R. Austin

AV Incorporated/U.S. Air Force Research Laboratory, Wright-Patterson AFB, OH

Laser spike annealing (LSA) is a promising technique for rapidly investigating the modification of thin film materials due to thermal annealing. By scanning a focused continuous-wave laser across the thin film surface, localized heating can be achieved with heating/quenching times as short as microseconds and temperatures exceeding 1000 °C. The laser intensity and scan rate can be varied, allowing thousands of distinct annealing conditions to be studied on a single sample, including dwell times several orders of magnitude shorter than what can be achieved with rapid thermal annealing. In this work, LSA is applied to the oxidation of hafnium and MoS_2 thin films, two materials whose oxides have shown promise in neuromorphic device applications. Tunable oxidation is achieved by varying the laser conditions in a controlled oxygen environment, enabling access to a wide range of effective temperatures and heating times. The resulting structural and compositional modifications are characterized using X-ray diffraction, Raman spectroscopy, and X-ray photoelectron spectroscopy. Simple memristor devices are fabricated using the laser-oxidized materials within a device stack, allowing structure-property-performance relationships to be established by coupling characterization results with device performance metrics.

Process-Based Programming of Spatially Varying Nanocarbon Properties by Laser Writing for Multifunctional Flexible Devices

Mostafa Bedewy

University of Pittsburgh, Pittsburgh, PA

Laser writing of functional nanocarbon has emerged as a powerful route for rapid, maskless fabrication of devices; however, most demonstrations rely on uniform processing conditions that limit spatial functionality and application breadth. In this invited talk, I will present a process-science framework for using spatial and temporal laser parameters as local control knobs to program spatially varying morphology, chemistry, wettability, electrical, and electrochemical properties within a single, continuous architecture on flexible substrates. Rather than treating laser-induced graphene (LIG) as a fixed material, our work views it as a tunable outcome of coupled thermal, chemical, and kinetic processes that can be engineered through beam delivery and scan strategy. First, I will show how spatial modulation of laser dose, achieved through controlled defocus and multi-pass irradiation, enables adjacent LIG regions with similar morphology but sharply contrasting electrical resistivity and surface energy. This capability allows a single laser-written structure to simultaneously function as pump-free microfluidic channels driven by wettability gradients, programmable Joule heaters with large local temperature contrasts under a single bias, and thermochromic displays in which pixels are addressed through resistivity encoded directly in the material. Finite-element modeling linked to experimental measurements enable tailoring these spatially resolved electrothermal properties. Second, I will discuss process-based routes for tailoring 3D porous graphene chemistry and electrochemical performance without post-processing. Sequential laser irradiation ("re-lasing") provides kinetic access to enhanced graphitization and reduced impedance by decoupling carbonization and structural reorganization. Moreover, I will should how heteroatom incorporation can be modulated by combining molecular engineering of the precursor with laser-controlled reaction pathways to tune surface chemistry and functionality. These strategies enable order-of-magnitude improvements in electrochemical impedance and electrochemical detection of nanomolar concentrations of neurotransmitters like dopamine and serotonin. Finally, I will briefly highlight how laser-induced surface texturing and chemistry control can be combined to produce superhydrophobic and parahydrophobic surfaces, enabling droplet pick-and-place application, which further illustrates the versatility of process-driven property programming. Together, these examples demonstrate how laser processing can serve as a unifying manufacturing platform for creating multifunctional nanocarbons-based flexible and wearable devices, where application-specific performance emerges directly from spatiotemporal control of laser-matter interactions rather than by complex multi-material integration or challenging multi-step processing.

Engineering Thin-Film Optoelectronic and Ferroelectric Materials via High-Throughput Laser Processing

***Brian Everhart**, Drake Austin, Jose Flores, Michael Newburger, Deep Jariwala, Troy Olsson, Nicholas Glavin*

AV Incorporated/U.S. Air Force Research Laboratory, Wright-Patterson AFB, OH

Laser processing has demonstrated transformative potential for tailoring thin-film materials across metals, oxides, transition-metal dichalcogenides (TMDs), and metal nitrides, leveraging continuous-wave (CW) laser heating under controlled gas environments for high-throughput materials synthesis. This data-driven approach enables mapping of structure–property relationships across reaction conditions, enabling the mapping of application-ready films as well as precursors for subsequent reactions and device fabrication. For example, precisely tailored molybdenum oxide precursor films can improve orientation-specific selenide crystallinity and corresponding refractive indices, verified by micro-ellipsometry. Building on this structure–property mapping, laser processing is applied to condition electrodes and tailor crystallinity for seeding high-quality aluminum scandium nitride (AlScN) films. AlScN is a BEOL-compatible ferroelectric with strong potential for nonvolatile memory and related computing functions. Because the underlying electrode structure (e.g., aluminum and other metals/nitrides) critically influences AlScN growth, this work applies localized laser processing to pre-condition electrode microstructure and surface chemistry on Si/SiO_2 within BEOL thermal budgets (≤ 400 °C). Spatially confined heating in a reducing atmosphere drives recrystallization, grain coarsening, and oxide reduction. Synchrotron GIWAXS enables mapping of phase/orientation changes of both the underlying electrode as well as the AlScN grown from the electrode seed layer, enabling structure-property mapping of electrode composition and its impact on AlScN crystallinity and orientation. Collectively, this work demonstrates laser processing as a transferable pathway for applying structure–property maps to synthesize high-quality thin films for next-generation electronics.

Photonic Post-Processing of Printed Inks on Flexible Substrates

Mark Poliks

SUNY Binghamton University, Binghamton, NY

Additive and hybrid electronics require highly conductive printed materials on various substrates. Achieving high electrical conductivity on thermally sensitive substrates is challenging when using conventional oven-based sintering methods. Advanced sintering methods, including pulsed photonic and laser direct write methods provide an effective means to improve printed material properties with rapid, high-energy annealing without thermally damaging the underlying substrate. In this talk a variety of applications that use either particle or particle-free inks will be described.

Additive Nanomanufacturing and Dry Printing Electronics and Functional Devices

Masoud Mahjouri-Samani

Auburn University, Auburn, AL

Additively manufactured electronics (AMEs) have gained significant momentum in recent years due to their low-cost fabrication, reduced electronic waste, and ability to support multifunctional, conformal devices. As demand grows for lightweight, customizable, and scalable consumer and industrial products, the need for advanced printing methods has become increasingly clear. Yet most existing fabrication approaches still rely on ink-based technologies such as inkjet and aerosol jet printing, which face persistent limitations, including contamination, complex and costly ink formulations, and restricted material compatibility. These constraints hinder the creation of pure, multimaterial, and high-performance electronic systems. In this work, I introduce a laser-based additive nanomanufacturing (ANM) technique that enables dry, ink-free, and solvent-free printing of electronics and functional devices on a broad range of substrates. The method generates pure nanoparticles of metals, semiconductors, and insulators, such as silver, copper, zinc oxide, and aluminum oxide, in situ and on demand inside a mini chamber. These nanoparticles are then sent to the printing nozzle, where they are laser-sintered in real time to form precise patterns and devices on planar or three-dimensional structures. Mechanical and electrical characterization, including bending, cycling, and adhesion testing, demonstrates the robustness and exceptional performance of the printed devices. This work highlights the transformative potential of dry ANM for next-generation printed sensors and flexible hybrid electronic systems.

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Plasma Processing and Diagnostics

This session welcomes contributions focused on the development, understanding, and application of plasma-based techniques for thin film coatings and surface modification. The scope includes both established and emerging approaches for plasma-enhanced deposition and treatment, emphasizing the underlying physical and chemical processes, diagnostics, and modeling strategies that enable performance optimization and scalability in industrial environments.

Topics of interest include:

- Physical vapor deposition (PVD) including magnetron sputter-deposition in conventional and non-conventional arrangements,
- Plasma-enhanced chemical vapor deposition (PECVD) both on process and application side,
- Plasma-based etching in the semiconductor industry and other applications,
- Development of novel plasma sources for materials processing (e.g., mid-pressure, atmospheric pressure, nanosecond-pulsing, micro plasmas, etc.),
- Hybrid systems and hybrid processes integrating different plasma technologies,
- Atmospheric-pressure plasma processing, including dielectric-barrier discharges and plasma jets,
- Plasma diagnostics for understanding plasma dynamics and plasma-material interaction,
- Modelling and simulation of plasma and plasma-surface interactions, and
- Novel plasma processing methods such as treatment of nanoparticles, nanomaterials, and liquids, as well as plasma catalysis.

This session is particularly relevant for industry practitioners, researchers, and scientists:

- Working on the design, scale-up, and implementation of advanced plasma sources and coating technologies,
- Developing novel plasma-based processes or deposition techniques, and
- Engaged in the experimental diagnostics of laboratory or industrial plasma systems.

By fostering a technical exchange among these communities, the session aims to advance both the fundamental science and practical applications of plasma processing in thin film technologies.

Continuous PVD Roll-to-Roll Precoated Material for Fuel Cells: Towards Volume Production of Metallic Bipolar Plates and Interconnects for PEM/SOFC Applications

G. Sjöblom

Alleima, Sandviken, Sweden

In order to facilitate volume production of components to the electrolyzer and fuel cell industry, roll-to-roll (or air-to-air) coating deposition presents a cost-effective path that is suited for mass production. For the past +20 years, the Surface Technology production and R&D units within Alleima have explored coil coatings for various applications, currently focusing exclusively on precoated material for fuel cell and electrolysis applications.

While the precoated route permits higher production rates than the postcoated path, there have been challenges along the way such as forming plates, ensuring coating adhesion, managing a highly variable substrate material, prolonging maintenance intervals and designing a stable strip transport subsystem. When coating metal coils that are several kilometers long, advanced quality control becomes paramount. Much effort has been spent implementing in-line laser marking, topographic surface inspection and thin film metrology as well as configuring an advanced system for signal acquisition. Accurately measuring the interfacial contact resistance of PEM coatings is also essential to our success.

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Process Monitoring, Control, and Automation

As the fourth industrial revolution transforms manufacturing, the demand for intelligent, automated vacuum processing systems is rapidly growing. This session explores the forefront of automation technologies reshaping thin film deposition, plasma processing, and surface engineering.

Achieving high repeatability, reproducibility, and yield levels requires robust solutions for real-time process monitoring and control. While the benefits - such as increased throughput, reduced material and energy waste, and lower operational costs - are well recognized, the path to reliable automation remains complex. Challenges include sensor and actuator integration in harsh environments, data fusion across different systems, the development of adaptive, autonomous control algorithms and cybersecurity.

This session focuses on practical solutions while highlighting the latest advances in:

- Embedded real-time sensors and actuators,
- Cyber-physical monitoring and control systems,
- Digital twins for process control,
- Automation and digitalization,
- AI and machine learning for predictive and adaptive automation,
- Robotic systems for material handling and process execution, and
- Autonomous materials discovery and optimization platforms.

We welcome contributions from researchers, engineers, and solution providers that address these challenges through innovative technologies, case studies, or system-level implementations. Presentations that demonstrate practical applications, integration strategies, or lessons learned from deployment are especially encouraged.

Join us to explore how automation and digitalization enable the next generation of intelligent vacuum processing systems.

Beyond Ion Gauges: Wide-Range, Maintenance-Free Vacuum Sensing for Modern Coating Systems

***Caspar Ask Christiansen**, Ole Wenzel*

Sens4 A/S, Hellebaek, Denmark

Precise and reliable vacuum measurement is essential to achieving consistent, high-quality results in modern vacuum coating processes. Traditionally, this has required a combination of sensors—including ionization gauges—to cover the full vacuum range. However, recent advancements in sensor design and materials now make it possible to significantly extend the functional range and durability of thermal and mechanical gauges, challenging long-standing dependencies on fragile, high-maintenance technologies.

This talk presents recent breakthroughs in vacuum gauging that enable wide-range, gas-independent measurement without the need for ionization gauges. Central to this development is the integration of MEMS-based Pirani sensors with high-resolution piezo resistive diaphragm sensors and capacitance diaphragm gauge sensors, enabling seamless pressure coverage across six decades. The inclusion of automatic zero-offset adjustment of the diaphragm type sensors further reduces drift and eliminates the need for frequent manual zero adjustment, offering huge savings.

To address the challenges of harsh process environments, advanced protective strategies have been implemented. Conformal coatings—such as high-purity Al_2O_3 applied by atomic layer deposition (ALD)—provide exceptional resistance to corrosive gases, while preserving sensor sensitivity and response time. Novel replaceable baffle designs, further increase the resilience towards sensor contamination. These innovations dramatically extend sensor lifespan and reduce maintenance intervals, lowering total cost of ownership.

Finally, the talk will explore the role of modern digital interfaces, including EtherCAT, in enabling faster, more reliable integration of vacuum gauges into coating system control architectures. Together, these advancements represent a new generation of vacuum sensing solutions—robust, low-maintenance, and fully aligned with the demands of high-throughput, precision coating operations.

Transforming Process Innovation through Advanced Chamber Pressure Control

***Pedro Reyero Santiago**, Preston Ernst, Dominic Mayrhofer*

VAT Vakuumventile AG, Haag, Switzerland

New processes and applications in the vacuum industry, especially in semiconductor manufacturing, require faster and more precise control of the conditions in the vacuum chamber. VAT has developed a new pressure control solution to optimize performance on each process individually by leveraging auto-learning and feed-forward control strategies. This is achieved by training VAT's pressure control algorithms specifically on the

actual process of interest, instead of using a universal control strategy. Through this new approach, it is possible to achieve better raw pressure control performance, resulting in higher process efficiency, as well as on-wafer performance improvements. Furthermore, it opens the door to new process innovation in vacuum manufacturing by enabling new process control strategies that are challenging to achieve with state-of-the-art pressure control technology, such as stable control of highly dynamic pressure changes or maintaining a stable chamber pressure during fast gas pulses in Atomic Layer processing. Coupling these new control strategies with high-end control devices (sensors, drives, gas inlet systems, …) allows to push the performance to the system's physical limits for each particular process. Lastly, VAT is targeting higher run-to-run process repeatability and improved chamber-to-chamber matching with this new pressure control solution.

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Protective, Tribological, and Decorative Coatings

The Protective, Tribological and Decorative Coatings Technical Advisory Committee (TAC) encourages speakers to submit presentations dealing with design, research, development, applications, and production of coatings deposited with vacuum processes, the characterization of their properties related to wear, friction, and corrosion, and to assess their protection of the receiving components, such as cutting and forming tools, engine components, as well as decorative parts.

The use of such coatings is typically driven by performance requirements, reduction of life-cycle cost, environmental consideration, and durable cosmetic and aesthetic designs. These end-user motivations lead to dedicated coating and technology developments, vacuum coating equipment concepts, new testing procedures and methods, and production quality standards. Therefore, successful coating solutions in the marketplace require strong co-operation between market specialists, universities, suppliers, manufacturers, and end-users.

The TAC encourages speakers to present on the subjects of new emerging technologies. Developing and scaling up from laboratory to high volume production at high production yields is also of high interest of the participants in this session.

Today's global landscape is changing rapidly and will drive many new application developments that will include new coatings on new applications. Environmental pressure on CO_2 emissions and electroplating as well as fast moving communication technologies are well known examples of such change. Electrification of transportation and moving away from the combustion engine are daily news.

Topics of interest for this session include, but are not limited to:

Applications:
- Hydrogen economy related components,
- Coatings for high-performance engines, including hydrogen and e-fuels combustion,
- PVD and CVD coatings for cutting, forming and molding tools,
- Coatings for the reduction of friction and exhaust gas emissions,
- Low- and high-temperature coatings for aerospace applications,
- Decorative components and large area prefabricated sheets,
- Corrosion protective coatings (e.g. Zn:Al) on large-area surfaces, and
- Electroplating replacements by vacuum deposited coatings.

Development:
- Super-lubricity coatings,
- Corrosion protection,
- New colors,
- Hydrogen embrittlement barriers,
- Testing and evaluation of coating performance,
- Scale-up of vacuum coating processes for industrial demands,
- Failure analysis of coatings,
- Assessment, control and management of residual mechanical stress,
- Duplex coatings and thin-on-thick systems, and
- Modelling approaches to performance analysis and prediction.

Production Related:
- Reliability and life of coated parts and systems,
- Upscaling from laboratory to production,
- Scrap rates from percentages to ppm levels, and
- Integration of Industry 4.0 in vacuum coating plants.

PVD Coatings for Tribological Applications – Known Paths and New Perspectives

K. Bobzin, ***C. Kalscheuer***
RWTH Aachen University, Aachen, Germany

Physical Vapor Deposition (PVD) technology and coatings are integral part of today's products and production routes. Efficient process development, coatings tailored to specific applications, and performance prediction of coated components are crucial topics. Regarding process and coating development, experimental and iterative approaches are still common. However, synergies between experiment and simulative capabilities gain increasing importance. Regarding performance prediction of coated components, the interplay between experiment and simulation becomes even more important.

Within this presentation, tribological nitride, oxide and oxynitride coatings as well as self-lubricating coatings for tools and components are addressed. The deposition technologies span from magnetron sputtering over arc-PVD to gas flow sputtering. The field of applications reaches from cutting and forming tools until machine elements such as gears and chains.

Prediction of coating properties and coating performance in applications cannot be solved solely by physics-based approaches up to now. Within this context, approaches to determine coating properties from process parameters by data-driven methods are shown. Regarding performance prediction, greybox models that combine physics-based models and data-driven methods are very promising. Current research on greybox models for wear prediction of cutting tools is presented.

Target Microstructure and Coated Tool Lifetime

Christos Pernagidis[1], *Marian Harsani*[2], *Anas Ghailane*[1]

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$Al_{70}Cr_{30}$ targets provided by Avaluxe were compared to those from two other suppliers in terms of microstructure using SEM and XRD. The results were correlated to tool lifetime assessed by taking images, with optical microscope, of cutting tool flank and rake face, at cutting distances of 90m, 270m, 360 m and 450 m. The tools coated with AlCrN coating from $Al_{70}Cr_{30}$ Targets from Avaluxe started showing a wear at a distance of 450 m, while the other coatings showed failure at 90 m for supplier B and 270 m for supplier A. The cutting velocity was 100 m/min and the workpiece was steel 42crMo6.

The microstructure revealed that the Avaluxe Target, that showed better cutting performance, had the lowest lattice strain, the highest powder particle size, and a median crystallite size between supplier A and supplier B.

A possible explanation of this correlation in light of the effect on generation of droplets was discussed.

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Quantum Computing

Quantum computing promises to harness the power of quantum mechanics to solve problems unfathomable for classical computers to resolve. Quantum computing, once a theoretical dream, is now experiencing an unprecedented surge of progress. Driven by intense research efforts, substantial investments, and collaboration across academia and industry, quantum computing technology is rapidly approaching reality with a promise to revolutionize fields ranging from materials science and drug discovery to finance and artificial intelligence. The quantum computing session aims to explore the current state and prospects of this transformative technology.

The session welcomes researchers, academics, and industry leaders to explore the cutting edge of quantum computing and share their insights on its remarkable emergence. We seek submissions on a range of topics, including:

Quantum Hardware and Software:

- Progress and challenges in superconducting qubits, trapped ion, topological, and other platforms,
- Novel device architectures and fabrication techniques,
- Algorithmic breakthroughs, development frameworks, and their practical applications,
- Error correction and fault-tolerance techniques, and
- Benchmarking and performance analysis.

Scalability Challenges:

- Bridging the gap between quantum and classical systems, and
- Architectures for large-scale quantum computing.

Applications:

- Emerging applications in materials science, drug discovery, and encryption,
- Quantum-enhanced machine learning and artificial intelligence, and
- Financial modeling and risk analysis.

Impact:

- The ethical implications and impact of quantum computing on society,
- Educational initiatives and talent development for the quantum workforce, and
- Commercialization and industry trends in quantum technology.

Complete Hamiltonian Control with Multi-Mode Superconducting Circuits

Vivek Maurya, Daria Kowsari, Kumar Saurav, Rajamani Vijayaraghavan, Daniel Lidar, ***Eli Levenson-Falk***

University of Southern California, Los Angeles, CA

High-fidelity multi-qubit control is essential for quantum processors to achieve practical advantage over classical computers. For analog quantum simulation, it is especially useful to have general control over a multi-qubit Hamiltonian. However, most processor architectures have a limited multi-qubit gate set to work with, meaning that arbitrary operations may require many gates, reducing fidelity. Multi-mode superconducting circuits provide a possible solution, as their strong couplings and mode hybridization allow a wide variety of control techniques. We present results on the trimon 3-mode circuit, a ring of 4 Josephson junctions with 4 capacitor pads implementing 3 modes of oscillation, all similar to transmon qubits. The modes all have strong dispersive interactions, leading to native 3-qubit gates. We demonstrate how we can implement a wide variety of canonical 2-qubit and 3-qubit gates with the trimon. We use ordinary microwave drives and 2-tone Raman drives to achieve arbitrary Hamiltonian control in the 2-qubit space, and discuss simple modifications of the device to achieve arbitrary 3-qubit control. We discuss possible integration of trimons into large scale architectures and the possibility for compact error suppression encodings.

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Thin Film Contributions for the Hydrogen Economy

This session is focused on the role of physical vapor deposition (PVD) and related thin film and surface engineering technologies in the emerging hydrogen economy. This session aims to bring together experts, researchers, and industry professionals from around the world to share their knowledge and insights on the application of PVD thin film coating techniques in advancing the use of hydrogen as a clean energy source.

Participants will have the opportunity to present their research findings, case studies, and innovative approaches in utilizing PVD thin film coating technology for various aspects of the hydrogen economy. The topics of interest include but are not limited to: PVD coatings for hydrogen storage materials, PVD methods for fuel cell catalyst preparation, thin film coating-based hydrogen production and purification techniques, and advancements in thin film coating processes for the manufacturing of hydrogen-related devices and components. Specific industrial implementation of solutions is of critical importance to the SVC's international stakeholder base.

The SVC TechCon provides a unique platform for scientists, engineers, and industry leaders to collaborate, exchange ideas, and explore the potential of thin film coating technology in shaping the future of the hydrogen economy. We encourage interested individuals and organizations to submit their abstracts showcasing their contributions to this rapidly evolving field. Together, let us uncover the transformative capabilities of thin film coating technology and pave the way for a sustainable and efficient hydrogen-powered future.

Hydrogen: Boon or Bane? Opportunities and Challenges in Coating Solutions for Industrial Scale-Up

Nazlim Bagcivan

Schaeffler Technologies AG & Co. KG, Herzogenaurach, Germany

The industrialization of coating solutions plays a pivotal role in enabling the large-scale production of green hydrogen, a cornerstone of the global energy transition. As societies strive toward sustainability, the transformation of manufacturing processes becomes essential—not only to reduce carbon emissions but also to support the development of resilient and environmentally friendly technologies. Coatings are critical in hydrogen production systems, particularly in electrolyzers, where they enhance efficiency, durability, and corrosion resistance.

Research and development efforts have focused on creating advanced functional coatings that meet the demanding requirements of green hydrogen applications. These include catalytic coatings, protective layers for bipolar plates, and surface treatments that improve conductivity and longevity. However, transitioning these innovations from laboratory-scale prototypes to industrial-scale production presents significant challenges. These range from material scalability and process integration to cost-effectiveness and regulatory compliance.

Industrializing coating technologies requires interdisciplinary collaboration and robust processes to ensure reproducibility and quality at scale. Moreover, the integration of sustainable materials and energy-efficient deposition techniques is vital to align with the broader goals of a climate-neutral society.

This presentation uses proton exchange membrane (PEM) electrolysis and PEM fuel cells as examples to showcase the latest developments and discuss the challenges and opportunities involved in scaling these solutions from the perspective of an industrial company. By addressing these aspects, it contributes to the ongoing transition to a sustainable industrial landscape and supports the realization of a hydrogen-based energy economy.

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WebTech Roll-to-Roll Technologies and Innovation

WebTech is the forum for flexible web and roll-to-roll (R2R) processing at the SVC. It is the podium to present new achievements in processing of flexible substrates such as polymer, textile or glass. The session scope encompasses materials, manufacturing techniques, products, applications, market developments and economical aspects of this versatile high-volume manufacturing method.

The WebTech TechCon session typically features presentations on materials, deposition processes, manufacturing techniques (including "best practices"), use cases / application examples, market analysis and business perspectives in all areas related to R2R processing.

Some pertinent topic focus areas are:

- Substrate materials and technologies (polymer, flexible glass, fabrics and non-wovens, etc.),
- Deposition sources and deposition modalities specific to R2R processing,
- Inline process diagnostics and control (particularly for non-transparent coatings),
- Modeling and simulation of R2R processes,
- Examples and approaches to utilize artificial intelligence (AI), machine learning, and other "Industry 4.0" modalities in R2R,
- Aspects of progressing R2R coatings from concept demonstration

Society of Vacuum Coaters Foundation annual

CASINO Night

One complimentary entrance with each full conference registration

$200 in play money included, donate to earn more

Cash bar with one complimentary drink and small bites

Funds support Foundation scholarship activities

Beacon Ballroom, Hyatt Regency Long Beach

MONDAY 27 APRIL 2026

8:00 PM to 10:00 PM

$75 Admission; must be 21 or older

www.svcfoundation.org

SVCF

to commercial scale,
- Coatings under harsh conditions,
- Interfacing with non-vacuum/atmospheric pre- and post-processing, including cleaning,
- Low-cost/high-performance barrier coatings, and,
- R2R processing for electronics, semiconductor and energy conversion applications.

INVITED SPEAKER:

Optimizing Barrier Performance in Formed Flexible Bags

Todd Fayne

Pepsi Co, Plano, TX

Barrier performance in formed bags remains a critical determinant of product shelf-life and consumer safety in flexible packaging. This performance is strongly influenced by the interplay between base film properties and aluminum metallization techniques. Conventional high-barrier substrates such as biaxially oriented polypropylene (BOPP) and polyethylene terephthalate (PET) offer dimensional stability and surface characteristics conducive to uniform metallization, resulting in low oxygen and moisture transmission rates. However, the forming process introduces thermal and mechanical stresses that can compromise metallization integrity through pinholes or cracks, reducing barrier effectiveness.

As global regulations increasingly restrict traditional plastics and mandate sustainable alternatives, metallization technology must evolve to accommodate more diverse materials such as bioplastics and polyethylene. These substrates present unique challenges, including lower thermal resistance, variable surface energy, and reduced stiffness, which can hinder metal layer adhesion and continuity. Addressing these challenges requires innovations in surface pretreatment, deposition control, and hybrid barrier systems to maintain performance without sacrificing recyclability or compostability.

This paper explores the implications of film property variability and metallization process parameters on formed bag barrier performance, highlighting strategies for adapting metallization to emerging materials. Emphasis is placed on optimizing adhesion, minimizing defect formation, and integrating metallization with sustainable packaging design. Future directions include plasma-enhanced deposition and nanocoating technologies to deliver high-barrier functionality while meeting regulatory and environmental objectives. These advancements are essential for ensuring packaging integrity in a rapidly evolving market landscape.

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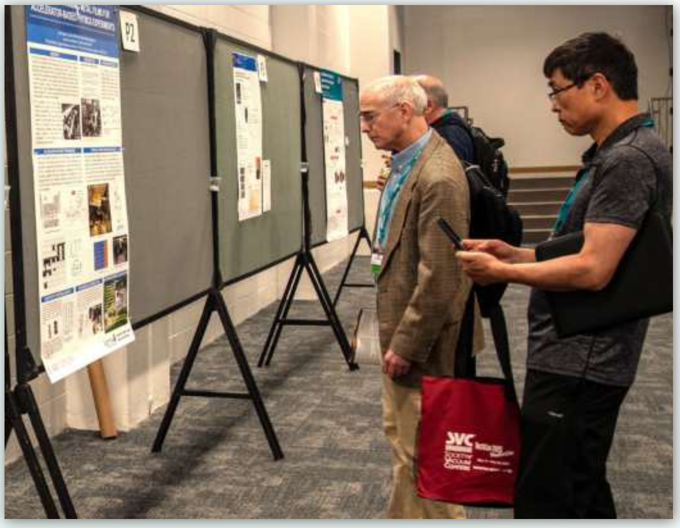


Technical Poster Session

Poster Presentations serve as an important component of the Technical Porgram by providing a format for extended discussions of the results in a casual environment.

The Program Committee encourages poster presentations on all topics covered in the Call for Papers. A $200 USD cash award for the Best Poster will be offered. This year the SVC Young Members Committee will be offering an additional $200 USD prize for the best Student/Young Member poster presented at the session.

Conference Calendar

Start planning now for your trip to TechCon 2026

SUNDAY April 26	MONDAY April 27	TUESDAY April 28	WEDNESDAY April 29	THURSDAY April 30

Education Program

30+ Tutorial Courses

TechCon Registration Counter Hours:

Sunday, April 26	7:00 a.m. – 10:00 a.m. and 4:00 p.m. – 7:00 p.m.
Monday, April 27	7:00 a.m. – 6:00 p.m.
Tuesday, April 28	7:00 a.m. – 5:30 p.m.
Wednesday, April 29	7:00 a.m. – 5:00 p.m.
Thursday, April 30	7:00 a.m. – 12:00 p.m.

Technical Program

Exhibit

Exhibit Open Hours

11 a.m. – 6 p.m. Tuesday
10 a.m. – 4 p.m. Wednesday

Conference Registration Open

Long Beach Convention Center

CONFERENCE REGISTRATION FEES*

Back AGAIN for 2026!

All paid conference registrations will include one free SVC in-person tutorial at the TechCon and a 30% discount on additional courses.

Attendee Registration

(through April 1, 2026/after April 1, 2026)

- ❑ Full Conference .... $995.00/$1095.00
- ❑ Media Personnel $0.00
- ❑ Student Conference .... $400.00/$500.00
- ❑ Young Members Group Conference .... $400.00/$500.00
- ❑ Exhibit Visitor Only .... FREE

Exhibitor Registration

(through April 1, 2026/after April 1, 2026)

- ❑ Exhibitor Booth Personnel and Manufacturer's Representative $0.00
- ❑ Exhibitor with Full Conference Registration .... $995.00/$1095.00

Special Events at the TechCon

- ❑ SVC Foundation 5K Run $40.00
- ❑ Awards Ceremony (Tuesday Morning) and Welcome Reception (Tuesday Evening) .... No Fee
- ❑ SVC Foundation Casino Night Fundraiser (Monday Evening) .... 1 Ticket Included with Full Conference Registration (additional tickets $75.00)
- ❑ Farewell Social (Thursday Evening) .... No Fee

**Pricing contingent on making hotel accommodations at the Hyatt Regency Long Beach/Hyatt Centric Long Beach*

Networking Opportunities at the 2026 TechCon

Make Connections

The TechCon is packed with networking events designed to connect vacuum coating and surface engineering professionals with the global SVC community. Each technical and social networking event provides a different forum for invaluable face-to-face interactions and the opportunity to collaborate with technical experts.

Technology Forum Breakfasts

Vacuum coating technology spans multiple applications and processes. Join a discussion group focused on a topic that's important to you. Enjoy the conversation over breakfast before the start of the technical program Monday, Tuesday and Thursday. Late afternoon sessions are currently under development for Monday and Thursday.

To all of our SVC Stakeholders:

The **Technology Forum Breakfasts** have emerged as one of the most significant networking events at the TechCon. These breakfasts, held from 7:30 a.m. to 8:30 a.m. during the TechCon are "loosely" organized around a specific topic where we provide a moderator, a continental breakfast, plenty of seating, and an opportunity for free form discussion to take place. In the TFBs problems are solved, new ideas are vetted, relationships are made and rekindled; all in the spirit of camaraderie that has made the SVC the most unique technical conference in our field. This year we are expanding the program even further with early evening Sunset sessions under development for Monday, April 27 and Thursday, April 30. Please be sure to check the daily schedule (the TFBs are offered on Monday, Tuesday, and Thursday of the TechCon) to find those topics that interest you! And remember, we are always looking for new topics as well as moderators to get the discussion going. Good luck and have fun!

– Frank Zimone, Executive Director

Exhibit Networking

Enjoy more opportunities than ever to visit the Exhibit Hall.

- Welcome Snacks and Cocktail Hour are two separate events held in the exhibit hall during the first day of the technical exhibition.
- Poster Session ■ Beer Blast

Additional Networking:

- Technical Program Keynote Presentations
- Exhibitor Innovator Showcase
- Colloquium Round Table Discussions

SVC Foundation Networking Events

CASINO NIGHT

Come and join us for an evening of fun and networking, all to help a great cause at the Annual SVC Foundation Casino Night on Monday, April 27, 2026.

RUN FOR A CAUSE!

Register for the Annual 5K Fun Run and support the scholarship efforts of the SVC Foundation. Bib pickup is tentatively scheduled for 5:30 a.m. on Wednesday, April 29, 2026, outside the Convention Center entrance.

Back by Popular Demand: FREE Technical Conference Admission for April 28th & 29th

Networking Opportunities at the 2026 TechCon

2026 SVC TechCon Farewell Social

Date: **Thursday, April 30, 2026**

Everyone is invited to attend

The **Farewell Social** will be the last networking event of the TechCon and will commemorate what promises to be the most successful TechCon yet! Come join us as we celebrate our Young Members and all the new connections that were made after a densely packed four day program.

2026 SVC Awards Ceremony and Welcome Reception

Date: **Tuesday, April 28, 2026**

Everyone is invited to attend

The **Awards Ceremony** will introduce and recognize the Nathaniel Sugerman Memorial Award recipient, SVC Fellow-Mentor Award recipients, and Sponsored Student awardees.

The **Welcome Reception** is a popular networking event at the TechCon. It offers a relaxed venue to meet friends and colleagues and provides the opportunity to make new connections. In 2026 the Welcome Reception will be break for snacks at 1:30 p.m. and a cocktail hour at 5:00 p.m; all held in the exhibit hall.

Job Board

There will be a Job Board in the exhibit hall adjacent to the poster session. Open positions as well as resumes of those looking for a position can be posted. Messages for interested parties, either potential employer or employee, can also be posted on the board.

Back by Popular Demand: FREE Technical Conference Admission for April 28th & 29th

FROM THE EDUCATION DIRECTOR

Certainly the 2026 TechCon in Long Beach feels like an eternity from now, but you can rest assure that planning is well underway! Since we all said goodbye in Nashville, we spent time assessing the program and thinking about new courses to offer. We learned that our offerings in Nashville continued to be well subscribed, with an average course enrollment that was comparable to the last few years. Several of our courses did quite well. For example, "Troubleshooting for Thin Film Deposition Processes" (C-212), taught by Mike Miller; "Diamond Like Carbon Coatings-From Basics to Industrial Realization" (C-320), taught by Lars Haubold, Christian Stein, and George Savva; "Application of Reactive Sputtering" (C-338), taught by Ralf Bandorf and Holger Gerdes; "Deposition Process Simulation" (M-250) taught by Dennis Barton; and "Materials for PVD Applications" (C-110) taught by Christos Pernagidis and Anas Ghailane all had outstanding attendance. The latter was a new course offering this year, which makes its large enrollment great to see. As for new courses in Long Beach, we are actively developing courses on topics that will help our members develop the skills needed to excel in our craft. The current education schedule of 37 tutorials for TechCon 2026 begins on page 36.

Since some of you reading this might have missed us this year, we remind you that most of our courses are offered in our "on-site" program, where the instructors come to teach their course in the comfort of your own facilities. Alternatively, we have a portfolio of "on demand" educational videos as well. So, if you have new employees who need training or "seasoned" ones who need a refresher, contact us to see how we can help meet your needs.

Whether you want to add to your skills or refresh your old ones, understand the technology or the science behind it, or look into emerging science and technology, I'm sure we have a course that satisfies your needs. To see a listing of all the courses and offering platforms, please visit the SVC website and follow the "education" link.

If you have some questions, please ask. We are always happy to help!

— Scott Walton, SVC Director of Education
scott.walton@svc.org

All paid TechCon conference registrants receive one complimentary seat in any tutorial and a 30% discount for any additional tutorials purchased.

About Our Venue

Long Beach Convention Center, Long Beach, California, USA

The 2026 TechCon will be held in the "Center" of Southern California... the Long Beach Convention & Entertainment Center. Located in the heart of Long Beach, the Convention Center is an urban waterfront destination. The building has an impressive architectural design, modern enhancements, and eye-catching décor. The glass dome of the Atrium provides illumination by sunlight in daytime and by colorful LED lights in the evening. The exhibit hall and meetings rooms are perfectly suited for the TechCon and our emphasis on networking and technical exchange. Overlooking bustling Rainbow Harbor, Queensway Bay, and Pacific Ocean beachfront, the Center sits in the middle of Long Beach's downtown waterfront, within walking distance to first-class accommodations, shopping, dining, attractions, sightseeing along picturesque bays, and 5 1/2 miles of sandy beach. Long Beach is convenient to Los Angeles International, Long Beach, and Orange County Airports.

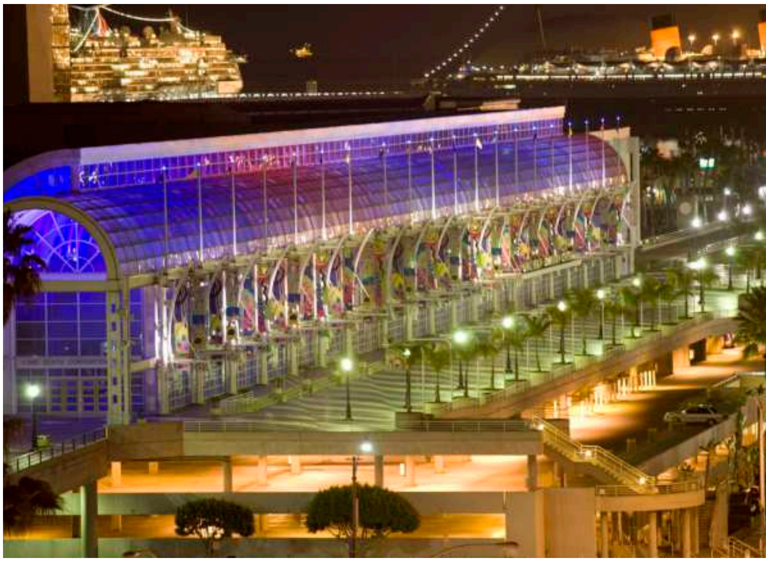
Room blocks and discounted rates have been organized for TechCon attendees. These accommodations are available at:

- $309 USD (double occupancy) - Hyatt Regency Long Beach Hotel, 200 S. Pine Avenue, Long Beach, CA 90802

  Located on a premier waterfront spot in the heart of downtown, Hyatt Regency Long Beach is the only 4 Diamond Award-winning Long Beach, California, hotel with all 531 rooms and suites offering ocean or harbor views. The Hyatt Regency Long Beach is connected directly to the Long Beach Convention Center and will house the majority of the TechCon's social events as well as meeting space/classrooms for the TechCon TFB and tutorial programs.

- $319 USD (double occupancy) - Hyatt Centric The Pike Long Beach Hotel, 285 Bay St, Long Beach, CA 9080

  Hyatt Centric The Pike Long Beach pays homage to the fascinating history of The Pike, an amusement park founded in 1902 that was a thriving destination for its bathhouse, wooden roller coaster, arcades and exciting family fun until 1979. This luxe hotel possesses a rooftop pool and bar with 360° panoramic views, places you in the middle of the neighborhood action so you can explore Long Beach's bustling shopping areas, non-stop nightlife and the rolling surf of California's Pacific Ocean. The hotel is a two-minute walk from the Long Beach Convention Center.



Important note! Discounted room rates are available **exclusively** on the dedicated hotel pages that will be accessible on the SVC 2026 TechCon registration site. ***The SVC does not engage with any third-party companies to provide hotel accommodations.*** Be aware that in all cases, organizations representing themselves as affiliated with the SVC when it comes to hotel accommodations for the TechCon are likely to have malicious motives leading to a nefarious outcome if you rely on them.

Technical Advisory Committees (TAC)

Advanced Multifunctional Coatings: Integrating Vacuum and Electrochemical Deposition for Sustainable Energy, Surface Protection, and Biomedical Innovations

Session Organizers (ECS):
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Session Organizers (SVC):
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Chris Stoessel, Stoessel Consulting, cstoessel@stoesselconsulting.net

Advances in Thin Film Sensor Technologies: Materials Design, and Applications

TAC Co-Chairs:
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Atomic Layer Processing (ALP)

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Matt Weimer, Forge Nano, Inc., mweimer@forgenano.com

Characterization, Testing and Failure Analysis of Thin Films, Coatings and Engineered Surfaces

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Coatings and Processes for Biomedical Applications

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Coatings for Energy Conversion and Related Processes

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Digital Transformation through Artificial Intelligence, Machine Learning, Simulation, and Data Science in the Thin Film Industry

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Electron Beam Processes

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Emerging and Translational Technologies and Applications

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Exhibitor Innovator Showcase

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High-Power Impulse Magnetron Sputtering – HIPIMS

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Large Area Advanced Packaging and Integrated Photonics

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Large Area Coatings

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Optical Coatings

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Organic and Perovskite Electronics

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Photonically-Induced Transformations of Thin Films and Surfaces

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Processing Monitoring, Control, and Automation

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Protective, Tribological, and Decorative Coatings

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Quantum Computing

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Thin Film Contributions for the Hydrogen Economy

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WebTech Roll-to-Roll Technologies and Innovation

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SVC Society of Vacuum Coaters

TechCon 2026 Long Beach

Technical Program April 27 – April 30
Education Program April 25 – April 30
Technology Exhibit April 28 – April 29

69th Annual SVC Technical Conference • April 25 – 30, 2026
Long Beach Convention Center, Long Beach, California, USA

Processing Cluster

- C-103 An Introduction to Physical Vapor Deposition (PVD) Processes
- C-201 Electron Beam Evaporation for Thin Film Deposition
- C-204 Basics of Vacuum Web Coating
- C-207 Evaporation as a Deposition Process
- C-208 Sputter Deposition for Industrial Applications
- C-210 Introduction to Plasma Processing Technology
- C-212 Troubleshooting for Thin Film Deposition Processes
- C-214 Thin Film Deposition Optimization
- C-240 Fundamentals of Ion Beam Sputtering
- C-245 Industrial Broad Beam Ion Sources
- C-250 Introduction to Pulsed Laser Deposition
- C-280 Thermal Spray Technology
- C-304 ITO and Other Transparent Conductive Coatings: Fundamentals, Deposition, Properties, and Applications
- C-306 Non-Conventional Plasma Sources and Methods in Processing Technology
- C-307 Cathodic Arc Plasma Deposition
- C-308 Tribological Coatings
- C-310 Sputtering
- C-314 Plasma Modification of Polymer Materials and Plasma Web Treatment
- C-316 Introduction to Atomic Layer Deposition (ALD) Processes, Chemistries, and Applications
- C-323 Fundamentals of High Power Impulse Magnetron Sputtering (HIPIMS)
- C-324 Atmospheric Plasma Technologies (half day)
- C-332 Zinc Oxide-Based and Other TCO Alternatives to ITO: Materials, Deposition, Properties and Applications
- C-334 Manufacture of Precision Evaporative Coatings
- C-336 Transparent Gas Permeation Barriers on Flexible Substrates
- C-337 ITO and Alternative TCO: From Fundamentals to Controlling Properties
- C-343 From Basic Aspects to Industrial Components and Applications in HIPIMS Technology
- C-333 Practice and Applications of High Power Impulse Magnetron Sputtering
- C-338 Application of Reactive Sputtering
- M-120 Design of Experiments for R&D
- M-150 Cleaning Fundamentals for Coating Applications
- M-240 Basics and Applications of Electron Beam Technology for Manufacturing Processes
- VT-230 Design and Specification of Vacuum Deposition Systems

Optical Cluster

- C-205 Introduction to Optical Coating Design
- C-216 Practical Design of Optical Thin Films
  - C-218 Advanced Design of Optical Thin Films
- C-217 Practical Production of Optical Thin Films
- C-340 Plastic Optics - Coatings and Antireflective Structures
- C-341 Processing on Flexible Glass - Challenges and Opportunities
- M-205 The Craftsmanship of Ophthalmic Coatings

Vacuum Technology Cluster

- M-140 Mass Flow Controllers: Fundamentals, Troubleshooting, and Calibration
- VT-201 High Vacuum Systems and Operations
- V-202 Vacuum System Gas Analysis
- VT-203 Residual Gas Analyzers and Analysis
- V-204 Vacuum Systems Materials and Operations
- V-207 Operation and Maintenance of Production Vacuum Systems
- V-208 Basic Ananlysis of Mass Spectrometer Spectra
- V-209 Fundamentals of Vacuum Technology and Vacuum Gauging
- V-210 Pumps Used in Vacuum Technology
- V-211 Vacuum Hardware and Vacuum Leak Detection
- V-212 Vacuum System Design
- VT-220 Practical Guide to Vacuum System Operation Using a Trainer System
- VT-230 Design and Specification of Vacuum Deposition Systems
- VT-240 Practical Elements of Leak Detection
- VT-245 Hands-on Helium Mass Spectrometer Leak Detection

SVC Society of Vacuum Coaters
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Course Catalog (September 2025)

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Characterization Cluster

- M-102 Introduction to Ellipsometry
- M-103 In Situ Spectrascopic Ellipsometry
- M-110 Introduction to X-ray Photoelectron Spectroscopy
- M-130 Scanning Electron Microscopy Sample Preparation, Image Optimization, and Microanalysis
- M-230 Nanoscale Heat Transfer in Thin Films and Interfaces
- M-250 Deposition Process Simulation
- C-322 Characterization of Thick Films, Thin Films, and Surfaces

PVD Cluster

- C-103 An Introduction to Physical Vapor Deposition (PVD) Processes
- C-201 Electron Beam Evaporation for Thin Film Deposition
- C-207 Evaporation as a Deposition Process
- C-208 Sputter Deposition for Industrial Applications
- C-212 Troubleshooting for Thin Film Deposition Processes
- C-214 Thin Film Deposition Optimization
- C-240 Fundamentals of Ion Beam Sputtering
- C-250 Introduction to Pulsed Laser Deposition
- C-307 Cathodic Arc Plasma Deposition
- C-310 Sputtering
- C-323 Fundamentals of High Power Impulse Magnetron Sputtering (HIPIMS)
- C-333 Practice and Applications of High Power Impulse Magnetron Sputtering
- C-334 Manufacture of Precision Evaporative Coatings
- C-338 Application of Reactive Sputtering
- C-343 From Basic Aspects to Industrial Components and Applications in HIPIMS Technology
- M-240 Basics and Applications of Electron Beam Technology for Manufacturing Processes
- M-250 Deposition Process Simulation

Application Cluster

- C-220 Introduction to Two-Dimensional Materials
- C-230 PVD Processing of Plastics for Better Protection, Reflection, and Decoration (half day)
- C-260 Organic Electronics - The Future is Bright
- C-270 Coatings, Thin Films and Surface Solutions for Biomedical Applications: An overview of market trends, synthesis and characterization
- C-304 ITO and Other Transparent Conductive Coatings: Fundamentals, Deposition, Properties, and Applications
- C-320 Diamond Like Carbon Coatings-From Basics to Industrial Realization
- C-329 Properties and Applications of Tribological and Decorative Coatings
- C-330 Introduction to Thin Film Photovoltaic Technologies (half day)
- C-332 Zinc Oxide-Based and Other TCO Alternatives to ITO: Materials, Deposition, Properties and Applications
- C-336 Transparent Gas Permeation Barriers on Flexible Substrates
- C-337 ITO and Alternative TCO: From Fundamentals to Controlling Properties
- C-339 Mechanical Heart Valve Thrombosis: An Introduction and Review (half day)
- C-340 Plastic Optics - Coatings and Antireflective Structures
- C-341 Processing on Flexible Glass - Challenges and Opportunities
- C-342 Thin Film Photovoltaic Solar Cells
- M-140 Mass Flow Controllers: Fundamentals, Troubleshooting, and Calibration
- M-201 Flexible Electronics
- M-205 The Craftsmanship of Ophthalmic Coatings
- M-210 Introduction to Solid-State Thin Film Batteries
- M-220 Thin Film Superconductor Tapes
- M-240 Basics and Applications of Electron Beam Technology for Manufacturing Processes
- M-250 Deposition Process Simulation

Business Cluster

- B-101 Creating a Business from your Idea, Product or Service
- B-110 Getting the Most Value out of Marketing without Spinning your Wheels
- B-120 Introduction to Patents and Trademarks
- B-130 Doing Business in the U.S.A.

TUTORIAL COURSES SCHEDULE

TECHCON EDUCATION SOLVES VACUUM COATING PROBLEMS!

The TechCon Education Program complements the technologies and applications featured in both the Technical Program and the Exhibit, presented by highly-respected professionals in the vacuum coating industry.

SVC Tutorials provide problem-solving and practical knowledge of vacuum coatings and processes. Return to work with solutions to your everyday vacuum coating challenges.

You do not have to register for the conference or be an SVC Member to take a Tutorial Course.

Note: All paid conference registrations include a free tutorial as well as a 30% discount on all additional tutorials that are purchased.

Full Day Course times:
9:30 a.m. – 5:00 p.m.

Half Day Course times:

AM 9:30 a.m. –1:00 p.m.
PM: 1:30 p.m. – 5:00 p.m.

All courses are full day unless specified AM or PM

Sunday, April 26, 2026

B-140 Level Up: Career and Commercial Skills for Emerging Talent in the PVD Industry — 6:30PM – 10:00PM
Hurkmans/Sanchez/Wäckerlin — Professional: $0 | Student/Young Member: $0

C-103 An Introduction to Physical Vapor Deposition (PVD) Processes — 9:30AM – 5:00PM
Morse — Professional: $690 | Student/Young Member: $280

C-110 Materials for PVD Applications — 9:30AM – 5:00PM
Pernagidis/Ghailane — Professional: $690 | Student/Young Member: $280

C-230 Processing of Plastics for Better Protection, Reflection, and Decoration ***AM*** — 9:30AM – 1:00PM
Soper/Vergason — Professional: $470 | Student/Young Member: $180

C-310 Sputtering — 9:30AM – 5:00PM
Bandorf — Professional: $690 | Student/Young Member: $280

C-323 Fundamentals of High Power Impulse Magnetron Sputtering (HIPIMS) — 9:30AM – 5:00PM
Ehiasarian — Professional: $690 or Student/Young Member: $280

M-102 Introduction to Ellipsometry ***PM*** — 1:30PM – 5:00PM
Hilfiker — Professional: $470 | Student/Young Member: $180

M-150 Cleaning Fundamentals for Coating Applications ***AM*** **New!** — 9:30AM – 1:00PM
Wheeler — Professional: $470 | Student/Young Member: $180

M-250 Deposition Process Simulation ***PM*** — 1:30PM – 5:00PM
Gerdes/Barton — Professional: $470 | Student/Young Member: $180

VT-201 Vacuum Systems, Materials and Operation — 9:30AM – 5:00PM
O'Hanlon — Professional: $690 | Student/Young Member: $280

C-201 Electron Beam Evaporation for Thin Film Deposition ***AM*** **New!** — 9:30AM – 1:00PM
Belan — Professional: $470 | Student/Young Member: $180

C-220 Introduction to Two-Dimensional Materials ***AM*** — 9:30AM – 1:00PM
Muratore — Professional: $470 | Student/Young Member: $180

M-110 Introduction to X-Ray Photoelectron Spectroscopy ***AM*** — 9:30AM – 1:00PM
Linford — Professional: $470 | Student/Young Member: $180

M-120 Design of Experiments for R&D — 9:30AM – 5:00PM
Grace — Professional: $690 | Student/Young Member: $280

M-201 Flexible Electronics ***PM*** — 1:30PM – 5:00PM
Muratore — Professional: $470 | Student/Young Member: $180

M-230 Nanoscale Heat Transfer in Thin Films and Interfaces ***PM*** — 1:30PM – 5:00PM
Hopkins — Professional: $470 | Student/Young Member: $180

VT-203 Understanding and Using Residual Gas Analyzers — 9:30AM – 5:00PM
O'Hanlon — Professional: $690 | Student/Young Member: $280

SCHEDULE CONTINUED

Tuesday, April 28, 2026

C-205 Introduction to Optical Coating Design — 9:30AM – 5:00PM
Sargent — Professional: $690 | Student/Young Member: $280

C-210 Introduction to Plasma Processing Technology ***AM*** — 9:30AM – 1:00PM
Baránková/Bárdos — Professional: $470 | Student/Young Member: $180

C-245 Industrial Broad Beam Ion Sources ***AM*** **New!** — 9:30AM – 1:00PM
Rubin — Professional: $470 | Student/Young Member: $180

C-306 Non-Conventional Plasma Sources and Methods in Processing Technology ***PM*** — 1:30PM – 5:00PM
Baránková/Bárdos — Professional: $470 | Student/Young Member: $180

C-337 ITO and Alternative TCO: From Fundamentals to Controlling Properties — 9:30AM – 5:00PM
Bright — Professional: $690 | Student/Young Member: $280

VT-230 Design and Specification of Vacuum Deposition Systems — 9:30AM – 5:00PM
Belan — Professional: $690 | Student/Young Member: $280

VT-240 Practical Elements of Leak Detection — 9:30AM – 5:00PM
Deluca — Professional: $690 | Student/Young Member: $280

Wednesday, Apr

C-212 Troubleshooting for Thin Film Deposition Processes — 9:30AM – 5:00PM
Vohra — Professional: $690 | Student/Young Member: $280

C-316 Introduction to Atomic Layer Deposition (ALD) Processes, Chemistries, and Applications — 9:30AM – 5:00PM
Biyikli — Professional: $690 | Student/Young Member: $280

C-320 Diamond-Like Carbon Coatings – From Basics to Industrial Realization ***PM*** — 1:30PM – 5:00PM
Savva/Haubold/Keunecke/Stein
Professional: $470 | Student/Young Member: $180

C-322 Characterization of Thick Films, Thin Films and Surfaces — 9:30AM – 5:00PM
Christensen — Professional: $690 | Student/Young Member: $280

Wednesday, April 29, 2026 *continued*

C-329 Properties and Applications of Tribological Coatings — 9:30AM – 5:00PM
Doll/Matthews — Professional: $690 | Student/Young Member: $280

C-338 Application of Reactive Sputtering — 9:30AM – 5:00PM
Bandorf/Gerdes — Professional: $690 | Student/Young Member: $280

M-103 In Situ Spectroscopic Ellipsometry ***PM*** **New!** — 1:30PM – 5:00PM
Pribil — Professional: $470 | Student/Young Member: $180

M-240 Basics and Applications of Electron Beam Technology for Manufacturing Processes ***AM*** — 9:30AM – 1:00PM
Saager — Professional: $470 | Student/Young Member: $180

M-260 Advanced Packaging ***PM*** **New!** — 1:30PM – 5:00PM
Banerjee — Professional: $470 | Student/Young Member: $180

VT-245 Hands-On Helium Mass Spectrometer Leak Detection – Session 1 ***AM*** **New!** — 9:30AM – 11:30AM
Deluca/Ridenour — Professional: $470 | Student/Young Member: $180

VT-245 Hands-On Helium Mass Spectrometer Leak Detection – Session 2 ***PM*** **New!** — 12:00PM – 2:00PM
Deluca/Ridenour — Professional: $470 | Student/Young Member: $180

Thursday, Apr

C-204 Basics of Vacuum Web Coating ***AM*** — 9:30AM – 1:00PM
Simmons — Professional: $470 | Student/Young Member: $180

M-140 Mass Flow Controllers: Fundamentals, Troubleshooting, and Calibration ***AM*** — 9:30AM – 1:00PM
Lewey — Professional: $470 | Student/Young Member: $180

M-210 Introduction to Solid-State Thin Film Batteries ***AM*** — 9:30AM – 1:00PM
Gaines — Professional: $470 | Student/Young Member: $180

Tutorial Classification

- **V/VT- VACUUM TECHNOLOGY**
- **C - VACUUM COATING DEPOSITION PROCESSES AND TECHNOLOGY**
- **M - MISCELLANEOUS TOPICS**
- **B - BUSINESS TOPICS**

The tutorial number indicates the level of topic specialization. Lower numbers are basic or introductory in nature, and higher numbers are a more specialized treatment of a specific topic.

Registration for Tutorial Courses

- Use the On-line TechCon resgistration system. All paid conference registrations include a free tutorial as well as a 30% discount on all additional tutorials that are purchased.
- You do not have to register for the TechCon to attend tutorial courses
- Tutorial course fees include entrance to the Exhibit Hall and all Exhibit Visitor privileges

Times

FULL-DAY COURSE TIMES: 9:30 a.m. - 5:00 p.m.
HALF-DAY COURSE TIMES: **AM** (9:30 a.m. - 1:00 p.m.) and **PM** (1:30 p.m. - 5:00 p.m.)
*All courses are full-day unless specified **AM** or **PM**.*

Discounts Offered to Multiple Registrants from One Organization

Receive 25% off each tutorial course registration for the second or more employee from the same company, enrolling in the same tutorial as the first employee. (Does not apply to the student tutorial course fee). Send an E-mail to **svcinfo@svc.org** and request the discounted fee. Discounts will be refunded after the TechCon.

Tutorial Course Cancellation Policy

Tutorial course cancellations received on or before March 25, 2026 will be refunded. Refunds will be made upon receipt of a written notice, less a $25 service fee for each cancelled tutorial course. No refunds will be made after March 25, 2026. Please send your written cancellation request to **svcinfo@svc.org**.

SVC INSTRUCTORS

Ralf Bandorf
born 1973, studied Physics at Friedrich-Alexander University Erlangen/Nuremberg, Germany and received his diploma in 1998. His work focused on preparation of metastable ironsilicides and phase characterization by LEED. In 1998 he joined Fraunhofer IST for his PhD thesis. Ralf Bandorf received his PhD in Mechanical Engineering in 2002 from Fraunhofer IST / Carolo-Wilhelmina Technical University Braunschweig, Germany. His thesis focused on sub-micron tribloogical coatings for electromagnetic microactuators. Ralf continued at Fraunhofer IST as a scientist, specifically as Project leader in Group Micro and Sensor Technology with a Focus on PVD and PACVD coatings. He worked in the field of plastic metallization for flexible circuits, piezoresistive materials (especially based on DLC), electrical conductive and insulating coatings as well as magnetic thin films. In 2007, he became Head of Group "Sensoric Functional Coatings" and since 2015 he has been Head in Group "PACVD and hybrid processes" at Fraunhofer IST. His focus is on PACVD with different excitation, plasma sources, hollow cathode processes, especially gas flow sputtering, and HIPIMS.

Ralf Bandorf is internationally recognized expert in the field of HIPIMS. He was session chair of the HIPIMS session at ICMCTF, US from 2009-2012. He has served as assistant TAC Chair at the Society of Vacuum Coaters since 2009. Ralf is the conference Chairman of the International Conference on Fundamentals and Applications of HIPIMS and Action Chair of the COST Action MP0804: Highly ionized pulse plasma processes (HIPP processes, 2009-2013), a European scientific networking activity gathering experts worldwide in the field of HIPP plasmas, especially HIPIMS.

Koushik Banerjee
has spent his career in semiconductor manufacturing focusing on developing advanced microelectronic packaging. He has a master's degree in mechanical engineering from Georgia Institute of Technology. Koushik worked at Intel Corporation for thirty-three years where he was a Vice President in the Technology Development Group. He has deep expertise in successfully developing transformative advanced packaging technologies. He holds over a dozen patents in this field. Koushik is passionate about technology and leadership development. He has written a book on business strategy setting, titled "Strategy Setting Fundamentals: Translate strategic thinking into results", available on Amazon.com. For leisure, he enjoys reading both fiction and non-fiction and traveling with his family.

Hana Baránková

is Professor at the Uppsala University and Research Leader of the Plasma group at the Angstrom Laboratory. She has been director and manager of several energy related projects and programs. She received her PhD in Electronics and Vacuum Technique from the Czech Academy of Science. Her primary interests are development of plasma sources and processes, innovation in coating technology, and plasma treatment of surfaces, gases and liquids. She has published over 160 scientific papers and conference contributions and holds several industrial patents on plasma systems. She is an inventor of metastable assisted deposition and co-inventor of the Linear Arc Discharge (LAD) source, the Magnets-in-Motion concept in plasma sources and Fused Hollow Cathode and Hybrid Hollow Electrode Activated Discharge (H-HEAD) cold atmospheric plasma sources. Hana Baránková has been serving 6 years on the SVC Board of Directors, and as TAC Chair of Emerging Technologies and organizer of Atmospheric Plasma Technologies session over the years. She is Secretary of SVC, Chair of the Student Sponsorship Committee, TAC Co-Chair of the Coatings for Biomedical Applications, and member of the Education and International Outreach Committees. Hana is 2006 Mentor Award recipient for the development of numerous novel plasma sources. She acts as a consultant and is a co-founder of two companies, BB Plasma HB and BB Plasma Design AB. She teaches several courses at the Uppsala University and abroad, for example, she has taught annual courses for SVC since 1997.

Ladislav Bárdos
is Professor at Uppsala University in Sweden and Research Leader of the Plasma group at the Angstrom laboratory. He received his PhD in Applied Physics from the Czech Acad. Sci. and a Doctor of Science degree from Charles University in Prague. He was awarded the Czechoslovak State Prize for outstanding research results in the plasma deposition of thin films. He has more than 35 years of experience in the field of applied plasma physics and thin films. He has published over 200 scientific papers and conference contributions, designed several plasma sources for industry and has 15 Czech, 7 Swedish and several international patents. His primary interests are microwave plasmas, including downstream ECR and surface-wave generation, and particularly the radio frequency generated hollow cathodes and hybrid sources at both low and atmospheric pressures. Lad Bardos was Program Chair for 2009 and 2010 SVC TechCons, has been serving 6 years on the SVC Board of Directors and is member of the SVC Education and Awards Committees and Co-Chair of International outreach Committee. Ladislav is 2010 Mentor Award recipient for leading research in plasma processes. He is a co-founder of two companies, BB Plasma HB and BB Plasma Design AB. He teaches several courses at the Uppsala University and abroad, for example, he has taught annual courses for SVC since 1997.

Dennis Barton
has studied Mathematics, Engineering and Chemistry at the Universities of Magdeburg, Braunschweig and Münster. In 2013 he received his master's degree at the Institute for Physical Chemistry at TU Braunschweig. In the following years, he worked on modelling of on-surface coupling processes and the development of embedding methods to combine periodic and non-periodic quantum chemistry frameworks for which he received his PhD from the University of Münster in 2017 ("Quantum-chemical investigation of on-surface reactions and the foundation of periodic density embedding"). Afterwards he moved to the University of Luxemburg for a two-year Postdoc position, where he implemented semi-empirical methods to describe Van-der-Waals interactions in different quantum chemistry codes. From 2020 to 2022, he worked in industry in the field of simulation data management. In August 2022, Dennis joined the group of Andreas Pflug at the Fraunhofer Institute for Surface Engineering and Thin Films (IST), where he is working on development and application of the PICMC code for the simulation of thin film coating processes.

SVC INSTRUCTORS

Rob Belan

graduated from Rutgers University with a BS in Physics and took graduate courses in Physics at City College of NY. Has worked in Vacuum Science since 1982 specializing in magnetron sputtering and other PVD techniques. He is currently the Technical Director at the Kurt J. Lesker Company and has lectured at many universities and companies across the world in PVD techniques and thin film growth.

Necmi Biyikli

was born in Utrecht, The Netherlands, in 1974. He received the B.S., M.S., and Ph.D. degrees in Electrical & Electronics Engineering from Bilkent University, Ankara, Turkey in 1996, 1998, and 2004 respectively. Dr. Bıyıklı's Ph.D. research concentrated on GaN/AlGaN-based ultraviolet and solar-blind photodetectors. Afterwards, during his postdoctoral research at the Virginia Commonwealth University, he worked on the MOCVD growth of AlGaN/GaN hetero-structures for various applications including high-performance transistors. Dr. Bıyıklı also worked as a research scientist at the Cornell Nanoscale Science and Technology Facility (CNF) where he developed RF-MEMS integrated multifunctional reconfigurable antennas. At the end of 2008 he joined UNAM – Materials Science & Nanotechnology Institute at Bilkent University, leading the "Functional Semiconductor Materials and Devices Research Group". After spending one year at Utah State University, in 2017 he joined the Electrical & Computer Engineering Department at University of Connecticut, where he leads the Atomic Layer Engineering Laboratory within the Center for Clean Energy Engineering (C2E2). His current research interests include atomic layer deposition of III-nitride, metal-oxide, and metal thin-films and nanostructures, selective atomic-scale processing, III-Nitride opto-electronics, piezo-electric thin-films for chemical and biological sensing, photovoltaics, and smart RF-antenna architectures. Dr. Biyikli is the recipient of EU-Marie Curie International Reintegration Grant Award in 2010 and METU-Parlar Foundation Research Incentive Award in 2013. Dr. Biyikli is a member of American Vacuum Society (AVS) and Materials Research Society (MRS) and has contributed to 300+ journal and conference publications.

Clark Bright

has worked in thin film technology for more than 45 years including research, development, and new product introduction. He co-founded the R&D department at Sierracin Corporation (now PPG Aerospace) and led the development of metallic thin film transparent conductive coatings (TCC) for aircraft windshields and canopies. He joined Xerox Electro-Optical Systems in 1972, to create and direct the Electro-Optical Device Technology Center (EODTC) for R&D and fabrication of EO devices used in Xerox products. In 1975, he founded Optical & Conductive Coatings (OCC) to perform R&D and production of TCC for military, industrial and scientific applications. OCC designed and manufactured (over 3000) M1 Tank windows with TCC heater deicing/defogging, EMI shielding and high transmittance in 3 wavebands: visible, NIR, and 1.06 μm laser range finder. He also led what is believed to be the first development of continuous thin film TCC for the mid-infrared (3μm - 5μm) waveband. Another OCC unique development was a patterned metallic coating for heating infrared windows with transmittance at visible through Far-IR wavelengths. OCC was acquired by Southwall Technologies (now Eastman Chemical) in 1992, and he became Director of Product Development. He led R&D and played a critical role in 2 production scale-ups of a durable 4-layer (ITO/SiO_2) AR/antistatic coating, magnetron sputter deposited, roll-to-roll on plastic film used by display manufactures (e.g., Sony). He was Vice President at Presstek, Inc., and its Delta V Technology subsidiary in 1998, where he directed the R&D of transparent conductive oxides (TCO), polymer multilayer (PML) technology, and transparent vapor barrier coatings, including the first barrier coatings using a TCO, (ITO). 3M acquired Delta V in 2000. As Senior Staff Scientist and Group Technical Leader with the 3M Corporate Research Laboratory he developed roll-to-roll coated, vacuum deposited, organic and inorganic multilayer thin film products for optical, transparent conductive, barrier and other applications. Retiring in 2013 after 13 years at 3M, he founded his current consulting practice - Bright Thin Film Solutions LLC. He served 12 years on the SVC Board of Directors and was President in 2004. In 2009, he received the SVC Fellow-Mentor Award, and in 2012 the Nathaniel Sugerman Award. He has been an invited, keynote and plenary speaker at many domestic and foreign conferences. He has published numerous papers on optical thin films, and transparent conductive coatings, including book chapters on transparent conductors in "Transparent Electronics: From Synthesis to Applications" (Wiley, 2010), and "Optical Thin Films and Coatings, from Materials to Applications" (Woodhead, 2013), (2nd edition, Elsevier, June 2018). He is inventor or co-inventor on at least 28 U.S. patents in the field.

Tom Christensen

is a Professor Emeritus in the Department of Physics at the University of Colorado at Colorado Springs. He received his B.S. in physics from the University of Minnesota in 1979 and his M.S. and Ph.D. degrees in Applied Physics from Cornell University. After several years at Sandia National Laboratories in Albuquerque he joined the University of Colorado faculty in 1989 where he has served as Department Chair, Dean and Provost. He has worked with vacuum technology, thin film technology and surface characterization since 1980 and has taught local AVS or SVC short courses since 1992. He is the author of "Understanding Surface and Thin Film Science" (CRC Press, 2023).

Jean-Pierre Deluca

retired from LACO Technologies in 2019, he recently started his own consulting Company (www.bdlredwood.com). Jean-Pierre holds a bachelor's degree in science (Electrical Engineering) from Century University NM and has over 39 years of experience in the leak testing afield (helium mass spectrometry, hydrogen, pressure decay, vacuum decay and mass flow). He has worked in numerous roles for leak instrument and leak testing equipment manufacturers, specifically as a product manager, applications engineer, international leak detection director and finally vice president of sales. Jean-Pierre has extensive experience and expertise in many industries including, automotive, medical, pharmaceutical, refrigeration and air conditioning, semiconductor, aerospace and defense, vacuum industry and assisted thousands of customers with their leak testing applications and projects. Additionally, he has audited hundreds of leak testing equipment/systems and helped customers to improve functionality, reliability, test quality and reduced cycle time. Jean-Pierre has written many technical articles and contributed to many others. He has presented over 500 training classes at customers' facilities and trade shows.

SVC INSTRUCTORS

Gary Doll
is the Timken Professor of Surface Engineering at the University of Akron. Prior to joining the University of Akron, Dr. Doll was the Chief Technologist of Tribology at the Timken Company, and Staff Scientist of Physics for General Motors Research Laboratories. Dr. Doll was elected as an ASM Fellow in 2009, and as an STLE Fellow in 2016 for his contributions to the field of Surface Engineering. He is a member of the SVC, STLE, ASME, and the ASM International organizations, and is an associate editor for Tribology Transactions. In 2016, he was awarded a Distinguished Fellowship by the Royal Academy of Engineering. Over his career, Dr. Doll has published over 300 articles and book chapters, edited numerous proceedings, and received more than 25 US Patents.

Arutiun P. Ehiasarian
joined the Nanotechnology Centre for PVD Research at Sheffield Hallam University, UK in 1998 where he obtained his PhD in Plasma Science and Surface Engineering. His research within NTCPVD has concentrated on development of plasma PVD technologies for substrate pretreatment prior to coating deposition to improve adhesion, deposition of coatings with dense microstructure, low-pressure plasma nitriding and hybrid processes of plasma nitriding/coating deposition. He has experience with cathodic vacuum arc discharges, dc and pulsed magnetron discharges, and radio-frequency coil enhanced magnetron sputtering. He utilizes plasma diagnostics such as optical emission spectroscopy (OES), electrostatic probes, energy-resolved mass spectroscopy and atomic absorption spectroscopy. Materials characterization includes high-resolution TEM, STEM, STEM-EDS, SEM, and XRD as well as mechanical testing available at NTCPVD. Arutiun is one of the pioneers of high power impulse magnetron sputtering (HIPIMS) technology and his work in the field has been acknowledged with the R.F. Bunshah Award (2002), the TecVac Prize (2002) and the Hüttinger Industrial Accolade. In 2011 he received the AVS Peter Mark Memorial Award as a top young investigator, and in 2012 he received the SVC Mentor Award. He is an author of more than 50 publications, 10 invited lectures, 3 patents and 1 book chapter in the field of PVD and HIPIMS.

J.R. Gaines
is the Technical Director of Education for the Kurt J. Lesker Company (Jefferson Hills, PA). The Lesker Company is a global scientific equipment manufacturer supplying materials and tools for vacuum-enabled innovation. Gaines has more than 40 years of experience in the research, development and commercialization of advanced materials technologies including superconductivity, semiconductors, cryogenics, space simulation, energy generation, energy conversion and storage. His experience includes vacuum systems, thin film deposition, inorganic chemistry, nanotechnology and advanced ceramic processing. He currently develops and delivers the Company's many educational programs through Lesker University teaching events.

Holger Gerdes
graduated from the Technical University in Braunschweig with a diploma in Physics in 2004. Afterwards, he was Research Fellow at the Institute of Micro Production Technology (IMPT) at the Leibniz University, Hannover. Since 2008, Holger has worked as a project leader in the group "Highly Ionized Plasmas and PECVD" at the Fraunhofer Institute for Surface Engineering and Thin Films IST. One of his main topics is the development of reactive processes especially in combination with HIPIMS (High Power Impulse Magnetron Sputtering).

Anas Ghailane
started his career in 2014, the year at which he received a Master of Science and Engineering degree from Saarland University, Germany; and EEIGM – University of Lorraine, France; respectively.

From 2014 – 2016, as a materials engineer, he occupied research and development engineer positions in corrosion of steel as well as metal forming. Then in 2017, Anas started a PhD in physics focusing on development of corrosion and wear resistant coatings using HiPIMS and dcMS. The PhD degree was received from University of Koblenz, Germany and did his experimental work at NTTF coatings GmbH, Germany, and University Mohammed 6 Polytechnique, Morocco.

Since 2022, Dr. Anas Ghailane works as a physical vapor deposition (PVD) consultant at Avaluxe Coating Technology GmbH & Co KG (ACT), Fürth, Germany.

Jeremy M. Grace
is currently a principal engineer at Idex Health & Science | Semrock, where he works in the area of thin-film interference filters for life sciences and other applications. Prior to his position at Semrock, he was a senior principal scientist at the Eastman Kodak company, where he worked in the areas of plasma surface modification, thin-film adhesion, sputter deposition, and organic vapor deposition. As a young scientist at Kodak, Jeremy learned DOE principles, and he has applied them in his work for the past 25 years. His experience has provided him knowledge and perspective that have helped him to mentor scientists and engineers in the application of DOE principles. Most recently, he presented a tutorial on DOE to fellow engineers at Idex Health & Science. Jeremy has written several patents and journal articles in the area of plasma modification of polymers. He is a member of the Society of Vacuum Coaters and the American Vacuum Society, and served as chair of the Upstate New York Chapter of the AVS (UNY-VAC) from 1998-2000.

Lars Haubold
graduated in Manufacturing Engineering at the University of Applied Sciences Dresden, Germany in 2002. For more than 15 years he does contract R&D at Fraunhofer USA in the area of vacuum thin film deposition and diamond-like carbon materials in particular. His projects cover the entire range from feasibility studies to industrial commercialization. His current position is Manager of Coatings Technology Group at Center for Coatings and Diamond Technologies. He has been a SVC member since 2007 and instructor at the annual conference since 2017.

SVC INSTRUCTORS

James N. Hilfiker

graduated from the Electrical Engineering Department of the University of Nebraska in 1995, where he studied under John Woollam. His graduate research involved in-situ ellipsometry applied to both sputter-deposition and electrochemical reactions, and optical characterization of magneto-optic thin films. He joined the J.A. Woollam Company upon graduation, where his research has focused on new applications of ellipsometry, including characterization of anisotropic materials, liquid crystal films, thin film photovoltaics, and Mueller matrix optical characterization. He has authored over 50 technical articles involving ellipsometry, including Encyclopedia articles and four book chapters on topics as varied as Vacuum Ultraviolet Ellipsometry, In-Situ Spectroscopic, and Dielectric Function Modeling. In 2015, James co-authored a book titled "Spectroscopic Ellipsometry: Practical Application to Thin Film Characterization."

Patrick Hopkins

is the CSO and co-founder of Laser Thermal, Inc, a company in based in Charlottesville, Virginia that has commercialized thermal conductivity measurement systems that provide non-contact metrologies for thermal properties of thin films, coatings and bulk materials. The mission of Laser Thermal is to provide accessible thermal measurements of materials, focusing on thin-film thermal conductivity with nanoscale resolution. By utilizing optical technologies, Laser Thermal provides simple, accurate, and rapid measurements of thermal properties, leading to increased customer knowledge of material properties.

Patrick is also a Professor in the Department of Mechanical and Aerospace Engineering at the University of Virginia, with courtesy appointments in the Department of Materials Science and Engineering and the Department of Physics. Patrick has been on the faculty of UVA since 2011, following a Harry S. Truman Postdoctoral Fellowship at Sandia National Labs. Patrick's current research interests are in energy transport, laser-material processes and nanoscale and ultrafast processes in condensed matter, soft materials, liquids, vapors and plasmas. Patrick's group at the UVA uses various optical thermometry-based experiments to measure the thermal conductivity, thermal boundary conductance, thermal accommodation, strain propagation and sound speed, and electron, phonon, and vibrational scattering mechanisms in a wide array of bulk materials and nanosystems.

In the general fields of nanoscale heat transfer, laser interactions with matter, and energy transport, storage and capture, Patrick has authored or co-authored over 275 technical papers (peer reviewed), and has been awarded 5 patents focused on materials, energy and laser metrology for measuring thermal properties. Patrick has been recognized for his accomplishments in these fields via an Air Force Office of Scientific Research Young Investigator Award, an Office of Naval Research Young Investigator Award, the ASME Bergles-Rohsenhow Young Investigator Award in Heat Transfer, the ASME Gustus L. Larson Memorial Award, and a Presidential Early Career Award for Scientists and Engineering, for which Patrick met President Barack Obama in 2016. Patrick is a fellow of ASME and a recipient of an Alexander von Humboldt Fellowship for Experienced Researchers.

Martin Keunecke

joined in the Fraunhofer Institute for Surface Engineering and Thin Films (IST) in Braunschweig, Germany in 1998, after university studies in physics and mechanical engineering. He completed his thesis on the development and application tests of tool coatings 2007. He is responsible for new coating and process development with PVD and PECVD technologies and other surface treatment technologies in the field of friction reduction, hard and wear resistant coatings for tools and components for industrial applications, e.g. diamond-like carbon coatings for automotive applications. From 2012 till 2015 Martin Keunecke was the head of the department "New Tribological Coatings" at the Fraunhofer IST. Since 2016 he is the head of the group "Tribological Systems" in the "Center for Tribological Coatings" at the Fraunhofer IST.

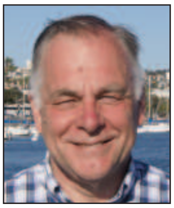
Wayne Lewey

is the Product Line Manager of Vacuum and Flow Products at Teledyne Hastings Instruments in Hampton, Virginia. He holds a BS in Chemical Engineering from North Carolina State University. He has worked at Teledyne Hastings Instruments for over 20 years, and most of that time was spent as their International Sales Manager.

Matthew Linford

graduated with a B.S. in chemistry from Brigham Young University in 1990 and received M.S. and Ph.D. degrees in materials science and chemistry, respectively, from Stanford University in 1996. While at Stanford he published the first two papers on monolayers on hydrogen-terminated silicon with his adviser Chris Chidsey. By Google Scholar these papers have been cited ca. 800 and 1300 times. After a post-doc at the Max Planck Institute of Colloids and Interfaces in Germany with Helmut Möhwald studying polyelectrolyte multilayers, he worked in industry for three years – one year with a large chemical company and two years with two start-up companies. In 2000, he became a faculty member at Brigham Young University and is now a full professor there. While at BYU, Linford has studied thin film deposition and characterization, new materials for separations science, statistical methods for data analysis, new materials for long-term digital data storage, and the chemomechanical functionalization of silicon. His work in separations science led to the launch of the Flare chromatography column that was sold by Diamond Analytics. His work in data storage led him to co-found Millenniata (now Yours.co), which sells a DVD disc that lasts 1000 years and a Blu-ray disc that will last at least 300. Linford has more than 350 publications, which include peer-reviewed papers, conference proceedings, book chapters, peer-reviewed contributions to Surface Science Spectra, commercial application notes, tutorial articles, and more than 40 patents. He is an editor for Applied Surface Science, an Elsevier journal with an impact factor of ca. 5.0. He is a contributing editor for Vacuum Technology & Coating (VT&C) for which he writes a ca. monthly column on surface and material characterization. He has been an associate editor for Surface Science Spectra since 2003. In 2014 he was made a fellow of the American Vacuum Society (AVS). In 2015 he was named an Alcuin Fellow at Brigham Young University (an award for excellence in teaching). By Google Scholar, his h-index is 40, his i10-index is 118, and his total number of citations is more than 9200.

SVC INSTRUCTORS



Allan Matthews

is a Fellow of the Royal Academy of Engineering and is Professor of Surface Engineering and Tribology in the School of Materials at the University of Manchester, UK. He is also Director of the BP-sponsored International Centre for Advanced Materials (ICAM). He spent his early career in the aerospace industry and carried out research into ion plating processes at the University of Salford before moving to the University of Hull, where he built up the Research Centre in Surface Engineering as Director for over 20 years. He moved the Centre to the University of Sheffield in 2003 and then to Manchester in 2016. His group researches plasma assisted processes, mostly for tribological coatings and diffusion treatments. He is Editor-in-Chief of the Elsevier journal Surface and Coatings Technology, a former member of the SVC Board of Directors and a former Chair of the British Vacuum Council and the AVS Advanced Surface Engineering Division Executive Committee.

Patrick Morse

is a seasoned expert with 20 years of experience in plasma physics and thin film deposition. With a strong track record of solving complex sputtering challenges and optimizing vacuum-based processes, Patrick specializes in creating Digital Twin simulations that bridge the gap between experimental results and theoretical predictions. He also shares his extensive knowledge as an Adjunct Instructor at the University of Arizona, teaching thin film deposition.

His career began at Advanced Process Technologies (later General Plasma Inc.), where he gained foundational knowledge in plasma-material interactions and magnetic confinement. At Sputtering Components Inc., he expanded his expertise to include molecular gas flow and electrical simulations, leading to the development of patented magnet bar designs used in numerous rotary cathode applications today.

Patrick's problem-solving acumen is evident in his successful resolution of challenging production issues, including a notable case where he drastically improved reactive sputtering uniformity by optimizing a gas manifold design through COMSOL Multiphysics simulations. His ability to diagnose and address undocumented phenomena, such as plasma spokes and interactions between plasma development and process zone geometry, further underscores his expertise.

Patrick's areas of expertise include large-area sputtering, PECVD sources, ion-beam etching, and Digital Twin simulations. He finds particular satisfaction in utilizing COMSOL Multiphysics to replicate and optimize real-world vacuum processes.

As a consultant with Arizona Thin Film Research LLC, Patrick leverages his extensive experience to help clients improve process efficiency and adapt to evolving industry challenges. He is passionate about sharing his knowledge and mentoring newcomers in vacuum coating technology, actively participating in events like TechCon and contributing to the Society of Vacuum Coaters (SVC).

Driven by a lifelong curiosity and a commitment to innovation, Patrick Morse continues to advance the field of vacuum coating through his analytical skills, practical experience, and dedication to continuous learning, now also through educating the next generation of thin film deposition experts at the University of Arizona.

Christopher Muratore

is the Ohio Research Scholars Endowed Chair Professor in the Chemical and Materials Engineering Department at the University of Dayton. Prior to joining the University, Professor Muratore spent 10 years as a staff member at the Air Force Research Laboratory and still works closely with multiple flexible electronics groups there. In 2013, he also founded m-nanotech Ltd., a consulting company specializing in thin film materials processing and characterization. Throughout his 20 year research career, Christopher's work has focused on developing an understanding of how to control structure and properties of thin films and surfaces for diverse applications, and their impact on properties and performance. His research group currently focuses on novel large-scale synthesis of materials for flexible, wearable electronic devices. He has 4 patents, published over 80 peer-reviewed articles and has served as guest editor for Surface and Coatings Technology and Thin Solid Films for five years.

John F. O'Hanlon

is Professor Emeritus of Electrical and Computer Engineering, the University of Arizona. He retired from IBM Research Division in 1987, where he was involved in thin-film deposition, vacuum processing, and display technology. He retired from UA in 2002, where he directed the NSF Ind./Univ. Center for Microcontamination Control. His research focused on particles in plasmas, cleanrooms, and ultrapure water contamination. He and Tim Gessert are co-authors of "A Users Guide to Vacuum Technology", 4th Edition, John Wiley and Sons, 2023

Christos Pernagidis

a materials science graduate, began his career in 1993 as part of the R&D group of major German producer of coating materials. His initial role involved overseeing and ramping up the production of TiAl for Oerlikon Balzers.

After three years of leading the production of coating materials, Christos transitioned into a sales role, becoming the sales manager with world-wide responsibility. In 2004, Christos and his partner co-founded Avaluxe International GmbH. This new venture focused on coating materials while also establishing strong partnerships with leading companies for magnetrons and power supplies. Under Christos's leadership, Avaluxe expanded

SVC INSTRUCTORS

its services to include thin film consulting and hands-on development of coatings with both decorative and functional properties.

Throughout his career, Christos has demonstrated expertise in materials science, particularly in the field of coatings and thin films. His experience spans research and development, production management, sales, and entrepreneurship, showcasing his versatility and comprehensive understanding of the industry.

Greg Pribil
graduated from the Electrical Engineering Department of the University of Nebraska-Lincoln. His graduate research included the development of a hollow cathode reactive sputtering UHV system with magnetic field confinement. His research focused on the deposition of a-Si:H, a-Ge:H and a-SiGe:H thin films for use in solar cells. He has been an applications engineer at the J.A. Woollam Company since January 2002, where he specializes in real-time process monitoring and control via in situ spectroscopic ellipsometry.

Mike Ridenour
With over 45 years of experience in vacuum technology and leak detection, Mike Ridenour brings deep technical expertise and industry insight. An Electrical Engineer by training, Mike has been with Leybold since 1980, where he has held leadership roles across Engineering Systems, Sales, Product Support, Marketing, Service, and Quality.
Today, as Sr. Product Sales Development Manager, Mike leads initiatives in leak detection, dry multistage roots pumps, and vacuum gauges—helping customers solve complex challenges with precision and innovation.

Binyamin Rubin
holds a PhD in Aerospace Engineering and has developed and characterized ion thrusters for space propulsion. In 2011 he transitioned to Veeco Instruments, where he currently serves as the Technology Manager for the Ion Beam Product Group. He has extensive experience in developing ion sources, ion beam deposition, and ion beam etch systems. Binyamin has published and presented numerous papers on ion beam sputtering, plasma diagnostics, and optical coatings.

Stefan Saager
studied physics at the Technical University Dresden with specialization to semiconductor physics. In 2015, he graduated to PhD in the topic of deposition and crystallization of silicon thin films by using e-beam technology. Since 2010 he is a research fellow at the Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP in Dresden. Since 2023 he leads the group Coating Metal & Energy Applications. His research interests include the development and the optimization of new vacuum-based deposition methods such as electron beam physical vapor deposition (EB-PVD) as well as the simulation of related thermal processes.

David Sanchez
has been a Chemical Engineer and Materials Scientist for 29 years. He was motivated by firsthand use of advanced thin film optics and technologies in the US Marine Corps. He completed his dual BS degree in California and went to work at OCLI/Flex in 1996 as a Process Engineer. He was classically trained in thin film technology from the best in the emerging field. David has since leveraged his experience and built a wide range of skills as a materials and applications scientist and engineer. For more than 28 years he has led many efforts to develop key materials and now supports the complete line of specialty inorganic materials, precious metals and rare metals for Materion Electronic Material's PVD, energy and semiconductor customers.

Robert Sargent
received his BA in Physics from UC Berkeley and his PhD in Optical Sciences from the University of Arizona. He has nearly 40 years of experience in optical coatings, including 10 years with Optical Coating Laboratory, Inc. and 24 years with Viavi Solutions (formerly JDSU). His industrial experience has included the development of deposition processes and filter designs for applications such as aerospace, biomedical instrumentation, and fiber-optic telecommunications. He currently leads R&D projects focused on the development of new thin film deposition processes.

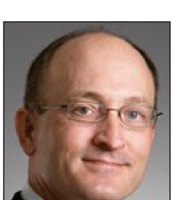
George Savva
obtained his Ph.D. from McMaster University, Canada where he studied ceramic/metal interface structures and diffusion paths related to high temperature oxidation. He has also worked in the area of materials for electrical vehicle batteries. His present position is Engineering Manager for Ionbond North America.

SVC INSTRUCTORS

Michael Simmons
is President of Intellivation, LLC, a vacuum coating equipment manufacturing company he founded in 2009. Since 2009, Intellivation has grown into one of the leading companies providing Roll to Roll vacuum coating systems and process support. Mike's extensive background in plasma processing and equipment continues to be enhanced by the installation of a R2R Lab system at Intellivation which has enabled Mike and Intellivation to become vacuum process knowledge leaders in the industry. Process knowledge includes a wide range of sputtering technologies as well as other PVD techniques. Mike is responsible for designing, manufacturing and installing a wide variety of equipment over the past 15 years, from production vacuum deposition R2R tools to R&D systems, and automation machinery. Roll to roll vacuum deposition is the primary focus for Mike and his team, as exemplified by Intellivation's innovative R2R series product line. He is a member of the Board of Directors of the Society of Vacuum Coaters (SVC), SVC Instructor for Web Coating, past Chair of AIMCAL's Vacuum Web Coating Committee, an active member of AVS and continuously supports the vacuum community through multiple initiatives. Mike earned his mechanical engineering degree (BSME) from the University of Idaho where he graduated with honors, and is a licensed Professional Engineer. Mike has published multiple technical papers and presented at global conferences on Vacuum Coating Processes, including but not limited to Vacuum Technology and State of the Art Roll to Roll Equipment and Processes.

Josh Soper
graduated from the United States Military Academy with a BS in Mechanical Engineering and from Norwich University with an MS in Organizational Leadership. He currently serves as the VP of Operations for Vergason Technology, Inc. He has been with VTI since 2015 and oversees all PVD equipment builds and coating services. He is responsible for developing coating recipes (PVD and PECVD) for new applications at VTI including thin films on plastic and painted substrates, and tribological coatings on metal substrates, using sputtering, PECVD, thermal evaporation, cathodic arc and HiPIMS deposition technologies.

Christian Stein
is a researcher at the Fraunhofer Institute for Surface Engineering and Thin Films in Braunschweig, Germany. He studied physics at the Philipps-University Marburg and graduated in 2008 with a diploma thesis on surface science. Fascinated in transferring research results to application, he completed his doctoral thesis on the development of tool coatings at the Technical University Braunschweig in 2015. His main research interests are hard and wear resistant multifunctional coatings for industrial tools and components and their deposition by PVD and PECVD processes.



Gary Vergason
has been working in the PVD industry for over 38 years, from engineering and operations to executive management. His cathodic arc source designs, developed while he was employed by Multi-Arc (IonBond), are still used around the world today. Gary founded Vergason Technology, Inc. (VTI) in 1986 and under his leadership the company has become a leading international supplier of innovative rapid-cycle PVD coating equipment and toll coating services. Gary has served as an SVC instructor, a member of the Board of Directors, served as President from 2016 to 2018 and chaired its first Topical Conference in 2009. He holds several patents in the PVD field and continues to influence this industry.

Akhil Vohra
is a Product Manager at Angstrom Engineering Inc. in Kitchener, Ontario, Canada. He received his M.Sc. in Chemistry from Guru Nanak Dev University in India in 2008. Upon completion of his Master's degree, he joined Lyallpur Khalsa College as a lecturer of chemistry teaching advanced organic and inorganic chemistry to undergraduate students. In 2011, Akhil moved to Canada to pursue his Ph.D. in Chemistry at University of Windsor. Akhil's research work was in the field of materials and surface chemistry with special focus on Stretchable and Flexible Organic Electronics. After graduation in 2016, Akhil joined Angstrom Engineering Inc. as a Test and Process Specialist before moving onto his current position in 2018.

Anellia Wäckerlin
is the Deputy Head of R&D at Glas Trösch AG. She holds Ph.D. degree in Nanoscience from University of Basel, Switzerland and engages herself in research and development of high-precision vacuum deposited nano-coatings for the last 17 years. The developments are published in over 20 scientific papers, for which she holds 3 patents. She joined Glas Trösch in 2017 as a project manager, during 2023 was a team lead, and since 2024 manages multiple development activities for the coating factories of Glas Trösch Group. The scope covers development of coating technology and processes, product- and software development, transfer to production, as well as support during the whole product/process/deployment lifetime.

Tyler Wheeler
is the Product Management/Sales/Product Line Manager for Ecoclean Inc. in Southfield Michigan. After his completion of the Manufacturing Engineering Technologies program, Mr. Wheeler has contributed in many capacities during his 15 year tenure with Ecoclean, from Mechanical Engineering to Applications Manager and served on the Global Ecoclean Product Line Development Committee. Mr. Wheeler regularly presents to industry and association groups on new technologies and the evolution of equipment designs needed to meet current and future cleanliness requirements.

was established in 1992 to commemorate the enduring efforts of Nat Sugerman (1922–1991) in founding, nurturing, and supporting the Society of Vacuum Coaters (SVC). Nat founded Providence Metallizing Company in 1951 and was a Charter Founder of the SVC and Corporate Sponsor Founder.
"...he thoroughly believed in the SVC and how pleased and proud he would now be to see what a great organization it has become."

— *Harold Gadon (retired, Providence Metallizing Company, Inc.)*

The purpose of the **Nathaniel Sugerman Memorial Award** is to encourage and recognize distinguished achievement in one or more of the following endeavors:

- For distinguished services to SVC
- For noteworthy educational contributions to the vacuum and/or vacuum coating industry
- For outstanding technical achievement
- For creative innovation in the development of a product or process pertaining to the vacuum

2026 Nathaniel Sugerman Memorial Award

For endowing the SVC with the skills and professionalism to survive and prosper in a turbulent world

Ed Wegener is an accomplished businessperson who has been a tireless promotor/servant of the SVC. Ed, more than anyone else, has been a "focused force" to professionalize the operation and management of the SVC and implement processes that have driven the SVC's financial security and operational efficiency. Had it not been for the development and nurturing of this risk mitigation mindset, it is certain that the SVC would not have survived the turbulence introduced by COVID-19. The SVC has benefited tremendously from Ed's mentoring and counsel, and it has been a joy to see him share his wisdom with the new leadership of the Young Members Committee at a time when most others would have chosen to step back and enjoy the fruits of a long successful career.

SVC Foundation:

Ed joined the SVCF as Treasurer in 2013, succeeding Jim Seeser. During that term as SVCF Treasurer, Ed refined Jim's excellent structure and financial systems that had been initially put in place, making some changes in the budgeting process to better match revenue to cash available for scholarships.

Ed served as the SVCF's President from late 2016 through 2019. During that time, he moved to expand the BOD by successfully recruiting capable volunteers. In 2018 he helped launch the first Casino Night fundraiser, which has turned into a fun social event at the TechCon and become a significant fundraiser. Ed was Gary Vergason's "co-pilot" in the launch the SVCF's Industrial Scholarship Program.

SVC:

Ed attended his first TechCon around 1988 and immediately saw the value of the SVC! He was one of the founding members of the Large Area TAC during the early 90s and led it until Michael Andreasen succeeded him in 1999. It has become a mainstay in the TAC world and has hosted many fine presentations over the years.

Mike Plaisted recruited Ed to run for the SVC BOD in 1995. Ed served two terms, notable for moving control of SVC's financial assets to a BOD Committee away from MPI (the outside management company tasked with running the SVC at the time). Out of this term of service both the Investment Committee and Finance Committee were formed, both of which he was part of until 2022.

Ed served as SVC Treasurer from 2000 through 2004, involved in managing the SVC's Investment Portfolio for several decades, managing through the Dot-Com Recession of 2001, the Great Recession of 2008 and COVID-19 in 2021. The most impactful thing Ed did in the Finance realm was in 2017 to propose to the SVC BOD a dramatic change in the SVC's investment philosophy from a very conservative fixed income portfolio to an aggressive stock-based portfolio utilizing ultra-low-cost index funds managed through Vanguard. Even though Covid hit three years later, the SVC was able to withstand the loss of revenue from two consecutive cancelled TechCons and emerge bruised but stable financially. Several years of increased investment income gave the SVC a significant financial cushion.

Ed was elected President-Elect in 2018 and was President from 2020-through 2022. In 2018 he organized a Future Sites Committee that developed policy recommendations regarding attributes of prospective conference sites and recommended that SVC always have a contracted venue for TechCons at least three years out. The policy of a "Four Eyes" contract review conducted by the Finance Committee in concert with the Executive Director began in 2019. The Future Sites Committee was disbanded in 2021 as its recommendations were incorporated into the current site selection process.

As SVC President in 2020-2022, Ed had the unique distinction of presiding over the activities in the COVID era. The focus was on surviving rather than significant innovation. The 2020 TechCon was cancelled and the 2021 TechCon became a virtual conference. The era of horse-trading future contract commitments for relief for attrition penalties commenced and impacted site selection criteria to this day. During that time, the SVC successfully converted to a 501(c)3 organization which allowed the SVC to accept tax-deductible charitable contributions.

Ed engaged Dr. David Aronoff, Dean of the Vanderbilt University Medical School as an advisor to the BOD regarding COVID. Dr. Aronoff's advice was invaluable to SVC and the BOD in a difficult period for the Society.

During Ed's tenure as an SVC Officer, he was able to implement a comprehensive performance review process for the Executive Director. Ed reinstituted some BOD training focusing on Robert's Rules of Order and the notion of 'making a motion" as a precursor to extended time spent on an issue at BOD meetings. Coupled with the adoption of a consent agenda and a motion agenda to streamline BOD meetings, the result was much more productive and focused sessions.

CAREER NOTES AND TECHNICAL ACHIEVEMENTS:

Viracon/Apogee Enterprises:

Ed's career in vacuum coating began when he joined a small glass fabricator called Viracon in 1985. In 1986 he became the first employee in a new venture with Viracon producing its own coated architectural glass coatings. The business grew rapidly and within five years it overtook established competitors to become the largest glass coating operation in North America, operating four football field sized glass coaters in Southern Minnesota. Ed's team "changed the rules" in coating glass for non-residential glass windows by reengineering coatings, procedures, and equipment for ultra-fast set up times. Coupled with a focus on creating value for customers, Viracon slashed lead times and offered a wide array of custom high-performance coatings. Viracon grew an astonishing 10X in ten short years and became an international leader in coated architectural glass.

In 1992, Ed's team developed and commercialized a high-performance double silver Low E coating that became the standard of the architectural glass industry. Combining high visible light transmission, color neutrality, and low solar heat gain, Solarscreen 2000 became the product of choice for architects and specifiers worldwide and was the growth engine of the company for decades.

Ed moved on to a business development role for the corporate parent Apogee Enterprises in 1996. In 1997 he sited a new factory in Georgia that is still in operation, employing over 300 people (sold to Cardinal Glass in 2019). In 1998 Ed negotiated a joint technical development agreement with a small New Jersey based company, SAGE Electrochromics. Ed led the move of SAGE to Southern MN where they and Viracon collaborated on development of a unique color switching thin-film technology applied on glass panels that had solar control properties. Although the partnership with Apogee/Viracon was dissolved in 2004, SAGE continued to flourish and thrive. Today it is housed in a 300,000 square foot facility in Southern Minnesota, wholly owned by the French conglomerate St. Gobain and is a leader in the switchable glass field.

Heraeus-Materials Technologies Division:

In 2011 Ed joined the German precious metals and technology company Heraeus. Ed's focus within Heraeus's Material Technology Division was its hard-disk drive target business. Heraeus had a large share of this business, supplying customers such as Seagate, Western Digital and Hitachi with gas atomized densified targets made from complex platinum, cobalt-chrome ruthenium alloys. Ed's engineering team developed a process to refine these spent targets on-site instead of going to a conventional refinery. The savings amounted to $4 million USD per year, and that achievement won a world-wide Heraeus Innovation Award. The product development team developed a fast-track prototyping procedure that cuts developmental target lead times by 60%. That innovation won a similar award.

DHF Technical Products:

With the help of a strong operations/customer service team DHF's sales tripled in 10 years and helped promote and build a national brand for DHF. Ed and team successfully advanced reducing total ownership costs of precious metal targets through intelligent design eliminating excess weight of precious metals.

Ed is known to abide by the adage that "the results any organization experiences are precisely attributed to how it is designed." This adage has guided his mentorship of the SVC and is precisely the reason Ed was awarded the 2026 Nathanial H. Sugerman Award.

SVC Fellow-Mentor Award

In 2001 the SVC Award Committee established the Mentor Award to recognize outstanding contributions to the development of vacuum coating technology or for special contributions to the Society. In 2022, the Mentor Award was expanded in scope and definition; renamed the "SVC Fellow-Mentor Award".

The Fellow-Mentor Award recognizes outstanding, sustained technical contributions to the advancement of vacuum coating, surface engineering, and related technologies through research, development, and technical leadership, as well as long-term contributions to the evolution of the SVC. The SVC Fellow-Mentor title is a lifetime recognition of distinction, rather than an award for a specific achievement. Recipients will exemplify the highest ideals of accomplishment and sharing of information embodied by the SVC community.

Since its' inception, fifty-nine individuals have been honored with the SVC Mentor Award. This year, the SVC is proud to induct our 60th member to this august body of scientific, professional, and educational contributors.

2026 Fellow-Mentor Award

For inspiring a generation of scientists and engineers to understand and enjoy the science of reactive sputtering, and for making complex concepts accessible through mentorship, teaching, and collaboration

Diederik Depla has been a tireless advocate for advancing both the science and community of vacuum coating, particularly through his research, mentorship, and educational contributions. His passion for reactive magnetron sputtering has inspired not only students and colleagues at Ghent University but also countless engineers, researchers, and professionals worldwide through his active participation in SVC events, tutorials, and online learning platforms. For many years, Diederik has distinguished himself by:

- Mentoring early-career researchers and creating pathways for young professionals to enter the vacuum coating and thin film community.
- Sharing knowledge generously, whether through his landmark book Reactive Sputter Deposition, his widely used SiMTRA simulation software tutorials, or his highly viewed SVC YouTube presentation "Tracking Sputtered Atoms – A DIY Approach," which remains the most-watched talk on the SVC channel. His theoretical insights—particularly on ion implantation and discharge voltage hysteresis—have become foundational references in our field. The SiMTRA simulation software, accompanied by his accessible and practical tutorials, has empowered countless researchers and engineers to visualize and analyze complex transport phenomena in sputtering systems. His findings continue to be a cornerstone in the development of advanced and predictive simulation approaches.
- Engaging beyond the lab, exemplified in his presentation at EdCon Europa (2023), where he described teaching "a subject very dear to me: reactive sputter deposition," and his active collaborations with both academic and industrial partners.
- Leadership in the broader vacuum science community, serving as Secretary of the Thin Film Division of IUVSTA, Chair of the Belgian Vacuum Society, and Belgian representative to international plasma and vacuum science initiatives.

Diederik embodies the spirit of the Mentor Fellow Award: he not only advances science but also uplifts people. He consistently demonstrates that science is not only about results but also about

2026 Fellow-Mentor Award Continued

curiosity, joy, and collaboration. His teaching style—often enhanced by innovative tools like interactive polling software (Mentimeter) in the SiMTRA YouTube tutorial or even using game cards to illustrate vacuum sputtering concepts on LinkedIn—underscores his ability to make complex material accessible, engaging, and memorable. Beyond his research, Diederik stands out for his approachability and his generous spirit. He has always been open to discussion, whether with early-career scientists or seasoned experts, welcoming questions and offering thoughtful, in-depth responses. This openness—paired with his clarity of thought and enthusiasm for the science—has had a ripple effect across our community.

His influence extends far beyond the lab. Whether through his co-authored book Reactive Sputter Deposition, his engaging conference presentations, or his innovative teaching techniques that bring abstract plasma concepts to life, Diederik has consistently shown that science and education go hand in hand. His work has inspired a generation of researchers not only to understand but to enjoy the challenge of studying reactive sputtering.

Diederik Depla has received his master's degree in chemistry in 1991 at Ghent University (Belgium). In 1996 he received a PhD in Solid State Chemistry on spray drying of precursors for superconductors. After a brief period as senior scientist in the Department of Solid State Sciences, in 1999 he became an assistant professor. As senior full professor, he is now head of the research group "Dedicated research on advanced films and targets(DRAFT)" in the same physics department. Two fundamental research questions have driven his research. The first question is how deposition conditions influence film growth, while the second question probes for the impact of reactive gas addition on the magnetron process. Under his guidance, the research group has distinguished itself from the traditional, technological approach, and has set an own course seeking for answers on the two above mentioned fundamental questions, translated in the mission statement of the group : "At DRAFT we want to become the recognized leader in the understanding of thin film growth by reactive magnetron sputtering, and to enjoy research by experiments and simulations". This "target on growth" approach has resulted in several publications in peer reviewed papers. He authored the book "Magnetrons, reactive gases and sputtering." He co-initiated in 2000 the successful RSD conference series. He has also received the Bill Sproul Award from AVS for "his persistence to unravel the fundamental processes during reactive magnetron sputtering."

2026 Student Sponsorship Program

The SVC Student Sponsorship Committee is pleased to sponsor these talented students who are presenting their work during the 2026 SVC Technical Program.

Iker Alfonso, *Universidad Publica de Navarra, Pamplona, Navarra, Spain*
Influence of Load, Sliding Speed and Dimple-Textured Area Density on the Tribological Behavior of AlCrN Coating

Veronika Červenková, *Polytechnique Montréal, Montréal, Quebec, Canada*
Challenges and Opportunities of Copper Nitride Nanostructures

Caroline Karina Chandra, *Technical University Darmstadt, Darmstadt, Germany*
Enhancing PEM Fuel Cell Performance: A Comparative Electrochemical Study of Low-Temperature Plasma Carburizing and Nitriding of Austenitic Steel 316L for Bipolar Plates

Hallie Echelman, *King's College London, London, United Kingdom*
High Voltage All-Evaporated 2.0eV Inorganic Perovskite Photovoltaic Devices

Alexandre Lussier, *Université de Montréal, Montréal, Quebec, Canada*
Ultra-Low Coating Thermal Noise Reflectors: The Case of Hydrogenated Amorphous Silicon for Gravitational Waves Detection

SVC acknowledges the SVC Foundation for providing travel sponsorships to the following students who are presenting their work during the 2026 SVC Technical Program. *Additional SVC Foundation Scholarship recipient.

Md Koushik Alam, *University of Oklahoma, Norman, Oklahoma*
Broadband MWIR Absorption in PbSe Mie Metasurface Photodetectors Using Deep Neural Networks

Khadija El Kindoussy, *Mohammed VI Polytechnic University, Ben Guerir, Morocco*
Influence of Silicon-to-Carbon Ratio on the Structural and the Electrochemical Performance of Si/C Thin Film Anodes for Lithium-Ion Batteries Fabricated Via Reactive Magnetron Sputtering

Nick Mikhalev, *University of Dayton, Dayton, Ohio*
Mass-Produced Wireless Two-Dimensional Electronic Devices for Hazardous Vapor Sensing Arrays

Azad Rahman, *University of Texas at Arlington, Arlington, Texas*
Design and Characterization of InAs/GaSb 4ML/8ML Type-II Superlattice-Based Mid-Wave Infrared Photodetector

Chukwudike Ukeje, *Imperial College London, London, United Kingdom*
Correlating Deposition Temperature with Structure and Sensing Performance in Palladium Thin Film Hydrogen Sensors

2026 Academic Scholarship Program

SVC acknowledges the SVC Foundation for awarding Academic Scholarships for the 2026/27 school year
*Also 2026 TechCon Presenter

***Jui-Che Chen,** *Feng Chia University, Taichung City, Taiwan*
SVC Foundation Scholarship
Time-Resolved OES Diagnostics of Gas Flow Sputtering Using a Copper Targe

***Zulkifl Hussain,** *University of Toledo, Toledo, OH*
SVC Foundation Scholarship
Epitaxial Growth from a Thermal Evaporator: Highly Active Arsenic Doped Single Crystal CdTe

***Michal Nowak,** *Military University of Technology, Warsaw, Poland*
J. A. Woollam Company Scholarship
Passive and Active Structural Color Control of the Metallic-Dielectric Thin Film Structures

***Isaac Ogunniranye,** *University of Toledo, Toledo, OH*
J. A. Woollam Company Scholarship
Minimizing Interfacial Recombination Losses in Perovskite Solar Cells through Selective Vacuum Deposition Processing

s

***Aesha Patel,** *University of Toledo, Toledo, OH*
David Glocker Endowed Scholarship
Front Contact (TCO/Emitter) Engineering for High-Efficiency CdTe-based Solar Cells on Ultra-Thin Cover Glass

***Shang-Chen Wu,** *Feng Chia University, Taichung City, Taiwan*
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Through-Glass Via Metallization by Using HiPIMS Copper Layer

A T M Mahbub Alahe, *Wayne State University, Detroit, MI*
SVC Foundation Scholarship

Alex Bordovalos, *University of Toledo, Toledo, OH*
Clark & Karen Bright Scholarship Honoring Angus Macleod

2026 Academic Scholarship Program cont'd

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2026 Industry Scholarship Program

SVC acknowledges the SVC Foundation for awarding Industry Scholarships to cover the travel expenses for the SVC TechCon in Long Beach, California. Both the SVC and the SVC Foundation are grateful to the Scholarship sponsors.

Gopi Krishna Samudrala, *Kurt J. Lesker Company*
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SVC Mission

To promote technical excellence by providing a global forum for networking, educating, and informing the stakeholders, the technical community & the industrial eco-system on all aspects of industrial vacuum coating, surface engineering and related technologies.

SVC Vision

To provide a dynamic global forum for transitioning and commercializing thin film and surface engineering innovation to industry.

The SVC Awards Committee Invites Your Nominations

The SVC Awards Committee is responsible for selecting the recipients of our awards: the **Nathaniel H. Sugerman Award** for distinguished achievement, and the **Fellow-Mentor Award** for significant contributions to the SVC or the vacuum coating industry. We request that nominations be sent to Chris Muratore, University of Dayton, Awards Committee Chair, cmuratore1@udayton.edu, by December 15, 2026. The criteria for the awards and a list of past award recipients can be found on the ***SVC website***.

Nominations should give a brief, thoughtful statement about the individual in light of the criteria for the proposed award. The Sugerman and Mentor Awards can be based on a broad range of possible contributions to the SVC and/or the vacuum coatings industry. Please consider candidates whose contributions are significant but perhaps not as apparent based on more formal mechanisms, i.e., scientific publications.

We encourage you to submit nominations for the 2027 awards now!

Fellow-Mentor Awardees are eligible for the Sugerman Award. Employees and contractors of the SVC and current members of the Awards committee are not eligible.

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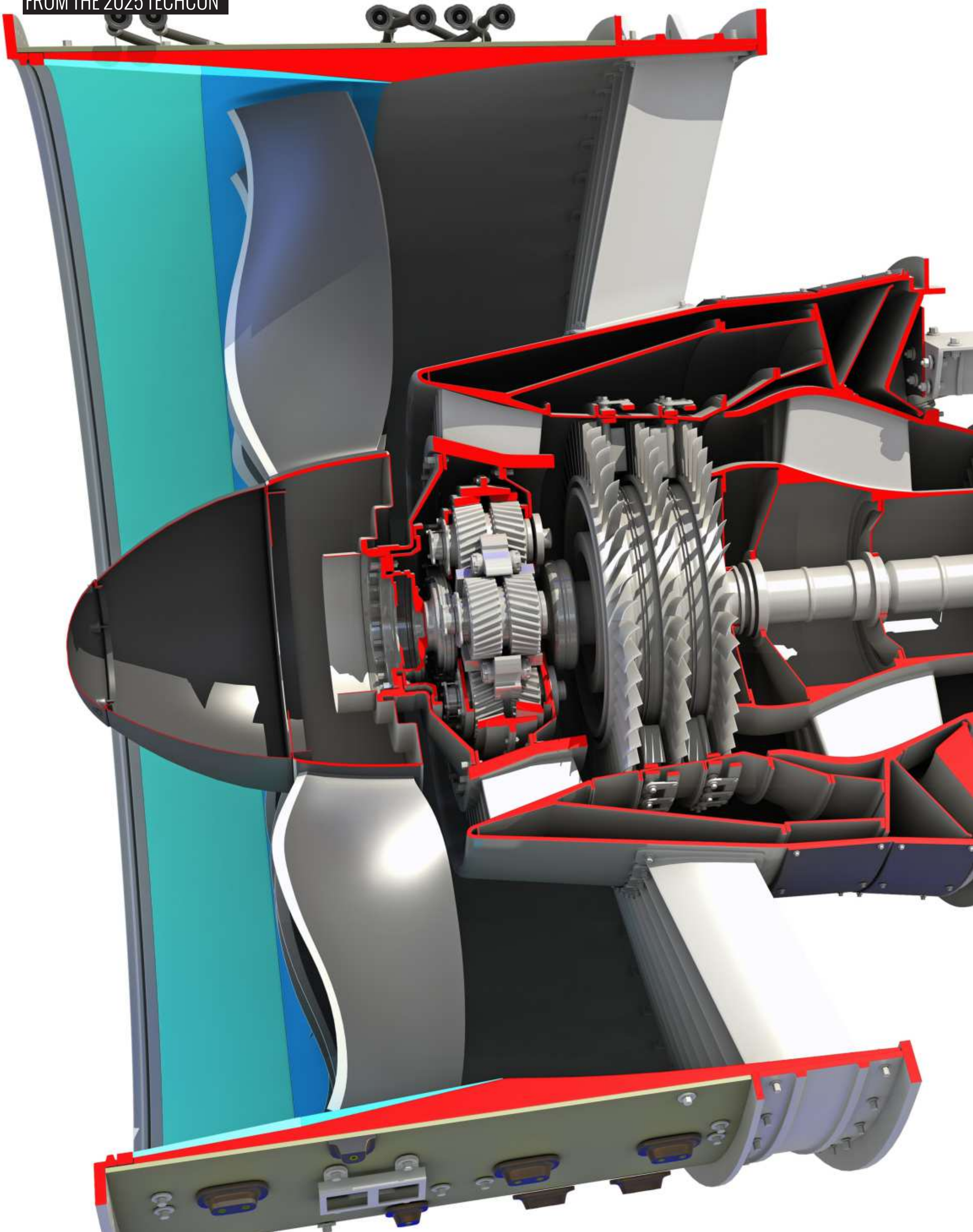
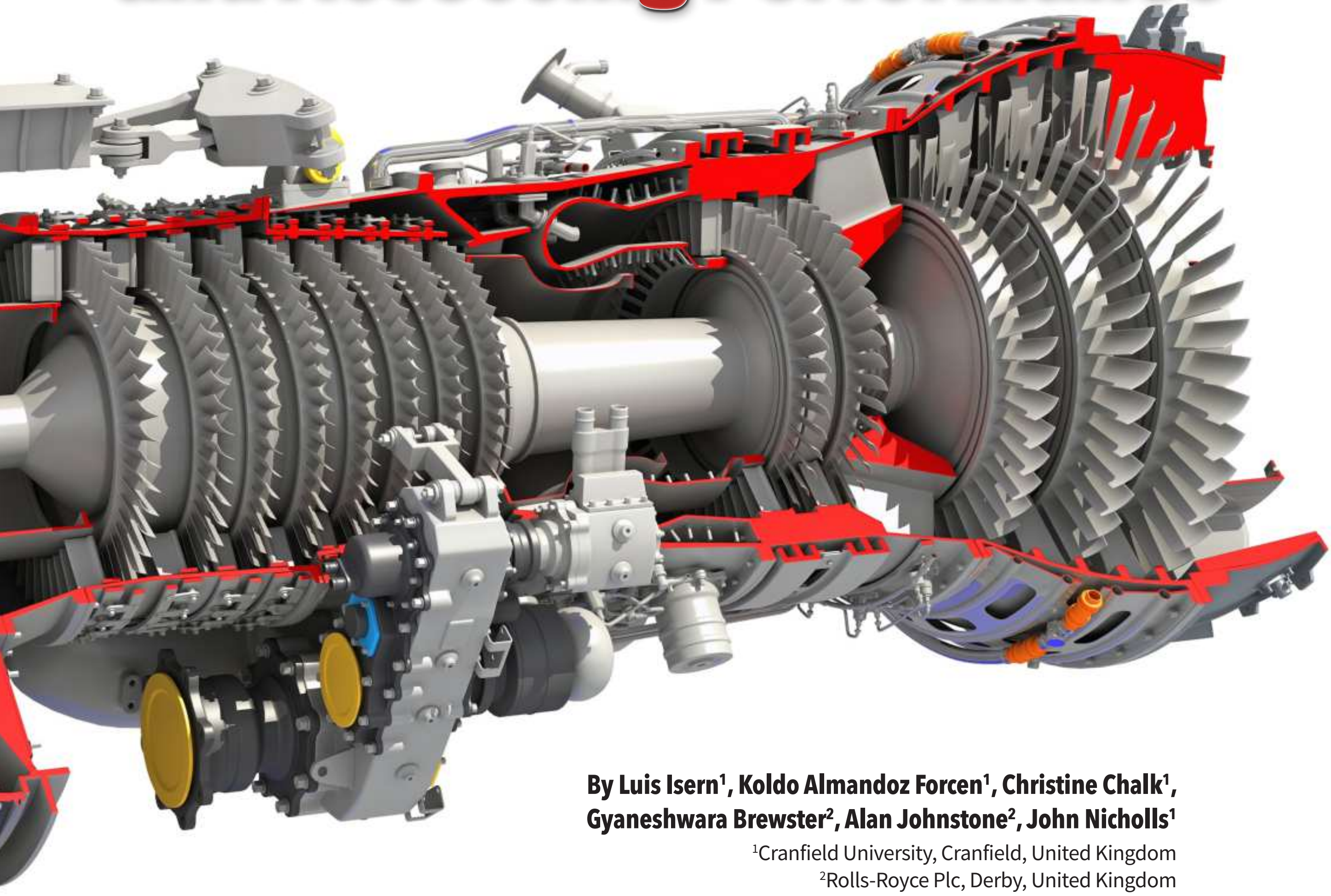
Jolanta Sapieha, Polytechnique Montréal, Canada| jsapieha@polymtl.ca

CONTRIBUTED PRESENTATION
IN POWERPOINT FORMAT
FROM THE 2025 TECHCON

Adapted from a Powerpoint Presentation that was presented at the 2025 68th TechCon



Rare Earth Zirconates for Thermal Barrier Coatings: Improving Manufacturability and Assessing Performance



By Luis Isern[1], Koldo Almandoz Forcen[1], Christine Chalk[1], Gyaneshwara Brewster[2], Alan Johnstone[2], John Nicholls[1]
[1]Cranfield University, Cranfield, United Kingdom
[2]Rolls-Royce Plc, Derby, United Kingdom

Key aero-engine components are subject gas stream temperatures above the melting point of their metal alloy, a demanding environment that can only be survived thanks to the combination of cooling and protection from Thermal Barrier Coatings (TBCs). Electron-Beam Physical Vapour Deposition (EB-PVD) can deposit TBCs with a unique columnar microstructure that is strain compliant and ideal to survive in cyclic, high-strain, high-thermal load environments, such as those of the rotating parts of the high temperature turbine.

CONTRIBUTED PRESENTATION
IN POWERPOINT FORMAT
FROM THE 2025 TECHCON

RARE EARTH ZIRCONATES FOR THERMAL BARRIER COATINGS: IMPROVING MANUFACTURABILITY AND ASSESSING PERFORMANCE

TBCs based on yttria-stabilised zirconia (YSZ) are tough and effective, but they are also susceptible to sintering and chemical attack by calcium magnesium alumino-silicates (CMAS) at higher operating temperatures, which are required to improve engine efficiency. Rare Earth Zirconates (REZ) are postulated as potential YSZ substitutes due to their higher resistance to CMAS attack, lower thermal conductivity and high phase stability, although they also exhibit a lower toughness and more manufacturability challenges. This work focuses on two known systems (Gadolinium and Lanthanum Zirconate – GZ and LZ), a novel system (Neodymium Zirconate - NZ), and YSZ references and explores co-evaporation and use of mixed-ingot oxides to overcome the manufacturability challenges in EB-PVD. The columnarity, general microstructure, and uniformity of all systems has been evaluated, with special emphasis on the LZ system that, traditionally, results in heterogeneous composition and lack of columnarity. The use of simple computer models has helped to understand the underlaying mechanisms of these challenges. The performance of the resulting TBCs has been evaluated for CMAS attack and high velocity erosion, considering depth of infiltration and reactive formation of protective compounds for the former, and erosion rates, damage mechanisms and proposed erosion testing alternatives for the latter. Overall, NZ seems a promising system on-par or better than GZ.

Note from Managing Editor: We are delighted to share with the readers of the Bulletin some of the interesting Powerpoint Presentations from past TechCons. We hope you find them as interesting as we do.

Sue Taube/Managing Editor

Rare Earth Zirconates for Thermal Barrier Coatings: Improving Manufacturability and Assessing Performance

Luis Isern[1], Koldo Almandoz Forcen[1], Christine Chalk[1], Gyaneshwara Brewster[2], Alan Johnstone[2], John Nicholls[1]
[1]Cranfield University, Cranfield, United Kingdom; [2]Rolls-Royce Plc, Derby, United Kingdom

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https://www.svc.org DOI: https://doi.org/10.14332/svc25.proc.0011

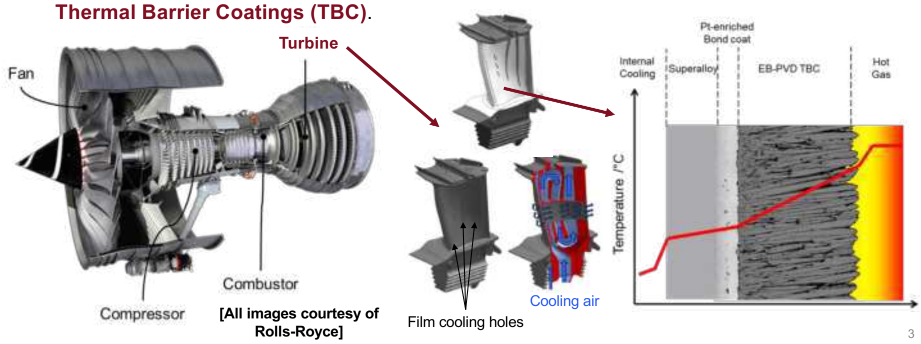
Rare Earth Zirconates for Thermal Barrier Coatings: improving manufacturability and assessing performance

Luis Isern*[1], Koldo Almandoz Forcen[1], Christine Chalk[1], Gyaneshwara Brewster[2], Alan Johnstone[2], John Nicholls[1].

[1] Surface Engineering and Precision Centre, Cranfield University, Cranfield MK43 0AL, UK.
[2] Rolls-Royce Plc, Derby DE24 8BJ, UK.

Motivation

- Aviation industry: quest to improve efficiency, reduce CO_2 emissions.
- How to survive high temperature, strain from high velocity rotation?
  - ➢ Advanced metallurgy and casting, advanced cooling solutions (internal and film), **Thermal Barrier Coatings (TBC)**.



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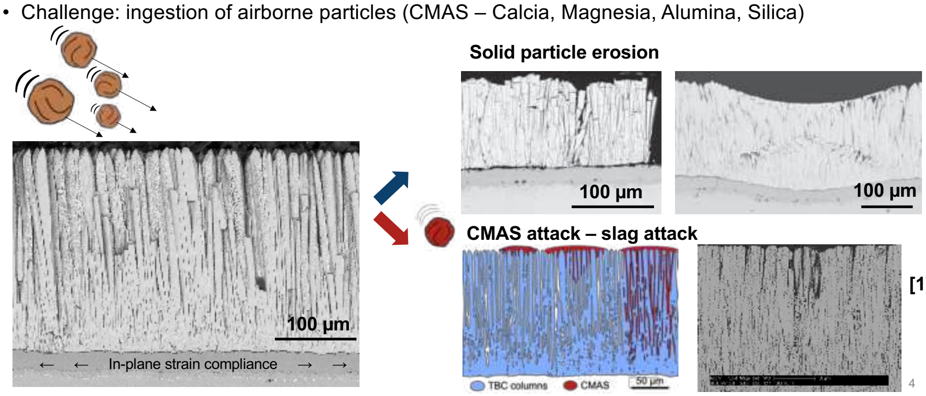
Motivation

- EB-PVD process: columnar microstructure for strain compliance!
- Challenge: ingestion of airborne particles (CMAS – Calcia, Magnesia, Alumina, Silica)



4

RARE EARTH ZIRCONATES FOR THERMAL BARRIER COATINGS: IMPROVING MANUFACTURABILITY AND ASSESSING PERFORMANCE

Contents

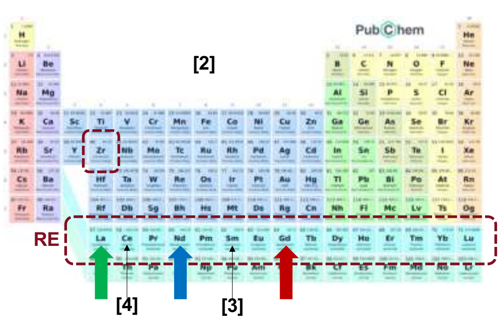
1. Rare-Earth Zirconates
2. Manufacturability of REZ
3. CMAS testing of REZ
4. Erosion testing of REZ
5. Conclusions

5

1. Rare-Earth Zirconates

Typical topcoat ceramic: Yttria-Stabilised Zirconia (Y_2O_3 + ZrO_2) (YSZ/PYSZ)

Proposed ceramics: **RE zirconates ($RE_2Zr_2O_7$)**



Advantages

- Improved resistance to CMAS attack vs PYSZ
- Improved resistance to sintering
- Reduced thermal conductivity vs PYSZ
- Phase stability at high temperatures

Challenges

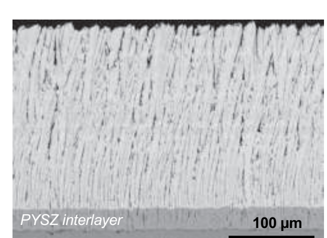
- Reduced toughness vs PYSZ
- Detrimental interaction with TGO
- Manufacturability issues

6

2. Manufacturability of REZ

Manufacturability?

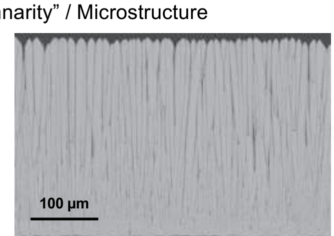
- Able to be evaporated (stable!)
- Retain or recuperate stoichiometry (avoid dissociation)
- Homogeneity
- "Columnarity" / Microstructure

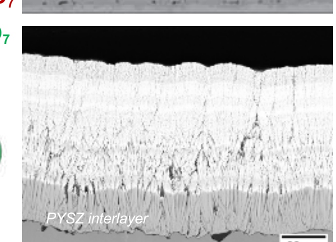


$Gd_2Zr_2O_7$

PYSZ

$La_2Zr_2O_7$





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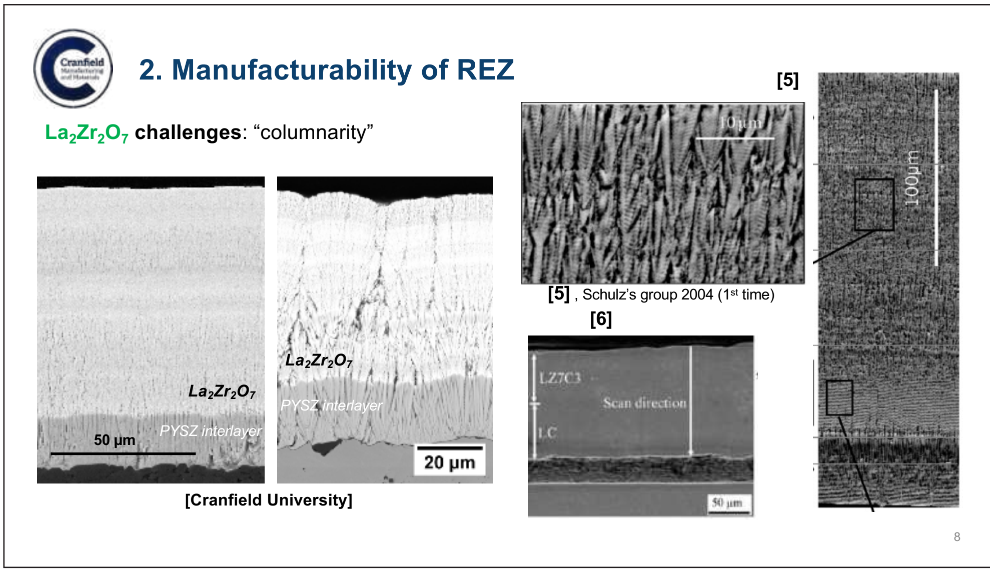

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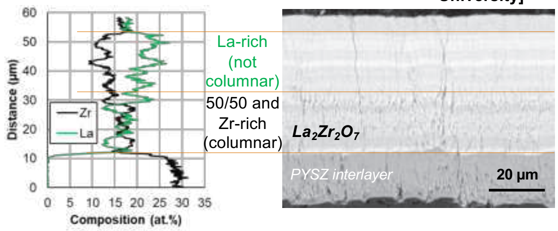
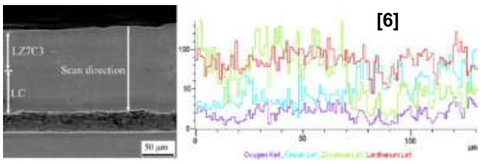
RARE EARTH ZIRCONATES FOR THERMAL BARRIER COATINGS: IMPROVING MANUFACTURABILITY AND ASSESSING PERFORMANCE

2. Manufacturability of REZ

$La_2Zr_2O_7$ challenges: homogeneity

[Cranfield University]





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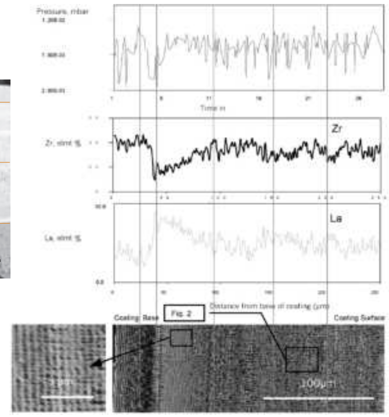


[5]

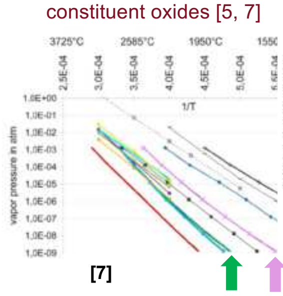
9

2. Manufacturability of REZ

Understanding the challenges

- Schulz's group observed:
  - ➢ link between composition variation and pressure variation [5]
  - ➢ differences in the vapour pressure of constituent oxides [5, 7]

- Our computer model [8] explains composition variation from vapour pressure differences:
  1. Oxide with higher vp evaporates faster
  2. Meltpool is enriched in oxide with lower vp



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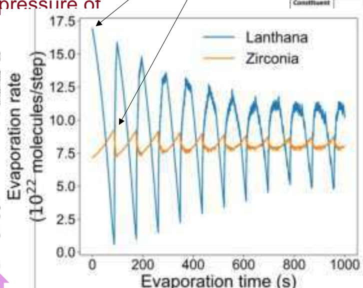
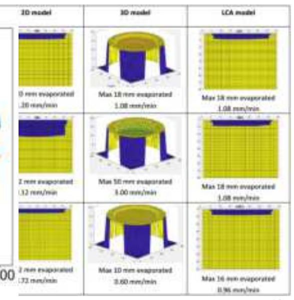




[8]

10

2. Manufacturability of REZ

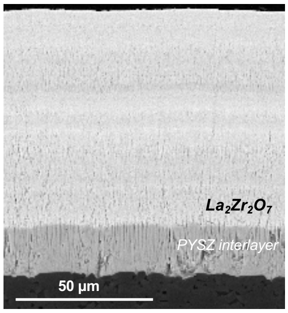
Potential solution: co-evaporation

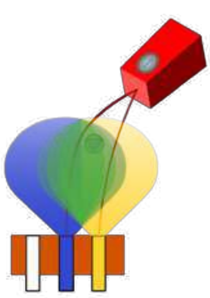
Evaporation of $La_2Zr_2O_7$ ingot

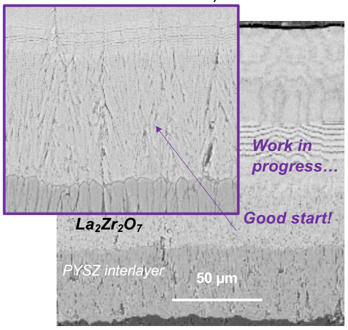
Hygroscopic!

Co-evaporation of La_2O_3 ingot and **PYSZ** ingot

(Beam jumping from 7YSZ to La_2O_3 ingot every <10 ms with our Von Ardenne EBE150)



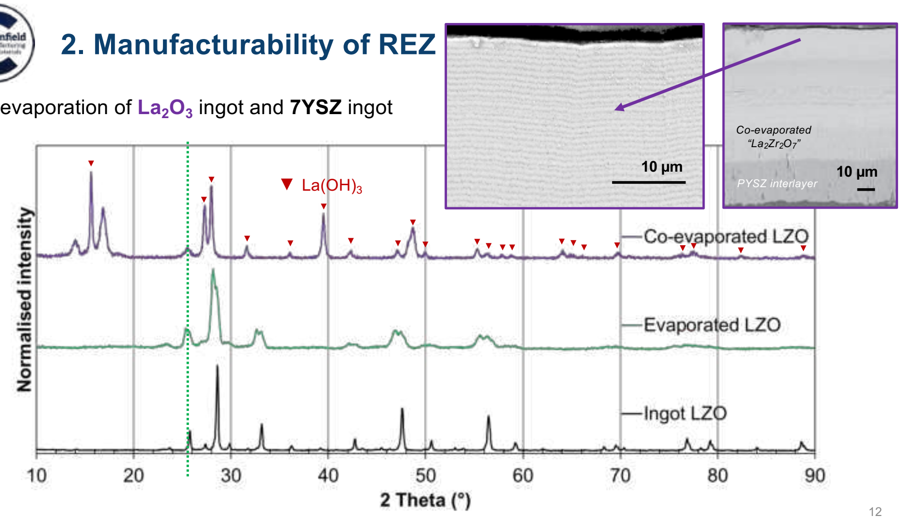




11

2. Manufacturability of REZ

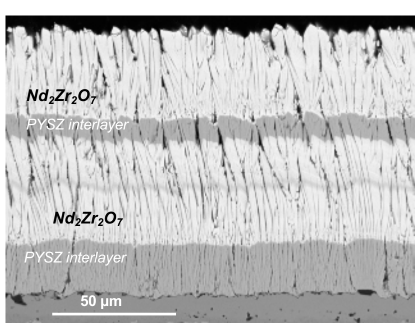
Co-evaporation of La_2O_3 ingot and **7YSZ** ingot

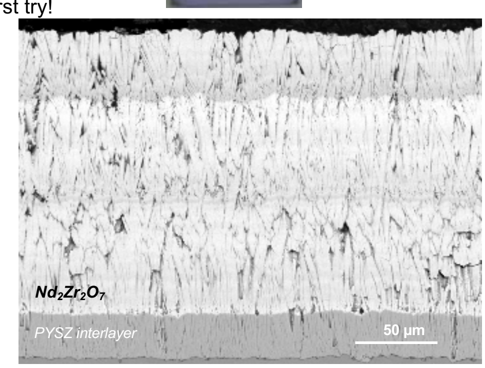


12

2. Manufacturability of REZ

- **First $Nd_2Zr_2O_7$ by EB-PVD**
- Good microstructure and homogeneity from first try!

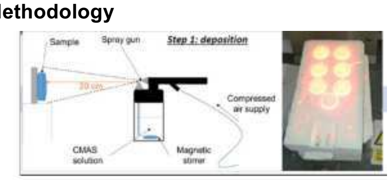




13

3. CMAS testing of REZ

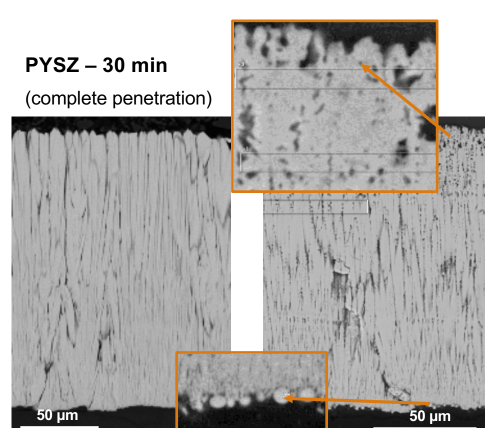
Methodology



- **Short isothermal exposure with CMAS (15±1 mg/cm²)** (from KAF's EngD, to avoid isothermal saturation of a system designed for a thermal gradient)
- **CMAS composition** (mol.%): 35% CaO + 10% MgO + 7% Al_2O_3 + 48% SiO_2
- **Exposure conditions**: 6 and 30 min at 1300 °C
- **Evaluation of results**:
  - Infiltration depth of CMAS melt.
  - Tracking Ca, Mg, Al, Si infiltration
  - SEM/EDX mapping

PYSZ – 30 min

(complete penetration)



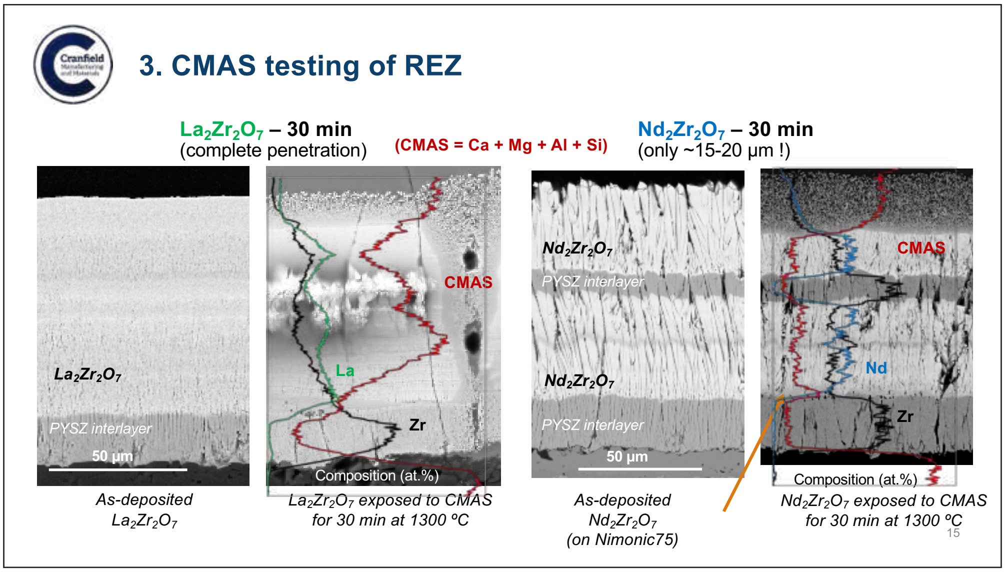
As-deposited PYSZ (on alumina!)

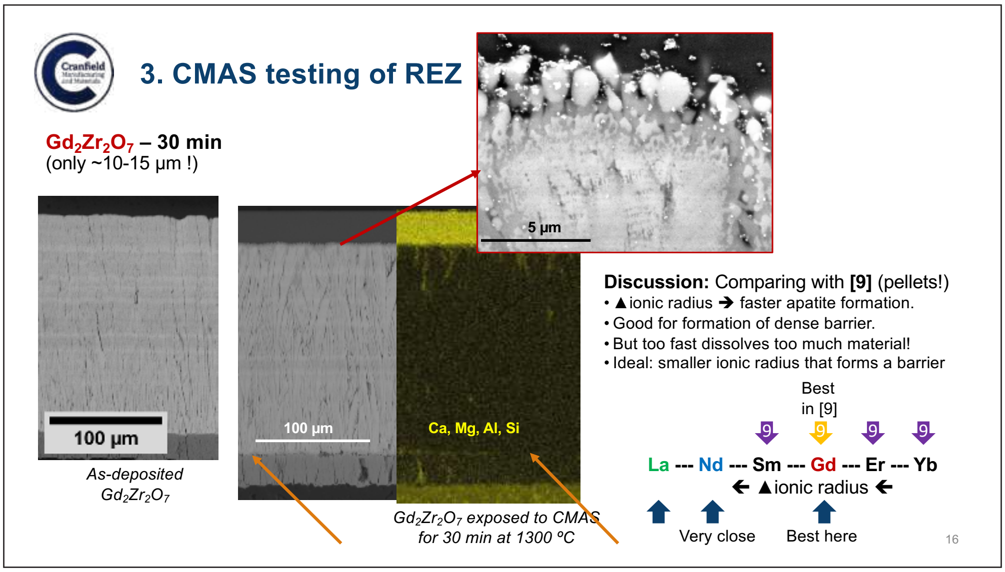
PYSZ exposed to CMAS for 30 min at 1300 °C

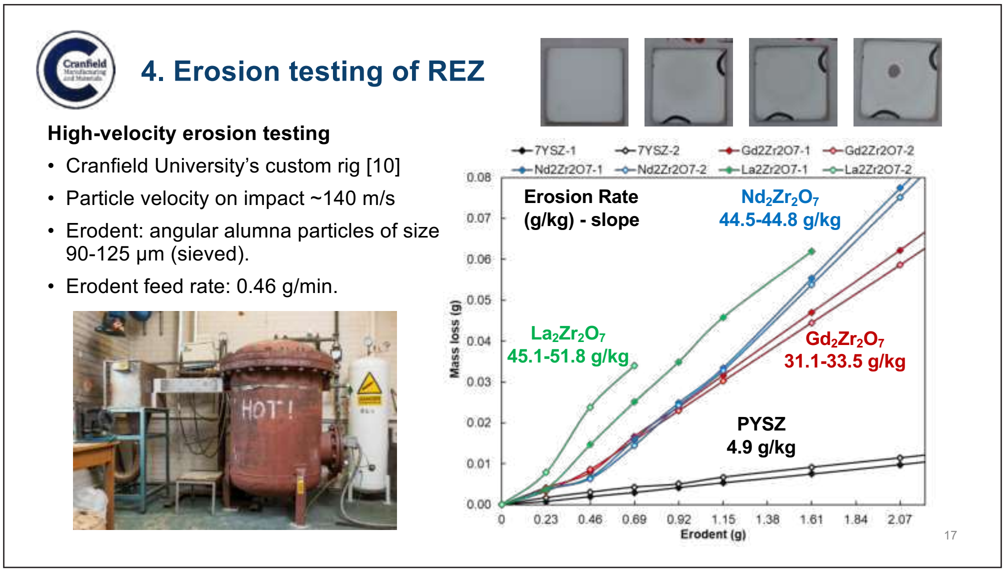
14

CONTRIBUTED PRESENTATION IN POWERPOINT FORMAT FROM THE 2025 TECHCON

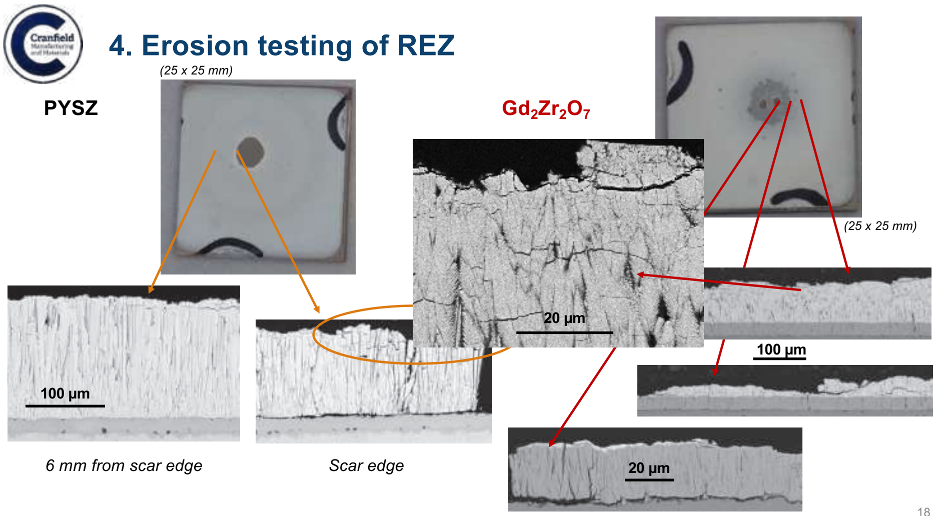
RARE EARTH ZIRCONATES FOR THERMAL BARRIER COATINGS: IMPROVING MANUFACTURABILITY AND ASSESSING PERFORMANCE







4. Erosion testing of REZ



18

5. Conclusions

- **RE zirconates** display differences in their manufacturability by EB-PVD and their performance depending on the specific oxide used.
- $Gd_2Zr_2O_7$ showed good resistance to CMAS attack and the best erosion resistance of all RE zirconates, although its erosion rate is still 6 times larger than PYSZ.
- $Nd_2Zr_2O_7$ achieves a defined columnar structure and relative through-thickness compositional uniformity. This novel coating has good resistance to CMAS attack, on par with $Gd_2Zr_2O_7$, but loses 37% more mass under erosion testing. Performance can potentially improve if compositional and microstructural homogeneity is optimised.
- $La_2Zr_2O_7$ displays a periodic through-thickness compositional variability.
  - Modelling attributes this to differences in the vapour pressure of the constituent oxides.
  - Co-deposition of La_2O_3 and PYSZ was not entirely successful, but specific deposition conditions seemed to produce a more homogeneous composition.
- $La_2Zr_2O_7$ columnar structure is either absent or very fine, with more defined columns correlating to Zr-rich bands whereas La-rich bands re-nucleate the columns or make them disappear. CMAS and erosion performance are low due to compositional and microstructural homogeneity issues.

20

Cranfield Manufacturing and Materials

Thank you!

And thanks to:

- Rolls-Royce for their collaboration and partial funding of this work.
- Innovate UK for their Smart Award project #10020751, “High temperature tools for designing sustainable erosion resistant coatings”, which partially funded this work.

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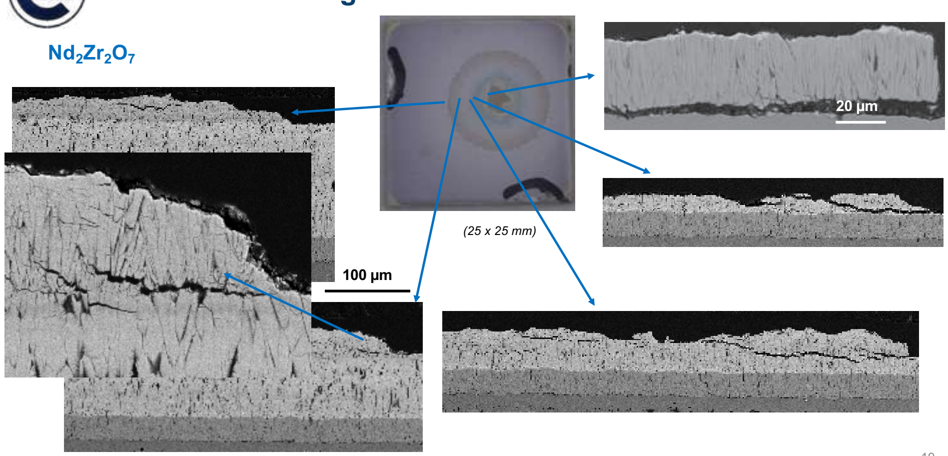
4. Erosion testing of REZ

$Nd_2Zr_2O_7$



19

About the Authors:
Luis Isern Arrom, Koldo Almandoz Forcen, Christine Chalk, Gyaneshwara Brewster, John Nicholls

Dr. Luis Isern Arrom is a Materials Scientist using surface engineering for protection of materials against extreme environments working at Cranfield University and is a Technology Platform Lead at the Royce Institute. He has experience in several coating deposition techniques (Chemical Vapour Deposition – CVD, Electron-Beam Physical Vapour Deposition – EB-PVD, electroplating, brush electroplating…) and is interested in the use of different coating morphologies and microstructures. Dr Isern's main areas of interest are the understanding of the damage mechanisms responsible for material degradation in extreme environments, the development, design and deposition of advanced coatings to protect surfaces against degradation in extreme environments, and the incorporation of digital tools to analyse damage mechanisms and design, produce and analyse the protective coatings.

Dr. Eng. Koldo Almandoz Forcen is an Aerospace Engineer and Materials scientist. His work has focused on the processing-structure-properties links of EB-PVD coatings, in particular, those of thermal barrier coatings for high temperature gas turbine applications. He is currently a researcher in the plasma coatings unit in the Tekniker Foundation, Spain.

Dr. Christine Chalk, now retired. Formerly, Senior Research Fellow in High Temperature Materials, Cranfield University. Her research interests included design and deposition of thermal barrier coatings (TBCs) by Electron-Beam Physical Vapour Deposition, in particular exploiting the chemistry of the lanthanide elements to optimise performance of TBCs within the operating environment of high temperature-high pressure gas turbine. Other interests include using Chemical Vapour Deposition for bond coats and oxidation/corrosion protection together with probing degradation mechanisms of coatings under harsh operating conditions.

Gyaneshwara Brewster is Surface Engineering Specialist in the Materials - Capability Acquisition team within Rolls-Royce plc, with significant experience in the field of high temperature materials, coatings and surface engineering. He holds a EngD from University of Cambridge, is a Chartered Engineer, a Fellow of the IoM3, and sits on the IoM3 Surface Engineering Division board. In his current role he is focussed on research & development of new coatings technology, specifically focussing on thermal barrier coatings, environmental barrier coatings and environmental degradation, and has a long track record of collaboration with international academic and industrial research partners.

Prof John Nicholls established the research group in Cranfield University working on: contaminant corrosion of materials for boilers, gas turbines and diesel engines; high temperature erosion, erosion-corrosion interactions; and the development and performance testing of coatings at high temperatures. Over more than 50 years at Cranfield, Prof Nicholls has published more than 250 papers, contributed chapters to and edited several books and is joint holder of nine coating patents, has given numerous keynote papers worldwide and is a contributor to the prestigious 'Gordon Research Conference', where he is regularly invited to speak, and was elected as Fellow of the Royal Academy of Engineering in 2009.

CONTRIBUTED PRESENTATION
IN POWERPOINT FORMAT
FROM THE 2025 TECHCON

Adapted from a Powerpoint Presentation that was presented at the 2025 68th TechCon

Leveraging “External Innovation” to Diversify the Innovation Pipeline in Functional Coatings and Surface Engineering

By Chris H. Stoessel
Stoessel Consulting / SputterTek LLC, Bodega Bay, CA

Successful commercialization of advances in coating and surface science increasingly depends on industry's ability to not only execute internal R&D efforts but to also effectively leverage innovation that is obtained from external partners. External innovation helps diversify the "Innovation Pipeline" and offers the opportunity to mitigate risks, accelerate time-to-market, nimbly react to shifting trends, diversify creative perspectives, and to take advantage of existing technology/market ecosystems.

CONTRIBUTED PRESENTATION IN POWERPOINT FORMAT FROM THE 2024 TECHCON

LEVERAGING "EXTERNAL INNOVATION" TO DIVERSIFY THE INNOVATION PIPELINE IN FUNCTIONAL COATINGS AND SURFACE ENGINEERING

Synergistic effects between external scale-up needs and complementary internal manufacturing capabilities or product line integration opportunities are particularly appealing. However, it can also pose challenges for corporate intellectual property strategies, stir "not invented here" resentments with internal innovation resources, requires efficient opportunity scouting, prudent due-diligence assessments, and a strategic corporate funding and investment approach. A wholistic commitment throughout the enterprise is required to effectively integrate external innovation into corporate business structures. In this talk, we will review various external innovation pathways, characterize their strength and weaknesses, and provide guidance on how to avoid common pitfalls to leverage external innovation opportunities for successful business growth in innovation-driven markets such as coatings and surface engineering.

Note from Managing Editor: We are delighted to share with the readers of the Bulletin some of the interesting Powerpoint Presentations from past TechCons. We hope you find them as interesting as we do.

Sue Taube/Managing Editor

Leveraging "External Innovation" to Diversify the Innovation Pipeline in Functional Coatings and Surface Engineering

Chris H. Stoessel, Stoessel Consulting / SputterTek LLC, Bodega Bay, CA

Successful commercialization of advances in coating and surface science increasingly depends on industry's ability to not only execute internal R&D efforts but to also effectively leverage innovation that is obtained from external partners. External innovation helps diversify the "Innovation Pipeline" and offers the opportunity to mitigate risks, accelerate time-to-market, nimbly react to shifting trends, diversify creative perspectives, and to take advantage of existing technology / market ecosystems. Synergistic effects between external scale-up needs and complementary internal manufacturing capabilities or product line integration opportunities are particularly appealing. However, it can also pose challenges for corporate intellectual property strategies, stir "not invented here" resentments with internal innovation resources, requires efficient opportunity scouting, prudent due-diligence assessments, and a strategic corporate funding and investment approach. A wholistic commitment throughout the enterprise is required to effectively integrate external innovation into corporate business structures. In this talk, we will review various external innovation pathways, characterize their strength and weaknesses, and provide guidance on how to avoid common pitfalls to leverage external innovation opportunities for successful business growth in innovation-driven markets such as coatings and surface engineering.

https://www.svc.org DOI: https://doi.org/10.14332/svc25.proc.0012

Leveraging “External Innovation” in Functional Coatings and Surface Engineering

Diversifying the corporate Innovation Pipeline beyond the walls of the corporate fortress

Dr. Chris H. Stoessel
Stoessel Consulting / SputterTek LLC

Note: this is an updated and abbreviated version of an invited talk given at the FCSE Conference in Montreal, Canada in 2024

“NIH” Syndrome

https://i.imgflip.com/2/20qbc8.jpg

"Airplanes are interesting toys but of no military value."
Marechal Ferdinand Foch, Professor of Strategy, Ecole Superieure de Guerre, 1911

"Who the hell wants to hear actors talk?"
H. M. Warner, Warner Brothers, 1927

"The bomb will never go off. I speak as an expert in explosives."
Admiral William Leahy, U.S. Atomic Bomb Project

"There is no reason anyone would want a computer in their home."
Ken Olson, president, chairman and founder of Digital Equipment Corp., 1977

Disruptorleague.com

NIH – “Not Invented Here”

External Innovation: **Sources**

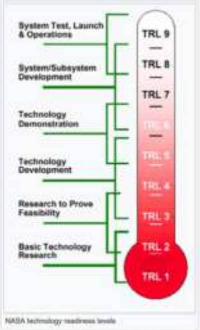
- Academia
- Technology transfer organizations
- Consortia
- Venture-funded start-ups

This talk mentions names of organizations and companies. Those names are mentioned as examples, and do not constitute a recommendation or endorsement unless explicitly stated otherwise.

External Innovation: **Fundamental "Rules of Play"**

- Licensing or downright ownership of external IP is typically required
- Respect and willingness to appreciate the work of others
- Willingness and creativity to negotiate win-win partnerships
- Willingness to share the "playground" with others (perhaps even competitors) without loosing sight of business priorities
- Tolerating and ability to manage risk
- Demonstrated commitment from C-Suite to the "External Innovation" concept, and cultural buy-in throughout organization

Innovation Readiness Assessment Metrics

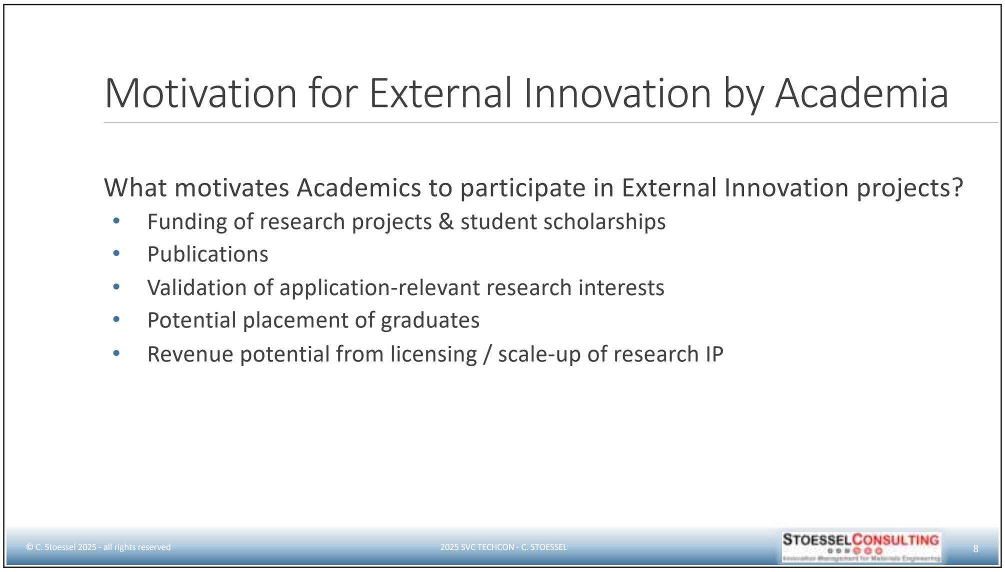


Manufacturing Readiness Level (MRL)		
Phase	MRL	State of Development
Phase 3: Production Implementation	9	Full production process qualified for full range of parts and full metrics achieved
	8	Full production process qualified for full range of parts
	7	Capability and rate confirmed
Phase 2: Pre production	6	Process optimised for production rate on production equipment
	5	Basic capability demonstrated
Phase 1: Technology assessment and proving	4	Production validated in lab environment
	3	Experimental proof of concept completed
	2	Application and validity of concept validated or demonstrated
	1	Concept proposed with scientific validation

From: http://www.dodmrl.com/MRL_Deskbook_2022__20221001_Final.pdf
Also see: http://www.dodmrl.com/MRL_Deskbook_2018.pdf

NASA: https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf
U.S. DoD: https://www.cto.mil/wp-content/uploads/2023/07/TRA-Guide-Jun2023.pdf
European Union: https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

External Innovation: **Academia**


Motivation for External Innovation by Academia
What motivates Academics to participate in External Innovation projects?
Funding of research projects & student scholarships
Publications
Validation of application-relevant research interests
Potential placement of graduates
Revenue potential from licensing / scale-up of research IP
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RD MATHIS COMPANY IS YOUR TOP RESOURCE FOR EVAPORATION SOURCES & MATERIALS.
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From baskets, boats & boxes to filaments, crucibles & liners, we offer an extensive selection of sources and materials to fill your every need. Contact us today.
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Since 1963

LEVERAGING "EXTERNAL INNOVATION" TO DIVERSIFY THE INNOVATION PIPELINE IN FUNCTIONAL COATINGS AND SURFACE ENGINEERING

External Innovation: **Academia "Goldilocks"**

"Target School(s)" with a long-term Master Agreement
- Excel in a strategically aligned technical specialty
- Depth & breadth in topic matter expertise to justify a strategic investment

- Long-term master agreements
  - "Platform" master terms for IP, funding parameters
  - Opportunity for "bespoke" projects that address specific corporate needs & capability gaps
  - Opportunity to build strategic partnerships on critical scientific topic matter expertise
  - Opportunity to leverage public funding (more common in EU / Asia than U.S.)
  - Pipeline for recruiting: interns, graduate projects

- But…:
  - Expensive: funding commitments for graduate / post-graduate projects can be several $100k per project
  - University partners prefer comprehensive (multi-student) and sustained (multi-year) funding packages for their students
  - Any IP is low TRL/MRL: concept / prototype stage – long way to go to productization

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External Innovation: **Academia-led Consortia**

Research consortia *(a few select examples…)*

- A single-university (but often multi-department)t R&D initiative to create critical mass in a common field of expertise
- Typically encourages corporate memberships to provide funding and unlock public / 3rd party funding
- The university's "Technology Transfer Office" typically negotiates membership and IP terms

Georgia Tech Advanced Manufacturing Pilot Facility

Stanford Engineering | Center for Automotive Research at Stanford

Virginia Tech | CPES

MIC-CSE NSERC Multisectorial Industrial Research Chair in Coatings and Surface Engineering

\+ Shared with other consortium partners – affordable
\+ Address a business-relevant strategic "theme"
! IP ownership may be diluted, but can still secure a business-relevant "niche" license

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External Innovation: **Technology Transfer Organizations**

(not to be confused with "Technology Transfer Office" of a University)

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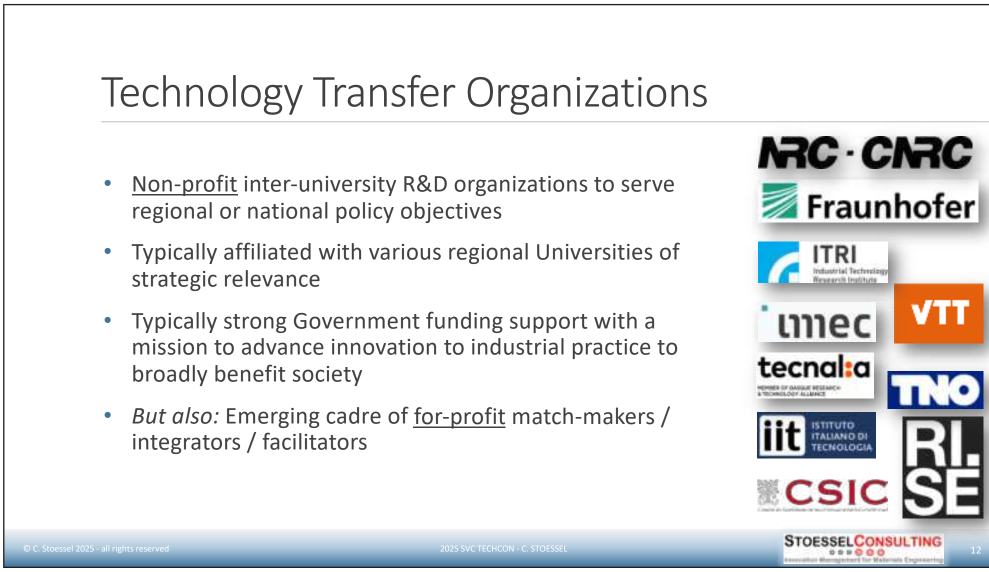
Technology Transfer Organizations
Non-profit inter-university R&D organizations to serve regional or national policy objectives
Typically affiliated with various regional Universities of strategic relevance
Typically strong Government funding support with a mission to advance innovation to industrial practice to broadly benefit society
But also: Emerging cadre of for-profit match-makers / integrators / facilitators
NRC · CNRC
Fraunhofer
ITRI
imec
VTT
tecnalia
TNO
iit ISTITUTO ITALIANO DI TECNOLOGIA
RI. SE
CSIC
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External Innovation: **Consortia**

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14

Consortia – Examples

https://www.nextflex.us/

NextFlex
(U.S. DOD-sponsored private / public R&D consortium, nation-wide)
- Focus: additive manufacturing / Flexible Hybrid Electronics
- 29 academic / non-profit members
- 62 industry members
- 22 U.S. Government members

https://www.aimphotonics.com/

AIM Photonics
(U.S. DOD-sponsored private / public R&D consortium, nation-wide)
- Focus: photonic circuits and electronics
- 29 academic / non-profit members
- 43 industry members
- 17 U.S. Government members

https://cqn-erc.arizona.edu/

CQN - Center for Quantum Networks
(U.S. NSF-sponsored private / public R&D consortium, nation-wide)
- Focus: "Building the Quantum Internet"
- 12 academic members

https://nfdi-matwerk.de/

NFDI-MatWerk
(German R&D consortium, nation-wide)
- Focus: Enable "Industry 4.0/5.0"-compatible materials property data structures
- 20 study projects, 17 use case demonstrations
- 15 academic / non-profit members

https://storaige.eu/

StorAIge
(ECSEL Joint Undertaking-funded R&D consortium, Euro-wide)
- Focus: advancing AI functionality at the edge for thin-film enabled electronic and sensor systems
- 15 academic / non-profit members
- 12 industry members
- 8 SMEs

https://www.anl.gov/lens?utm_source=web&utm_campaign=lens_consortium

LENS
(U.S. DOE-sponsored private / public R&D consortium)
- Focus: ".. demonstrate a new class of sodium-ion batteries (NIBs) …to surpass the specific energy and energy density of current graphite/lithium iron phosphate (LFP) batteries.."
- 6 national laboratories
- 8 universities
- N.a. industry members

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Consortia

+ Cost-efficient approach for ecosystem observation
+ Active participation heightens brand recognition, may influence policy
! Networking and opportunity discovery should be a key objective to participate, rather than generating / accessing / securing IP
! Often driven by national / regional policy priorities, requires conscious alignment for large multi-nationals
! Active participation requires top-level corporate buy-in to justify staff bandwidth beyond nominal membership dues

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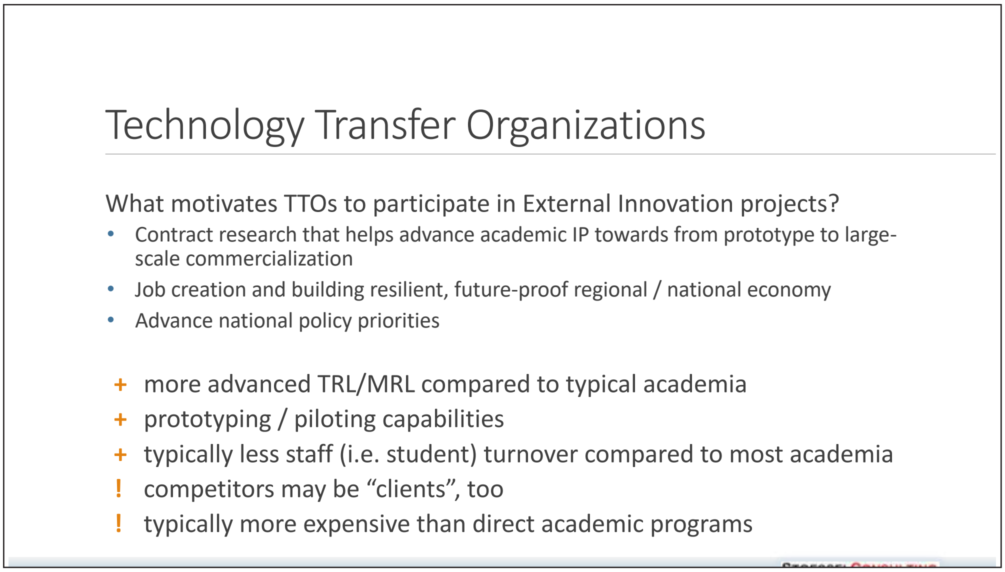
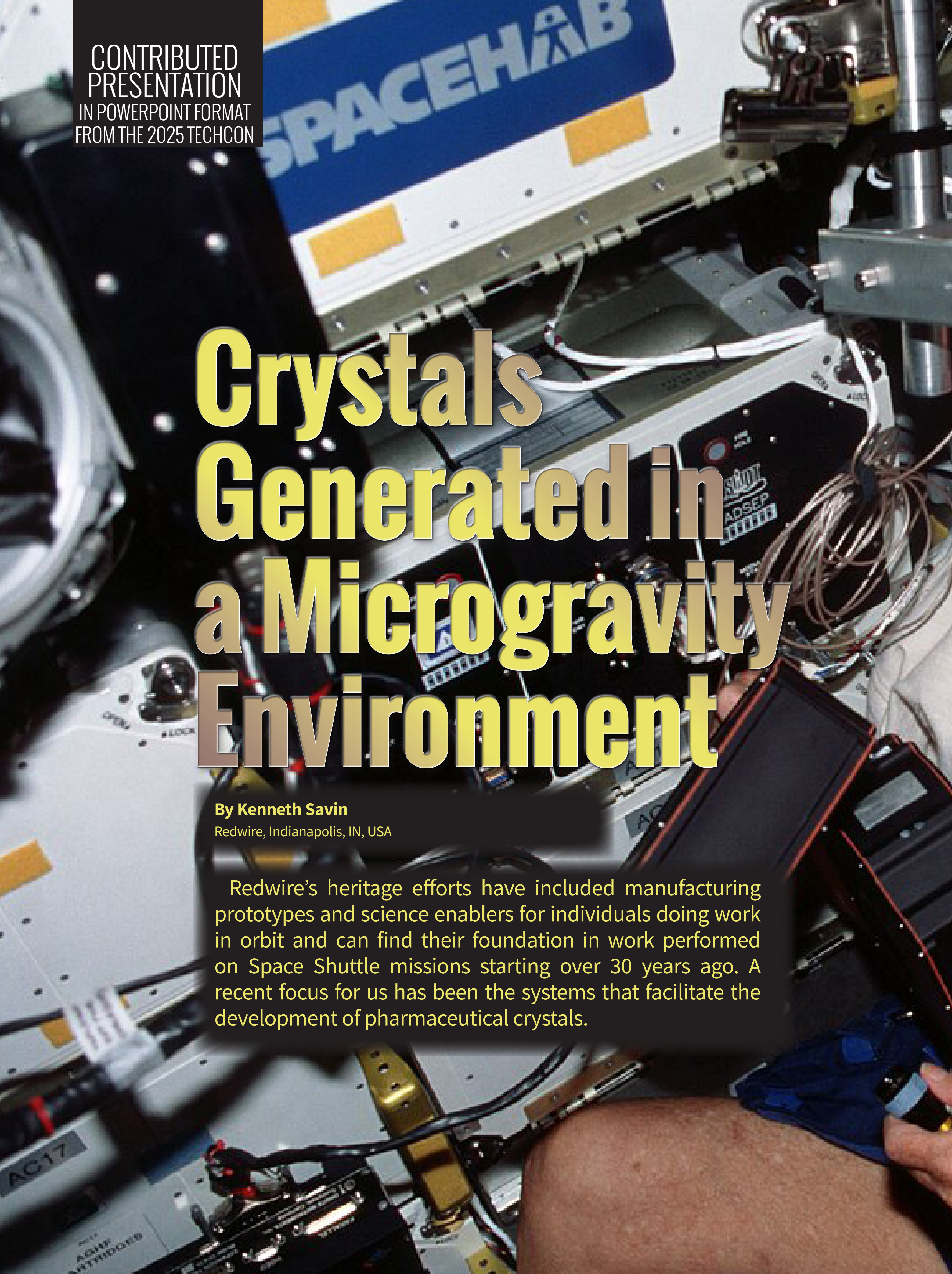


About the Author: Dr. Chris Stoessel

Dr. Chris Stoessel advises clients on innovation management in the thin films / materials science arena. After obtaining a Doctorate degree in Mechanical Engineering / Materials Science at RWTH Aachen university and completing post-doctoral studies at UCLA, he has led corporate R&D initiatives to commercialize thin film materials innovation for optical coatings, energy conversion, and flexible electronics. He has served the SVC with Board and Committee positions as well as President, and currently is the SVC Program Director.



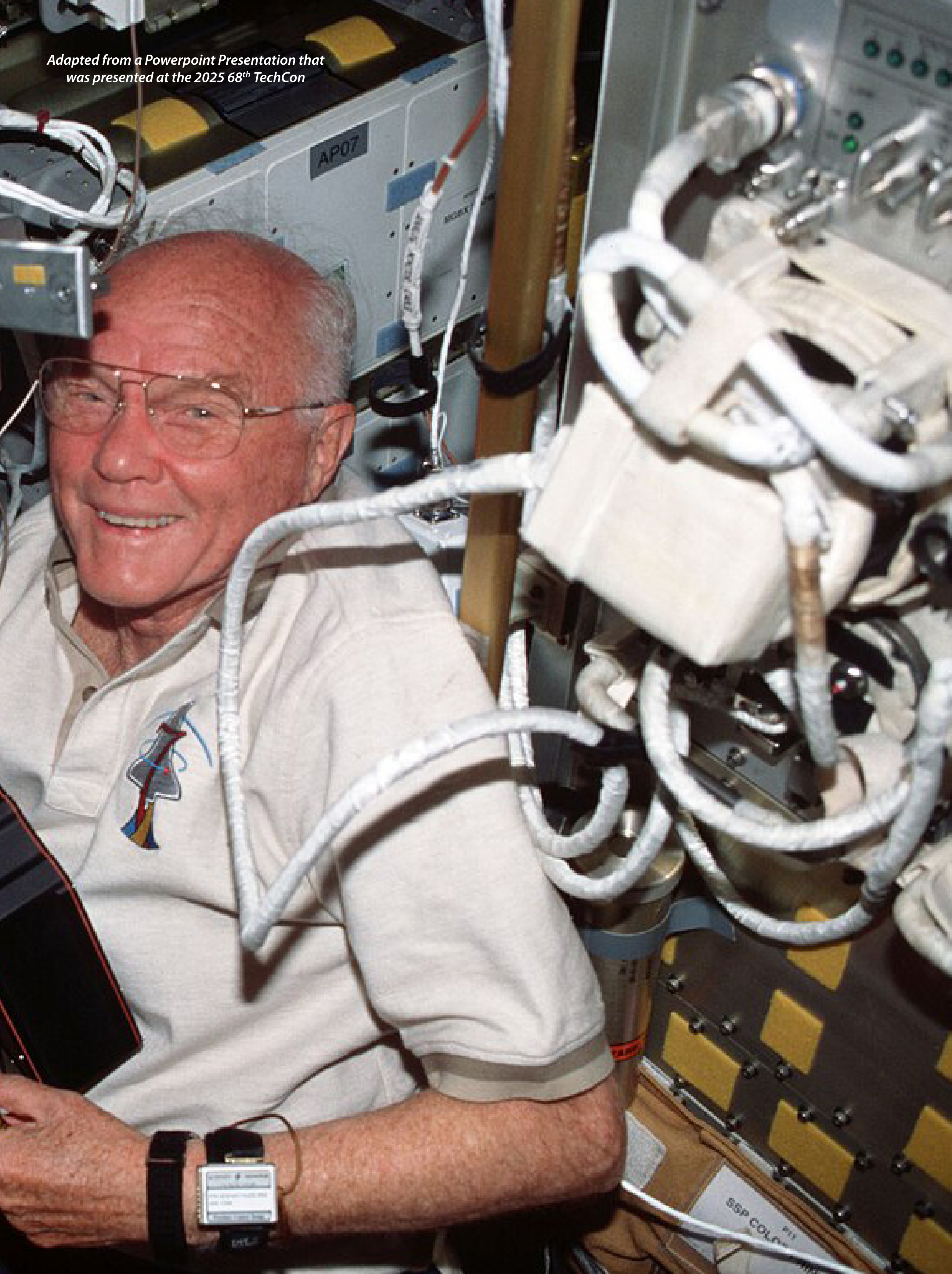
CONTRIBUTED PRESENTATION
IN POWERPOINT FORMAT
FROM THE 2025 TECHCON

Crystals Generated in a Microgravity Environment

By Kenneth Savin
Redwire, Indianapolis, IN, USA

Redwire's heritage efforts have included manufacturing prototypes and science enablers for individuals doing work in orbit and can find their foundation in work performed on Space Shuttle missions starting over 30 years ago. A recent focus for us has been the systems that facilitate the development of pharmaceutical crystals.

Adapted from a Powerpoint Presentation that was presented at the 2025 68th TechCon



In general, both small and large molecule drugs, are often best formulated as crystals. The crystalline state is more easily handled, isolated and is relatively stable but can suffer from polymorphism and size coefficients of variation that are too large. A potential solution to these problems was impressed upon us by the result found in the microgravity enabled crystal growing experiment of the monoclonal antibody, Pembrolizumab marketed by Merck as the product, Keytruda. Creating new forms and potentially improving the existing forms of drugs in microgravity with greater crystalline uniformity and less variation in size allows for new polymorphs could lead to faster development times, less waste in the process of making the drugs, and possibly lead to new modes of delivery. We will present results demonstrating the difference in crystals formed terrestrially vs those generated on the International Space Station Platform and describe the use of those crystals for future terrestrial production of pharmaceuticals.

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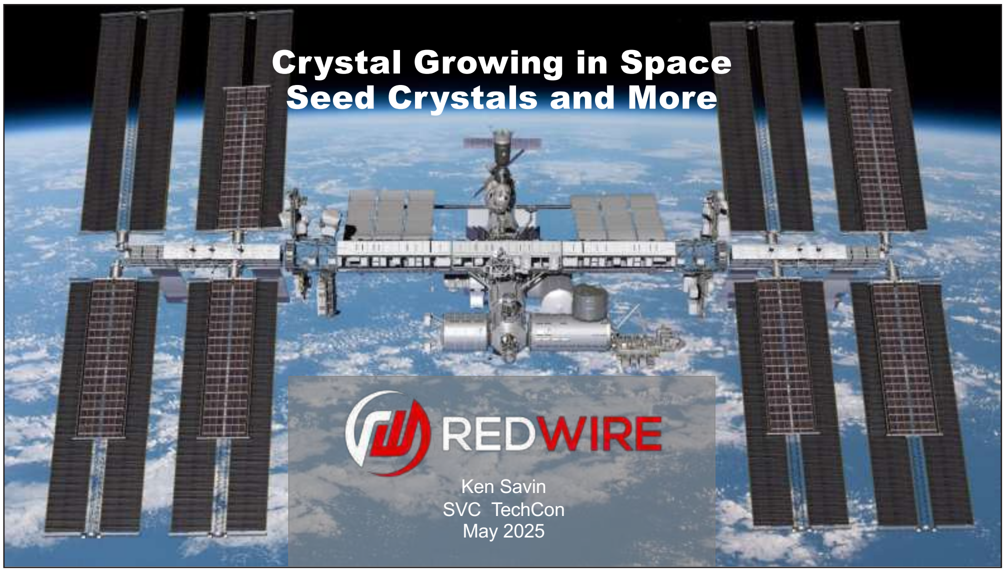
https://www.svc.org

DOI: https://doi.org/10.14332/svc25.proc.0002



Crystal Growing in Space
Seed Crystals and More
REDWIRE
Ken Savin
SVC TechCon
May 2025

Over 750 Employees in the U.S. and Europe
COLORADO (Littleton and Longmont)
• 102,000 sq. ft total in CO
• Clean Rooms
• RF & Antenna Systems
• Deployable and Retractable Space Structures
• Solar Arrays, Batteries, Thermal Products
• Space Systems Engineering Services
• Camera Systems
• Flight Avionics
• Data Recovery Systems
• In-House Testing Capabilities
• Digital Engineering
• Modeling & Simulation
CALIFORNIA
• Collaborating with JPL
• 80,000 sq. ft. office & manufacturing area
• 3-Story High Bay
• Deployables IA&T
• ISS & PPE Large ROSA IA&T
• High Power Solar Array R&D
Cleared Personnel
NEW MEXICO
• 14,000 sq. ft facility
• Operate and Maintain AFRL testing facility
• Design and Analysis Services
• Structural & Thermal Testing
• Launch Accommodation Hardware
• Thermal Control Hardware
• Deployable Technologies
FLORIDA
• Redwire Corporate Headquarters in Jacksonville
• 37,247 sq. ft facility
• Clean rooms
• Advanced In-Space Manufacturing Technology
• Large In-Space Manufacturing Project – OSAM-2/Archinaut One
• ISS Payload Development
INDIANA
• 22,000 sq. ft facility
• In-space Research
• ISS Payload Development
• Advanced Space Manufacturing Technology
• Biotechnology, bioprinting, on-orbit manufacturing
• ISS/CASIS
MASSACHUSETTS
• 18,000 sq. ft. facility
• Clean Rooms
• Sun Sensors & Star Trackers
• Integrated Camera Systems
• ADACS Systems
• Satellite Systems
BELGIUM
• QinetiQ Space NV
• 19,000 sq. ft. facility
• Hi-Ref SmallSats, Berthing & Docking Mechanisms, Avionics
DC/VA/MD
• Engaging NASA GSFC in MD
• 8,000 sq. ft. facility under construction (2/3 SCIF)
• SCIF, Classified Systems Access
• Digital Engineering Lab
LUXEMBOURG
• Redwire Engineering & Sales Center in Europe
• 2,500 sq. ft facility
• Robotic Systems
• Avionics
Merritt Island, FL (near KSC)
• 2,377 sq. ft. facility
• Strong partnership with NASA KSC
• Prelaunch processing laboratory and support
• Commercial partnership with Tupperware Brands
• In-space plant biology research
• ISS and lunar Payload Development
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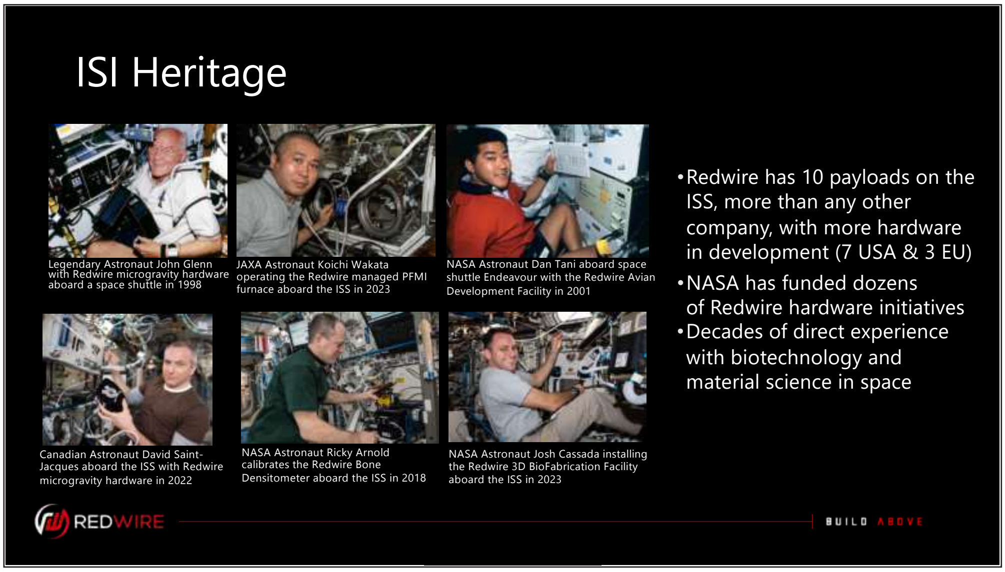

ISI Heritage
Legendary Astronaut John Glenn with Redwire microgravity hardware aboard a space shuttle in 1998
JAXA Astronaut Koichi Wakata operating the Redwire managed PFMI furnace aboard the ISS in 2023
NASA Astronaut Dan Tani aboard space shuttle Endeavour with the Redwire Avian Development Facility in 2001
Canadian Astronaut David Saint-Jacques aboard the ISS with Redwire microgravity hardware in 2022
NASA Astronaut Ricky Arnold calibrates the Redwire Bone Densitometer aboard the ISS in 2018
NASA Astronaut Josh Cassada installing the Redwire 3D BioFabrication Facility aboard the ISS in 2023
• Redwire has 10 payloads on the ISS, more than any other company, with more hardware in development (7 USA & 3 EU)
• NASA has funded dozens of Redwire hardware initiatives
• Decades of direct experience with biotechnology and material science in space
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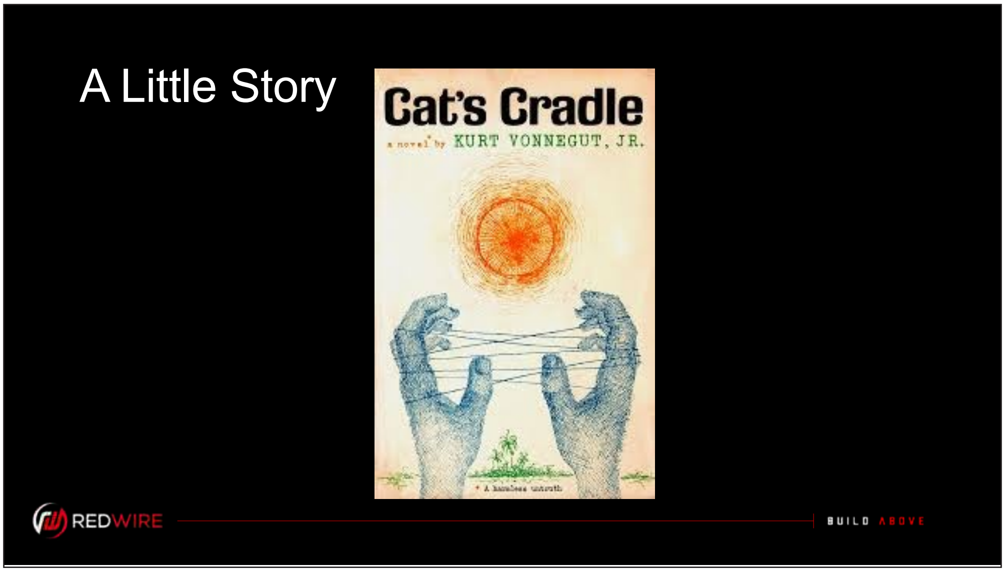

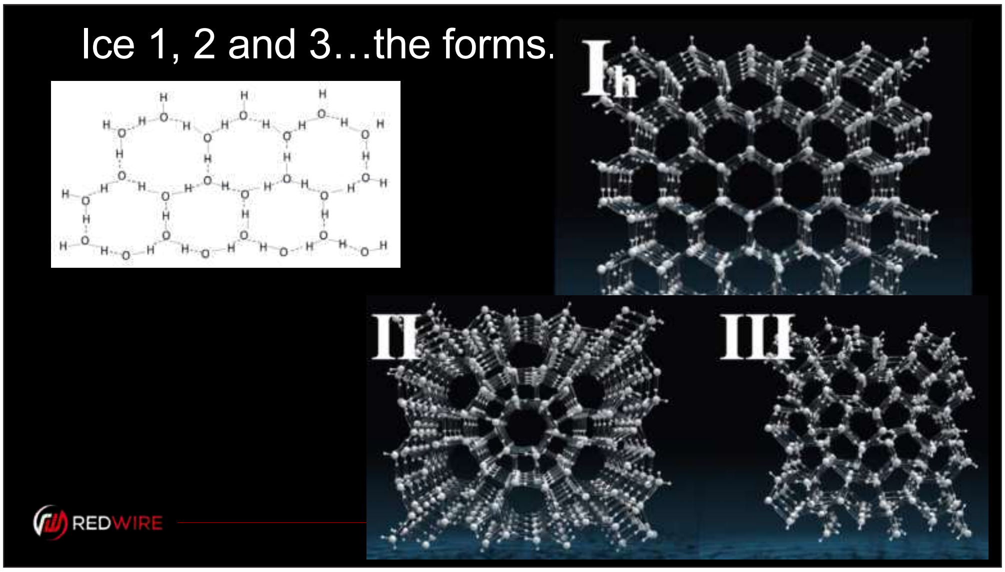

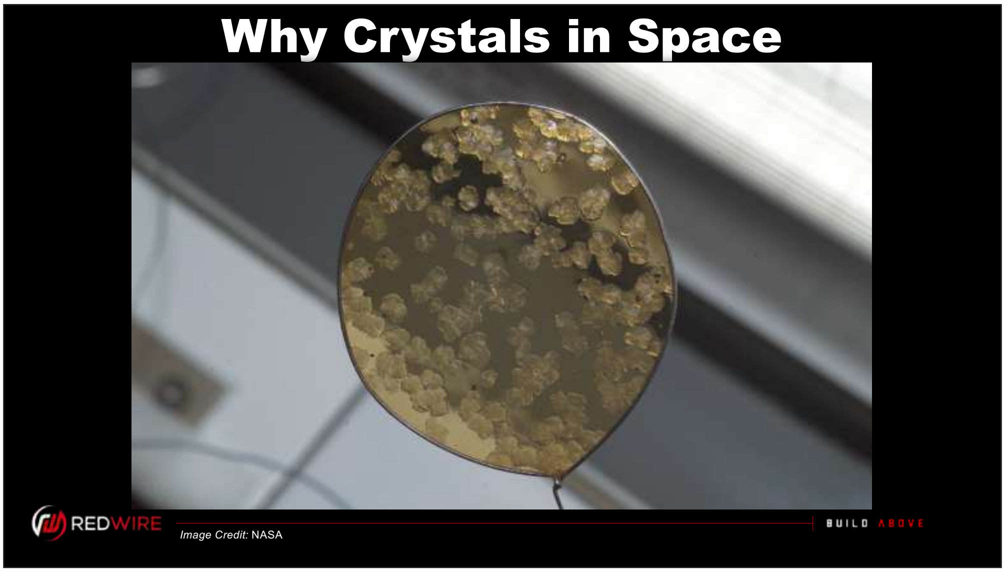


Really...Why Crystals in Space?
• Predictable, simple natural event
• Lots of history
• High Value Products
• Good value to mass ratio (Seed crystals especially!!!)
• Intellectual Property
REDWIRE
Image Credit: NASA
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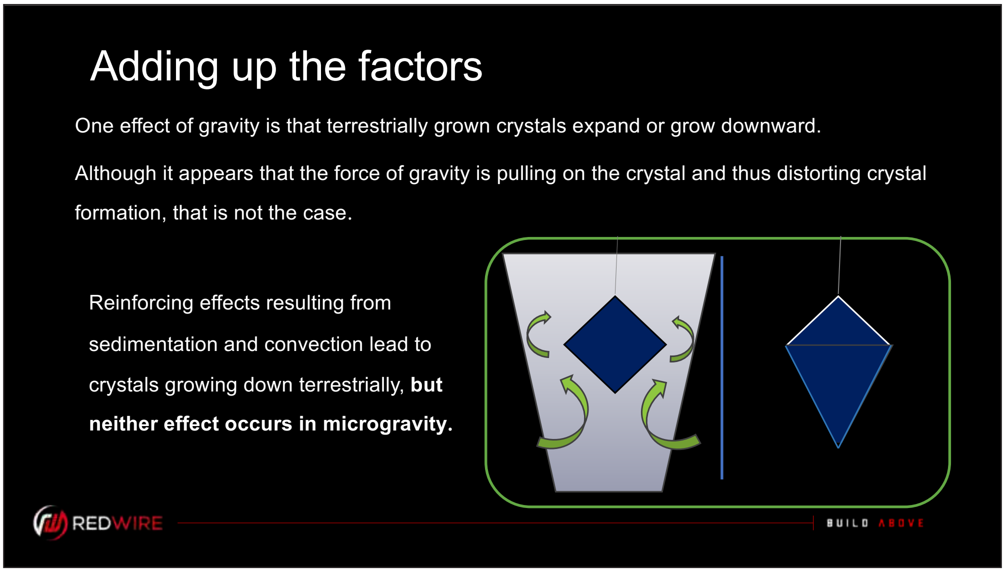
Adding up the factors
One effect of gravity is that terrestrially grown crystals expand or grow downward.
Although it appears that the force of gravity is pulling on the crystal and thus distorting crystal formation, that is not the case.
Reinforcing effects resulting from sedimentation and convection lead to crystals growing down terrestrially, but neither effect occurs in microgravity.
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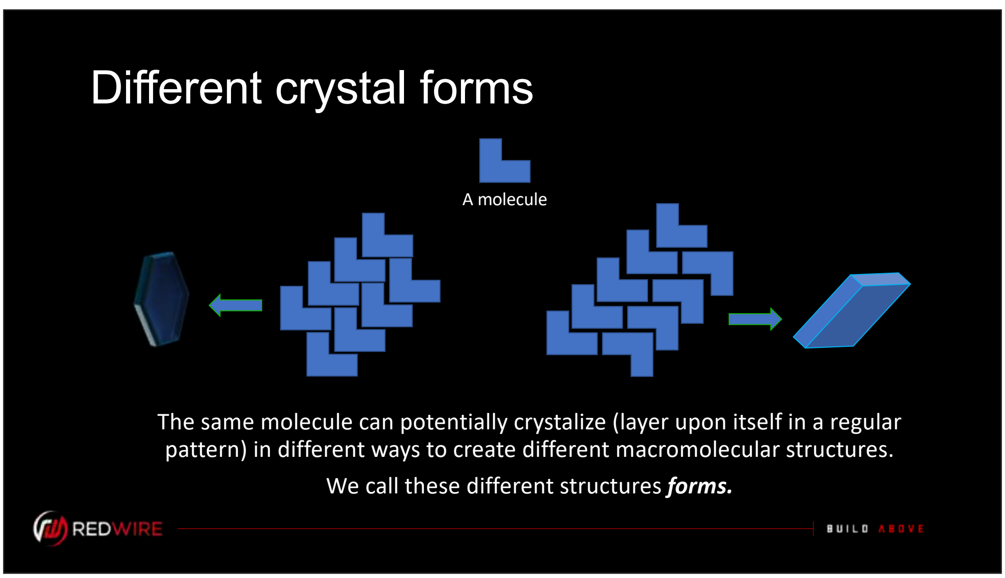
Different crystal forms
A molecule
The same molecule can potentially crystalize (layer upon itself in a regular pattern) in different ways to create different macromolecular structures.
We call these different structures forms.
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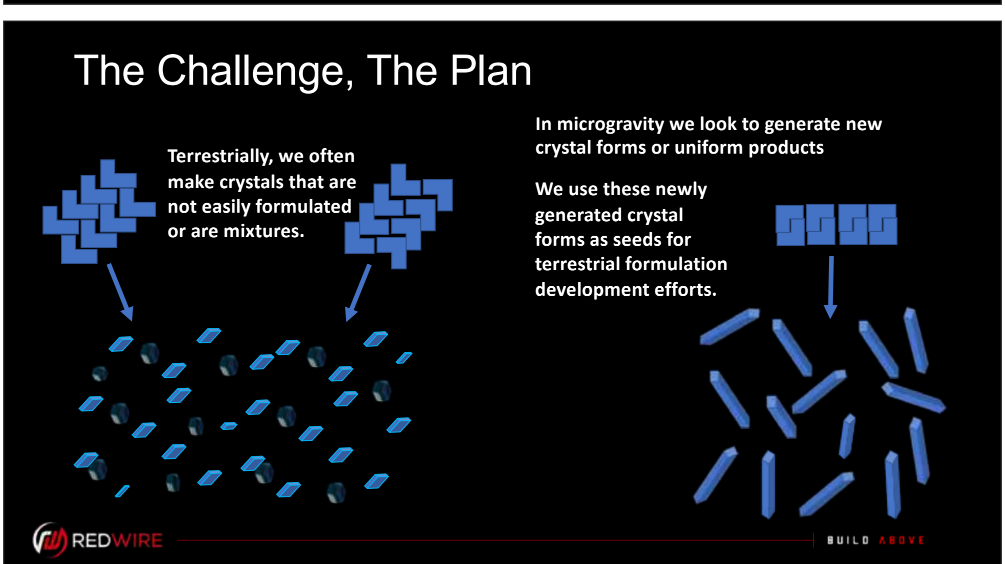
The Challenge, The Plan
Terrestrially, we often make crystals that are not easily formulated or are mixtures.
In microgravity we look to generate new crystal forms or uniform products
We use these newly generated crystal forms as seeds for terrestrial formulation development efforts.
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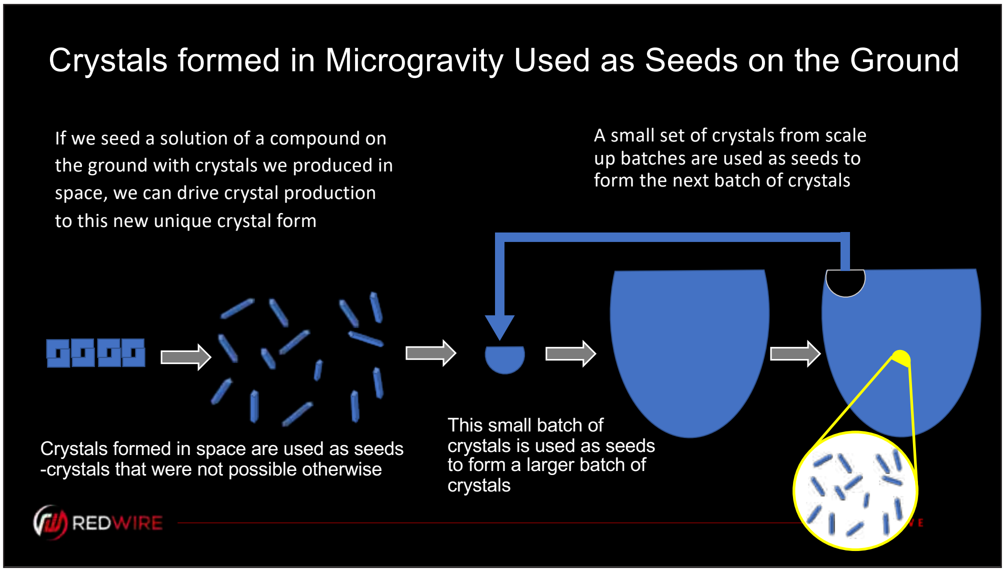
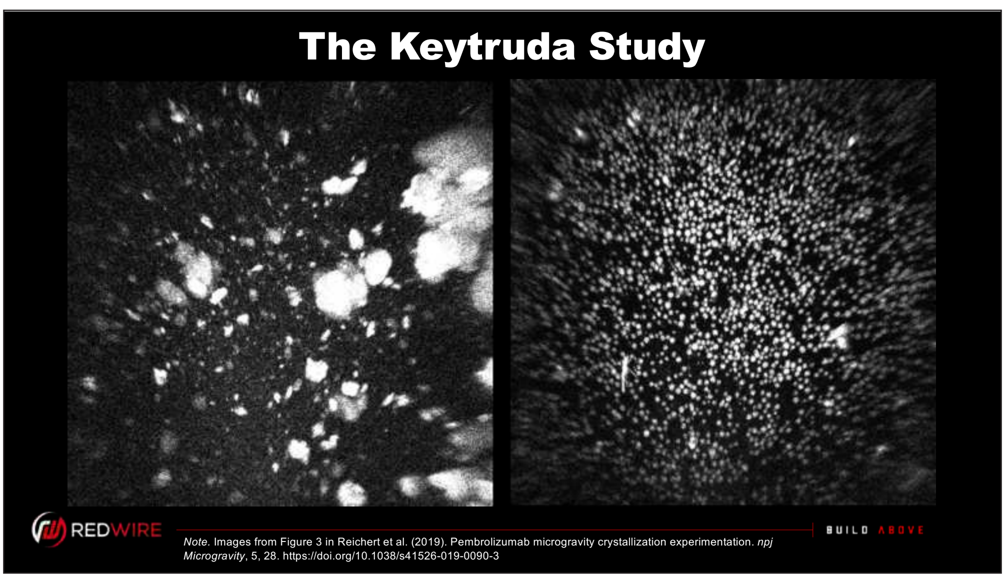

Crystals formed in Microgravity Used as Seeds on the Ground
If we seed a solution of a compound on the ground with crystals we produced in space, we can drive crystal production to this new unique crystal form
A small set of crystals from scale up batches are used as seeds to form the next batch of crystals
Crystals formed in space are used as seeds -crystals that were not possible otherwise
This small batch of crystals is used as seeds to form a larger batch of crystals
REDWIRE


The Keytruda Study
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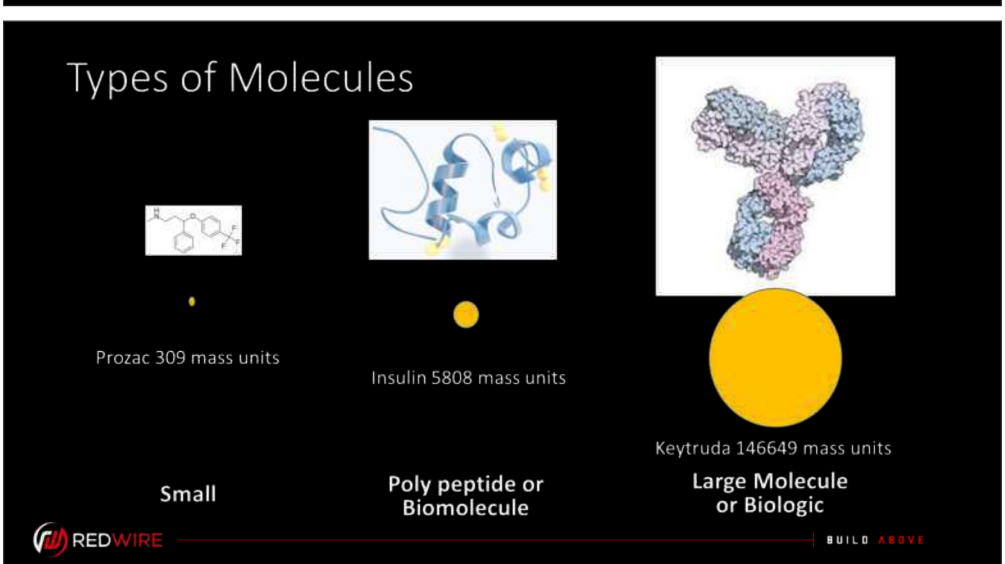
Note. Images from Figure 3 in Reichert et al. (2019). Pembrolizumab microgravity crystallization experimentation. npj Microgravity, 5, 28. https://doi.org/10.1038/s41526-019-0090-3


Types of Molecules
Prozac 309 mass units
Insulin 5808 mass units
Keytruda 146649 mass units
Small
Poly peptide or Biomolecule
Large Molecule or Biologic
REDWIRE
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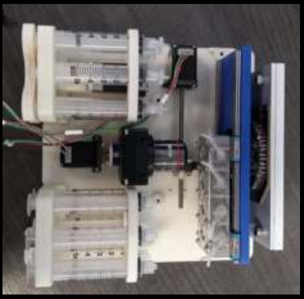
PIL-BOX Suite of Hardware

PIL-BOX Dynamic Microscopy Cassette (DMC)

- The PIL-BOX DMC is the first large molecule crystallization system to provide real-time observation of crystal growth crystallization processes through the manipulation, combination, and mixing of fluids for reformulating existing products or developing new products
- Real-time observations of crystal growth & morphology giving researchers data that they can compare with from ground control experiments
- Up to four unique experiments can be performed in each PIL-BOX DMC



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15

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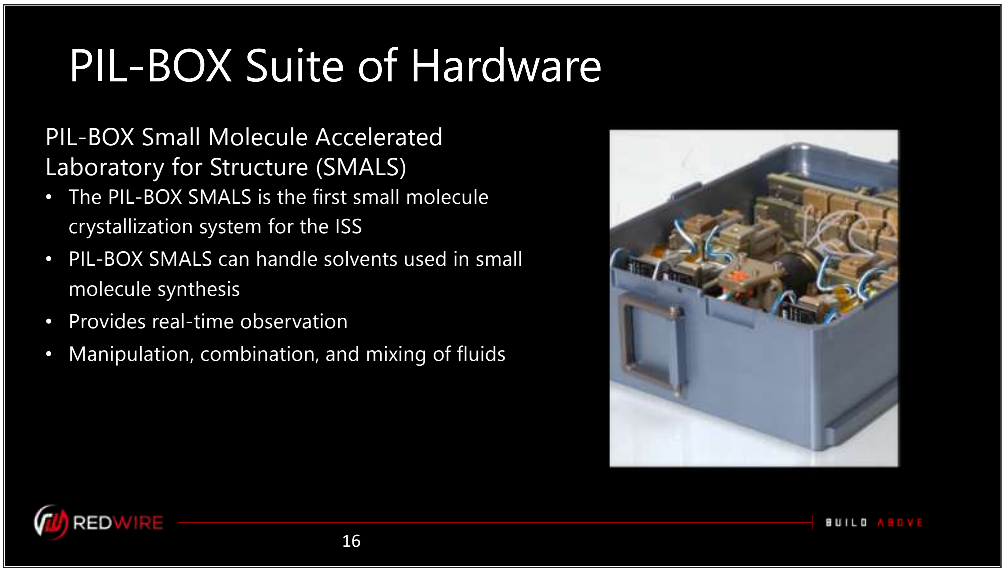
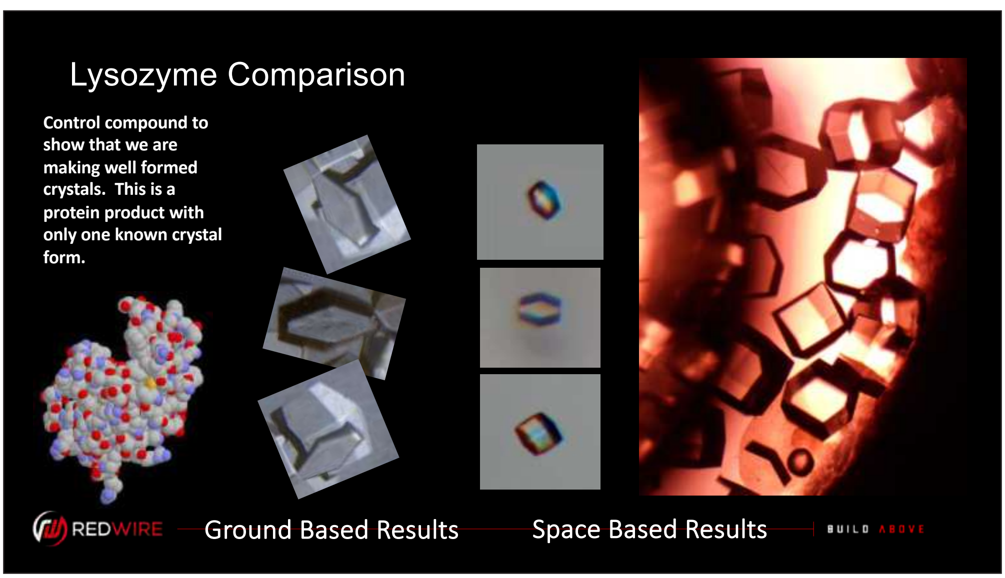
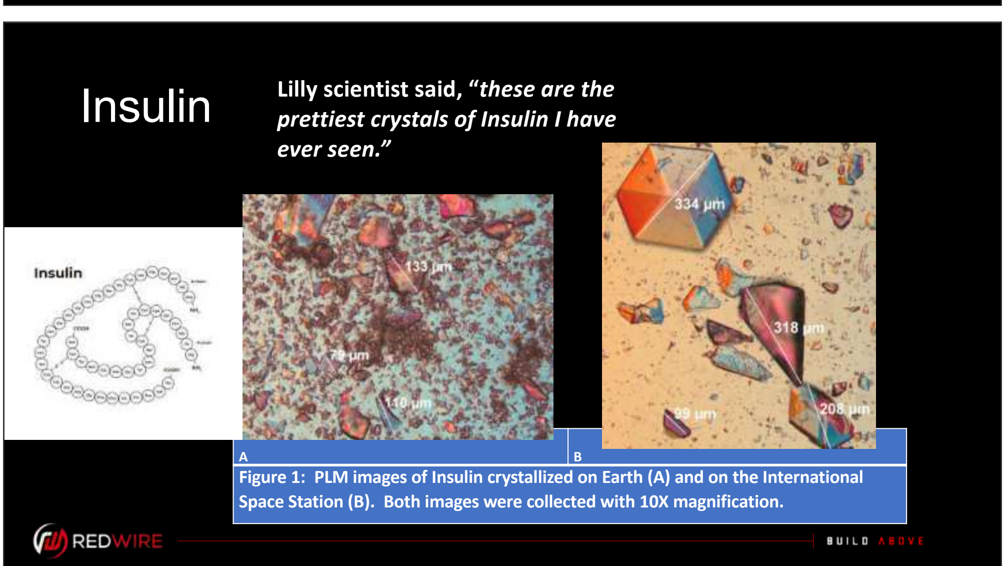
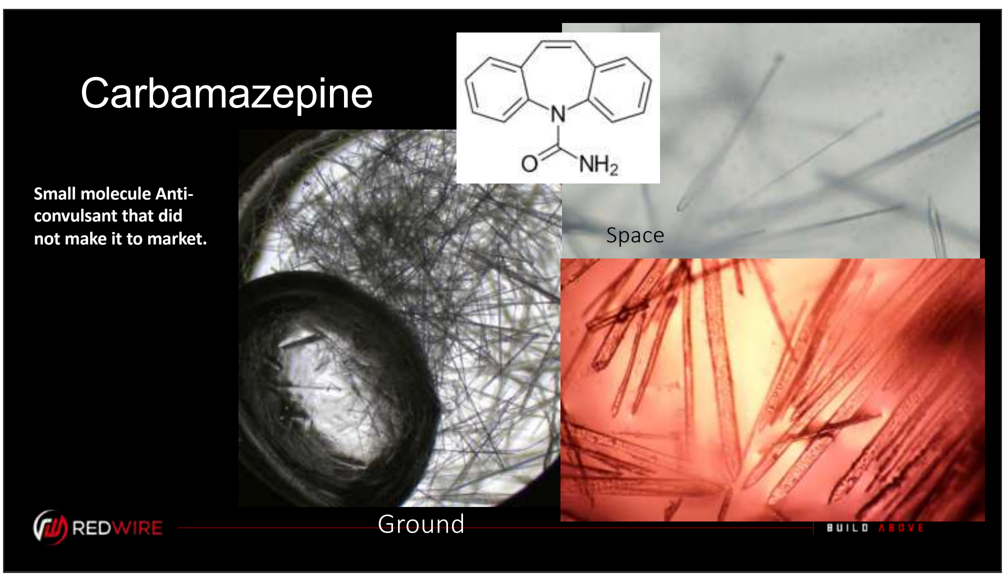
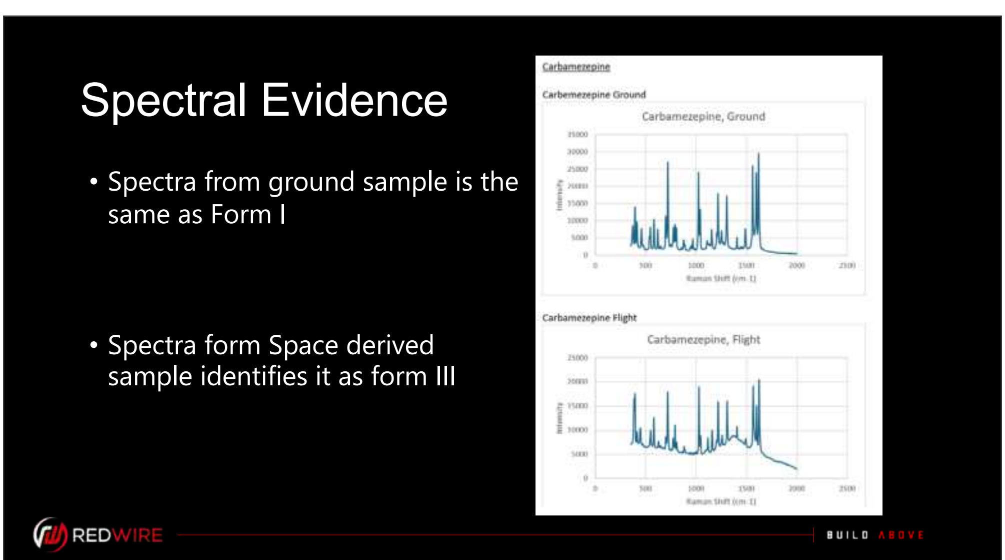

PIL-BOX Suite of Hardware
PIL-BOX Small Molecule Accelerated Laboratory for Structure (SMALS)
• The PIL-BOX SMALS is the first small molecule crystallization system for the ISS
• PIL-BOX SMALS can handle solvents used in small molecule synthesis
• Provides real-time observation
• Manipulation, combination, and mixing of fluids
REDWIRE
BUILD ABOVE
16

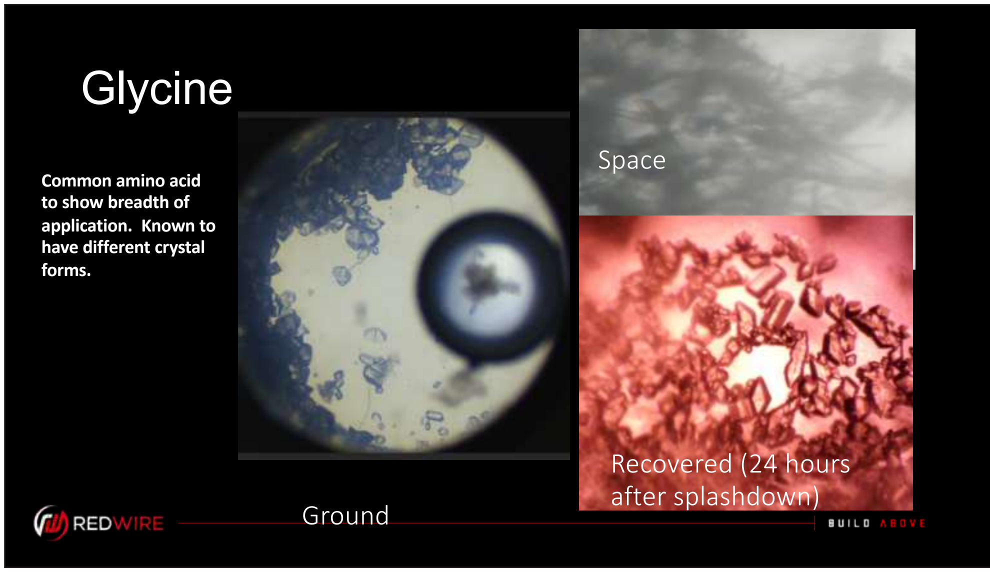

Lysozyme Comparison
Control compound to show that we are making well formed crystals. This is a protein product with only one known crystal form.
REDWIRE
Ground Based Results
Space Based Results
BUILD ABOVE


Insulin
Lilly scientist said, *"these are the prettiest crystals of Insulin I have ever seen."*
Insulin
133 µm
79 µm
110 µm
334 µm
318 µm
99 µm
208 µm
A
B
Figure 1: PLM images of Insulin crystallized on Earth (A) and on the International Space Station (B). Both images were collected with 10X magnification.
REDWIRE
BUILD ABOVE


Microgravity Grown Insulin Crystals
REDWIRE
BUILD ABOVE


Carbamazepine
Small molecule Anti-convulsant that did not make it to market.
N
O
NH2
Space
Ground
REDWIRE
BUILD ABOVE


Spectral Evidence
• Spectra from ground sample is the same as Form I
• Spectra form Space derived sample identifies it as form III
Carbamezepine
Carbemezepine Ground
Carbamezepine, Ground
Carbamezepine Flight
Carbamezepine, Flight
REDWIRE
BUILD ABOVE


Glycine
Common amino acid to show breadth of application. Known to have different crystal forms.
Space
Recovered (24 hours after splashdown)
Ground
REDWIRE
BUILD ABOVE


Glycine Transformation?
Space
Ground analysis one week after splashdown
REDWIRE

So, Mission Accomplished?

1) Demonstrate that the hardware can grow crystals in orbit.
2) Show that the crystals made in space are interesting/***special***
3) We can return the same crystals we see in space and if not, why?
4) Complete analytical review of the crystals and full experimental details of how the system delivered the results we are seeing.
5) Demonstrate that the crystals produced in space can be utilized to develop crystals terrestrially.
6) Build a business out of this effort and get investment.

REDWIRE BUILD ABOVE

The Team

- Professor Anne Wilson – CO-PI – Butler University
- Lilli Miller – Student Intern
- Stephen Tuma – Lead Engineer – Redwire
- Zachary Fisher – Engineer - Redwire
- Brian Gettler – Engineer - Redwire

REDWIRE BUILD ABOVE

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REDWIRE BUILD ABOVE 26


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SCAN ME

CONTRIBUTED ORIGINAL ARTICLE

Adapted from a manuscript that was presented at the 2025 68th SVC TechCon

On Metal Ion Escape in High-power Impulse Magnetron Sputtering

By Jon Tomas Gudmundsson[1,2], Kateryna Barynova[1], Nils Brenning[2,3], Joel Fischer[3], Daniel Lundin[3], Michael A. Raadu[2] and Martin Rudolph[4]

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High power impulse magnetron sputtering (HiPIMS) discharges with various elemental targets have been studied both experimentally and through modeling. In HiPIMS operation there is an inescapable trade-off between high deposition rate and high ionized flux fraction. A key parameter in determining the relation between deposition rate and the ionized flux fraction in a HiPIMS discharge is the back-attraction probability of the sputtered species. Based on modeling work we demonstrate that the back-attraction probability of the sputtered species decreases and the ion escape probability increases with increasing self-sputter yield of the target material. Similarly we find that the fraction of argon ions in the total ion current at the target surface decreases from roughly 100 %, for very low sputter yield, to almost zero with increasing self-sputter yield.

INTRODUCTION

Magnetron sputtering is a highly successful and widely used process for thin-film deposition. Magnetron sputtering is based on a low-pressure plasma discharge in which ions of a working gas, typically argon, are created and accelerated toward a solid target containing the film forming material [1]. A plasma discharge is created in the cathode target vicinity by a static magnetic field that traps the electrons. This plasma is easily observable as it appears as a brightly glowing torus adjacent to the cathode target surface. This torus is often referred to as the ionization region (IR). When operated as a dc magnetron sputtering (dcMS) discharge, the ions of the working gas bombard the target and the sputtered species remain mostly as neutral atoms. By applying high voltage pulses of low duty cycle to the cathode target, the discharge current density in the pulse can become very high. Consequently, the electron density is high and a significant fraction of the sputtered atoms coming off the target become ionized as they pass through this dense plasma and ions of both the working gas and ions of the target material bombard the target [1,2]. This also means that ions of the film-forming material are available for deposition onto the substrate, which can be highly beneficial for the resulting film properties. This variant of magnetron sputtering is referred to as high power impulse magnetron sputtering (HiPIMS) [2–4]. As the species of the film-forming material are ionized, the energy and direction of the ions bombarding the substrate can be controlled by biasing the substrate [5]. Control of the ion bombarding energy means that the need for external substrate heating can be significantly reduced, or even eliminated [6–8].

HiPIMS deposition has been demonstrated to deliver thin metal films with higher mass density and overall improved properties compared to dcMS deposited films [9]. The improved thin film properties are attributed to the increased ionization of the sputtered species in the HiPIMS process. In HiPIMS operation with a metal target the ionized flux fraction can be high, typically in the range 10 – 80 %, and it increases with increased discharge current density and decreased working gas pressure, as has been demonstrated experimentally for a number of target materials [10–14]. However, as also demonstrated in the study by Samuelsson *et al.* [9] the improved film properties are accompanied with a reduced deposition rate. The main reason for the reduced deposition rate is the return of the sputtered species back to the target after they have been ionized [15]. Consequently, in HiPIMS operation there is an inescapable trade-off between high deposition rate and high ionized flux fraction, known as the HiPIMS compromise [16]. A key parameter in the HiPIMS compromise is the back-attraction probability of the sputtered species [16,17]. Earlier we have explored how the back-attraction probability depends on the magnetic field strength [12,17,18], and the pulse length [19]. In recent studies we have observed that the sputter yield of the target material has a significant influence on the discharge properties, including the working gas rarefaction [20], recycling mechanism [21], and the back-attraction probability of the sputtered species [22]. Here, we discuss how the back-attraction probability or the ion-escape probability of the sputtered species and de-

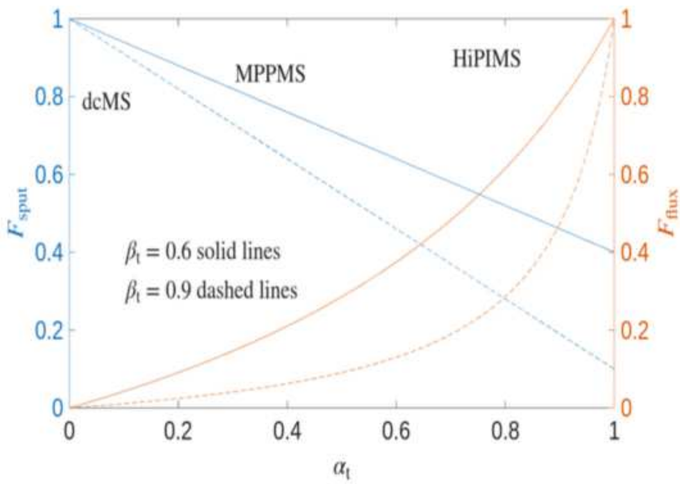

Fig. 1 — Illustration of the HiPIMS compromise: the necessary choice between a high degree of ionization and a high deposition rate. The blue curve (left axis) shows the flux available for deposition from Eq. (2). The red curve (right axis) shows the ionization fraction in that flux from Eq. (3). The back-attraction probability is $ß_t$ = 0.6 (solid lines) and $ß_t$ = 0.9 (dashed lines).

rived properties depend on the target material and in particular the self-sputter yield.

THE FLUX PARAMETERS

In thin film deposition the parameters of primary interest are the flux parameters; the deposition rate and the fraction of ions in the flux of the film forming material. The connection between the external control parameters (working gas pressure, pulse power density, the magnetic field strength, and the pulse configuration), and the aforementioned two flux parameters is typically studied using the two internal discharge parameters; the probability of ionization of the target atoms α_t and the probability of back-attraction of the target ions $ß_t$ [12,17,23]. Knowledge of these two internal discharge parameters provides a quantitative insight into the quality of a deposition process and its efficiency. The sputter rate-normalized deposition rate can be written in terms of the internal discharge parameters [23]

$$F_{\mathrm{sput}} = (1-\alpha_t) + \left(\frac{\xi_{\mathrm{ti}}}{\xi_{\mathrm{tn}}}\right)\alpha_t(1-\alpha_t) \tag{1}$$

where ξ_{ti} is the transport parameter for ions and ξ_{tn} is the transport parameter for neutrals of the sputtered species [15,24]. Eq. (1) can be approximated to become

$$F_{\mathrm{sput}} = 1-\alpha_t\beta_t = \frac{\Gamma^{\mathrm{DR}}}{\Gamma_0}. \tag{2}$$

for the special case when $\xi_{ti} = \xi_{tn}$ [12,25]. This is the ratio of the flux of sputtered species (ions and neutrals) out of the ionization region (IR) toward the diffusion region (DR) Γ^{DR} and the total flux of atoms sputtered from the target Γ_0 (atoms/s). This equation states that the sputter rate-normalized deposition rate is reduced as the ionization of the sputtered material and/or the probability that the ions return to the target increase [16]. As can be seen by looking at Eq. (2), the fraction of the sputtered species reaching the substrate F_{sput} and thus the deposition rate can be increased by decreasing the product $\alpha_t ß_t$. To increase the deposition rate two different parameters can therefore be influenced: decrease the probability of ionization of the sputtered atoms α_t, and/or decrease the ion back-attraction probability $ß_t$. Similarly, a relationship between the ionized flux fraction F_{flux} and the parameters α_t and $ß_t$ has been derived from the pathway model [26, 27]

$$F_{\mathrm{flux}} = \frac{\Gamma_{\mathrm{ions}}}{\Gamma_{\mathrm{dep}}} = \frac{\Gamma_0\alpha_t(1-\beta_t)}{\Gamma_0(1-\alpha_t\beta_t)} = \frac{\alpha_t(1-\beta_t)}{1-\alpha_t\beta_t} \tag{3}$$

where no additional ionization of the sputtered material in the diffusion region is assumed, and again we assume $\xi_{ti} = \xi_{tn}$.

The sputter rate-normalized deposition rate and the ionized flux fraction are plotted versus the ionization probability α_t in Fig. 1 for $ß_t$ = 0.6 and 0.9. The ionization probability is generally set by the peak discharge current density. Operation with $\alpha_t < 0.1$ can be considered to lie in the dcMS regime. The HiPIMS regime is reached for $\alpha_t > 0.5$. In between is the modulated power pulsed magnetron sputtering (MPPMS) discharge regime, that typically operates with longer macropulses and lower current density than HiPIMS. For a fixed back-attraction probability the sputter rate-normalized deposition rate decreases linearly with increasing ionization probability and the slope is steeper if the back-attraction probability is larger. Fig. 1 also shows the ionized flux fraction versus the ionization probability. We see that the ionized flux fraction increases with increasing ionization probability, and it increases faster for lower back-attraction probability. For low ionization probability, the ionized flux fraction is low, as observed in dc operation. In the HiPIMS regime the ionization probability is high and the ionized flux fraction can be high and it is higher for lower back-attraction probabili-

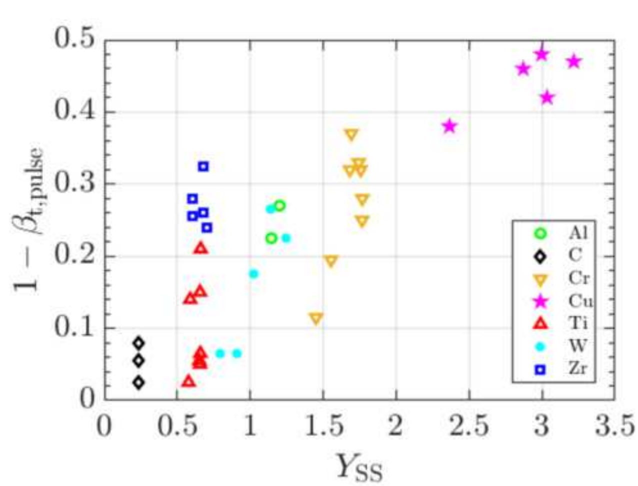

Fig. 2 — The target ion escape probability as a function of self-sputter yield. The data points are taken from modeled HiPIMS discharges using a graphite [31], a zirconium [32], a titanium [19,23], a tungsten [33], an aluminum [34], a chromium [35], and a copper [36] target.

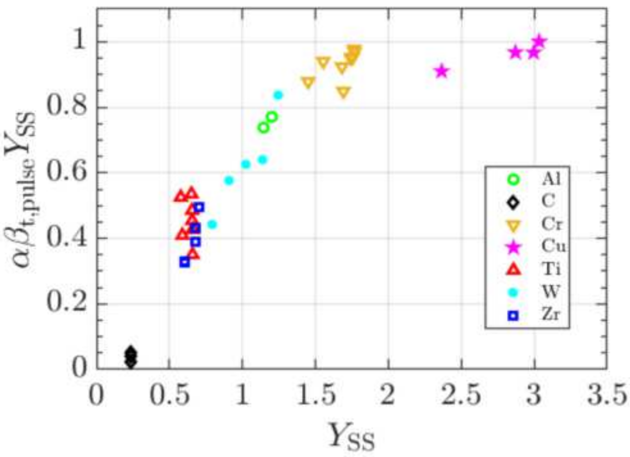

Fig. 3 — The product $\alpha_t \beta_t Y_{SS}$ versus the self-sputter yield. The data points are taken from modeled HiPIMS discharges using a graphite [31], a zirconium [32], a titanium [19,23], a tungsten [33], an aluminum [34], a chromium [35], and a copper [36] target.

ty. It is therefore always beneficial to have low back-attraction probability in HiPIMS operation.

THE IONIZATION REGION MODEL

The ionization region model (IRM) is a volume-averaged plasma chemistry model of a HiPIMS discharge that provides the temporal variation of the various species densities and the electron energy within the IR. It is a semi-empirical model that requires experimentally determined discharge voltage and current waveforms, the working gas pressure, the target and its dimensions, and the dimensions of the ionization region as input. The model provides insights into the temporal evolution of the species densities and the discharge current composition. It also provides information on the voltage drop V_{IR} across the IR, the ionization probability α_t, as well as the back-attraction probability β_t of the sputtered species [28]. The IRM only covers the target and the ionization region, which is defined as an annular cylinder of width $w_{RT} = r_2 - r_1$ positioned above the racetrack, and a length $L = z_2 - z_1$, extending from z_1 to z_2 axially away from the target surface. The details of the IRM, including the reaction rates for the various surface and volume processes that are taken into account, are summarized by Huo *et al.* [28]. More recent modifications concerning the treatment of the afterglow [19] and updated reaction rates [29] have been made, as well as a modification to the term that describes the kick-out by the sputtered species and contributes to working gas rarefaction as discussed by Barynova *et al.* [20]. The IRM is based on adjusting three fitting parameters: (i) the ion back-attraction probability for the metal ions $\beta_{t,pulse}$ and gas ions $\beta_{g,pulse}$, (ii) the potential drop across the IR, V_{IR}, and (iii) the electron recapture probability r. The last one is set $r = 0.7$ based on the work by Buyle *et al.* [30]. We can lock the model, and confine the two remaining fitting parameters, by using the

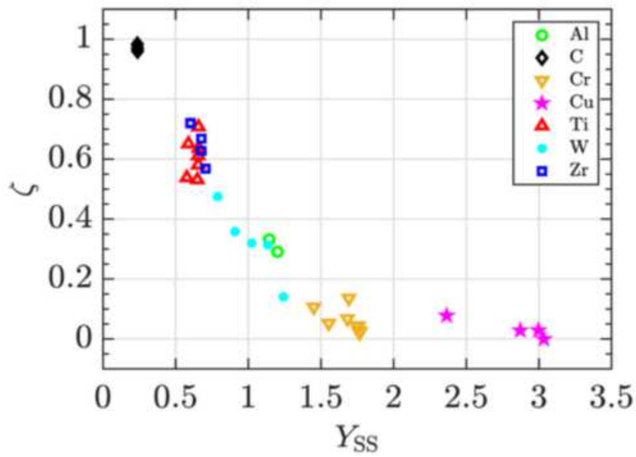

Fig. 4 — The fraction of Ar^+ ions in the total ion current bombarding the target ζ versus the self-sputter yield. The data points are taken from modeled HiPIMS discharges using a graphite [31], a zirconium [32], a titanium [19,23], a tungsten [33], an aluminum [34], a chromium [35], and a copper [36] target.

experimentally measured discharge current waveform and the measured ionized flux fraction as discussed by Butler *et al.* [27]. This approach is applied to most of the discharges modeled in this work. The IRM has been applied to study HiPIMS discharges with varying cathode targets. These discharges encompass seven different target materials, graphite [31], zirconium [32], titanium [11,16,19,23], tungsten [33], aluminum [34], chromium [35], and copper [13,36]. The discharges were operated using argon as a working gas with typical working gas pressures between 0.3 Pa and 2.7 Pa. Discharge current densities varied between 0.2 A/cm^2 and 2.8 A/cm^2 normalized to the target surface area. Note that for this work all the discharge parameters were re-calculated and analyzed using the most up to date version of the IRM [20,22].

THE ION ESCAPE PROBABILITY

As mentioned above we have modeled a number of HiPIMS discharges with varying target materials [20,22]. These studies indicate that the target material, and in particular the sputter yield, have significant impact on the discharge properties. Fig. 2 shows the target ion escape probability versus the self-sputter yield derived from these studies. We see that the target ion escape probability increases with increased self-sputter yield, and for copper the ion escape probability approaches roughly 50 %. This indicates that up to half of the copper ions created escape the ionization region toward the diffusion region, while for other target materials this fraction is much smaller, in the range 24 – 34 % for zirconium, and below 10 % for carbon ions. Note that for each of the target materials, the discharge current density, working gas pressure, discharge voltage, and pulse length may vary, which explains the spread in back-attraction probability and self-sputter yield for each target element.

Furthermore, in this most recent model study of HiPIMS discharges with various target materials we observed that the steady state electron temperature is inversely correlated to the sputter yield of the target material [22]. This is due to the atomic composition in the ionization region which shifts from being argon-dominated for low sputter yield targets to metal-rich for high sputter yield targets. The metal ionization rate coefficients are larger than the argon ionization rate coefficient for argon at lower electron temperatures. Therefore the electron heating is balanced by cooling at a much lower electron temperature. The electron temperature is therefore smaller in metal-rich plasma discharges compared to argon-dominated discharges. As a consequence the mean free path until ionization for sputtered metal atoms is on average further away from the cathode target surface in the case of metal-rich discharges as compared to argon-dominated discharges (see also Held *et al.* [37]). The remaining potential hill to climb, in order for a metal ion to escape to the bulk plasma, is therefore lower. Metal ions in those discharges can therefore escape more easily to the substrate region compared to metal ions in argon-dominated discharges, as can be seen in the increased ion escape probability with increased self-sputter yield in Fig. 2. Note that the atomic composition within the ionization region is not solely determined by the sputter yield of the target material, but also a consequence of recycling loops in which atoms in the ionization region, both working gas ions and target atom ions, are ionized and back-attracted to the target [21,38]. The working gas ions either backscatter from the target [39,40] or implant into the target, and subsequently diffuse back (as neutrals) into the IR [21,38]. Upon re-entering the ionization region, they can be ionized and back-attracted to the target again, which effectively traps them in a working gas recycling loop. Furthermore, a metal recycling loop exists that starts with sputtering fresh metal atoms into the ionization region, where they can be ionized and back-attracted to the target. The ion bombardment of the target then maintains a metal recycling loop. It is only because of these two recycling loops, that the high discharge currents in HiPIMS discharges are possible [21].

The condition for sustained self-sputtering, sputtering that relies exclusively on self-sputtering, is given as [41,42]

$$\alpha_t \beta_t Y_{SS} \geq 1. \quad (4)$$

For sustained self-sputtering the noble working gas is only needed to get the process started. Since $\alpha_t < 1$ and $ß_t < 1$ the condition $Y_{SS} > 1$ is necessary for sustained self-sputtering. Fig. 3 shows the parameter $\alpha_t ß_t Y_{SS}$ versus the pulse length for all the discharges studied. We see that this parameter increases with increased self-sputter yield and approaches sustained self-sputtering for chromium and copper targets, both of which have high sputter yield. One could ask why the discharge currents in discharges with strong metal recycling ($Y_{SS} > 1$) are not strongly amplified from these recycling loops. Oks and Anders [43] have pointed out the importance of the electron cooling by metal atoms for stabilizing current fluctuations. We can here add that the systematically lower electron temperatures observed in discharges with high sputter yield materials prevent an uncontrolled amplification of the discharge current.

The fraction of the ion current carried by Ar^+ ions can be estimated using [41]

$$\zeta = \frac{1 - \alpha_t \beta_t Y_{SS}}{1 + \alpha_t \beta_t (Y_{tg} - Y_{SS})} \quad (5)$$

where Y_{tg} is the sputter yield for ions of the working gas, Y_{SS} is the self-sputter yield, α_t is the ionization probability and $ß_t$ is the back-attraction probability. The fraction of Ar^+ ions in the total ion current to the target determined using Eq. (5) is shown versus the self-sputter yield of the target material in Fig. 4. The fraction of Ar^+ ions in the total ion current at the target surface is almost 100 % for a discharge with graphite target and falls to almost zero for a discharge with copper target. This also indicates that a HiPIMS discharge with graphite target is operated on working gas recycling and a discharge with a copper target operates on self-sputter recycling, while discharges with titanium, tungsten, and zirconium targets operate on a mixture of the two operating modes [21].

SUMMARY

The back-attraction probability or the ion escape probability has been determined for number of HiPIMS discharges with varying elemental targets. It is shown that the probability of ion escape increases and that the discharge becomes increasingly metal rich with increasing self-sputter yield of the target material. This is important, because for a given ionized flux fraction, the deposition rate is higher when the back-attraction probability is lower. Furthermore, we show that the parameter $\alpha_t \beta_t Y_{SS}$ increases with increased self-sputter yield and approaches sustained self-sputtering for chromium and copper targets, both of which have high sputter yield.

ACKNOWLEDGEMENTS

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ON METAL ION ESCAPE IN HIGH-POWER IMPULSE MAGNETRON SPUTTERING

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CONTRIBUTED PRESENTATION IN POWERPOINT FORMAT FROM THE 2025 TECHCON

Adapted from a Powerpoint Presentation that was presented at the 2025 68th TechCon

Flash Lamp Annealing – A New Approach to Surface Engineering Challenges

By Jörg Neidhardt[1], Thomas Preußner[1], Marcel Neubert[2], Joachim Ströbel[2]
[1]Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technologies FEP, Dresden, Germany
[2]ROVAK GmbH, Grumbach, Germany

Even though flash lamp annealing is not a new technology, commercially viable applications within the realm of coatings, thins films and surface engineering are still largely unexplored. Instead, static annealing procedures and/or deposition at elevated temperatures are frequently employed to adjust materials and/or surface properties for given applications. However, the applicable temperatures are often limited by substrate materials as well as unwanted side effects, such as diffusion, and/or economic considerations.

CONTRIBUTED PRESENTATION IN POWERPOINT FORMAT FROM THE 2025 TECHCON

FLASH LAMP ANNEALING – A NEW APPROACH TO SURFACE ENGINEERING CHALLENGES

Therefore, rapid (<50 ms) thermal annealing processes are an alternative technology enabling thermal treatment of functional layers and coatings. The limited penetration depth of the imposed heat can even allow the thermal treatment on temperature sensitive substrates. By superimposing periodic flashes and moving the substrate perpendicular to the lamp axis, large areas can be continuously and homogeneously annealed. Recent developments transferred this technology from lab-scale to a pilot scale level and even beyond providing a reproducible and effective large area treatment in air, controlled atmosphere or even in-line with vacuum processes. In comparison to conventional furnace processing, a superior energy efficiency is demonstrated at a comparatively small machine footprint at high throughput. This talk introduces the principles of flash lamp annealing as well as the available equipment options for (large area) thin film and surface treatment for up to pilot-level. These will be related to selected applications and use cases explored at Fraunhofer FEP over the last decade. Examples are crystallization of large area TCO coatings in combination with inline FLA on rigid and ultra-thin bendable glass, treatment of Ag-based lowE multilayer stacks, formation of antimicrobial as well as plasmonic nanoparticles, surface activation of TiOx thin films as well as toughening of plain glass surfaces. Furthermore, the FLA process itself is in the focus of research and commercial validation. Therefore, topics like long-term stability, scalability and energy efficiency will also be addressed.

Note from Managing Editor: We are delighted to share with the readers of the Bulletin some of the interesting Powerpoint Presentations from past TechCons. We hope you find them as interesting as we do.

Sue Taube/Managing Editor

Flash Lamp Annealing – A New Approach to Surface Engineering Challenges

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Flash Lamp Annealing
a new approach to surface engineering challenges

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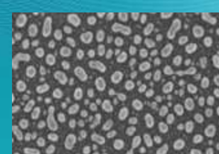
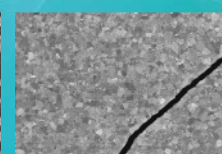
Marcel Neubert, Joachim Ströbel
ROVAK GmbH, Grumbach, Germany

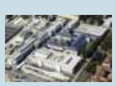
SVC TechCon 2025, Emerging Technologies (ETinv)

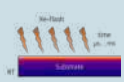


Outline

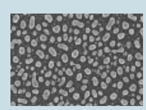
Flash Lamp Annealing (FLA)

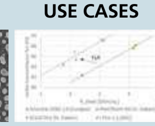

Fraunhofer and Fraunhofer FEP

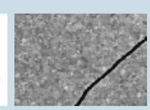

Introduction: What is FLA?

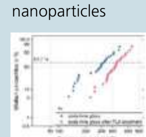

Pilotlab platforms for FLA

USE CASES

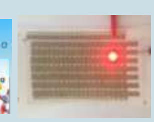

Formation of nanoparticles


Thermal-insulation coatings


Crystallization of thin films (ITO, TiO_2, …)


Glass strengthening


Photoadsorption of molecules


Printed electronic and sensors

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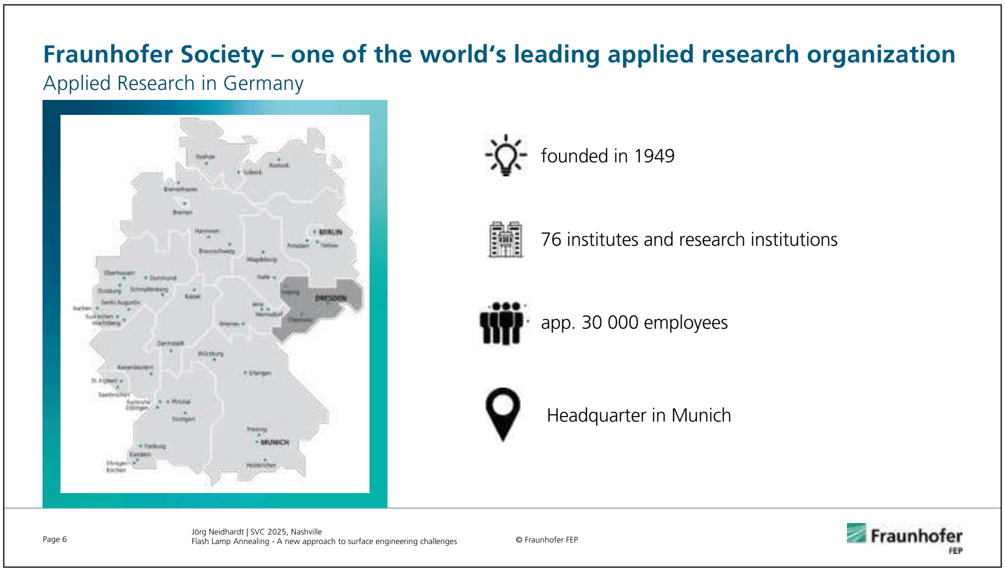
FLASH LAMP ANNEALING – A NEW APPROACH TO SURFACE ENGINEERING CHALLENGES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Applied Research in Germany
BERLIN
DRESDEN
MUNICH
founded in 1949
76 institutes and research institutions
app. 30 000 employees
Headquarter in Munich
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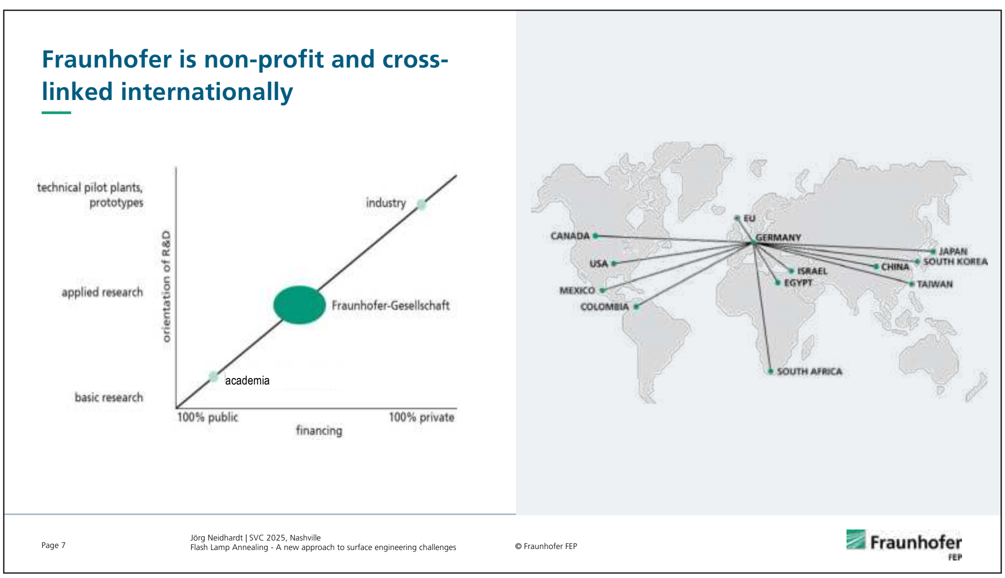
Fraunhofer is non-profit and cross-linked internationally
technical pilot plants, prototypes
applied research
basic research
orientation of R&D
industry
Fraunhofer-Gesellschaft
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Fraunhofer Institute Center Dresden
Overview
Was founded in 1991 and has a floor space of approx. 21,200 m²
IFAM
Fraunhofer Institute for Manufacturing Technology and Advanced Materials
IKTS
Fraunhofer Institute for Ceramic Technologies and Systems
FEP
Fraunhofer Institute for Electron Beam and Plasma Technology
IWS
Fraunhofer Institute for Material and Beam Technology
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FLASH LAMP ANNEALING – A NEW APPROACH TO SURFACE ENGINEERING CHALLENGES

About Fraunhofer FEP

The Institute in Figures

- Employees: 156
- Total budget: 23.3 M €
- Industry returns: 8.5 M €
- Public revenue: 3.7 M €
- Investments: 1.0 M €

(April 2025 | Figures from 2024)

Director

Prof. Dr. Elizabeth von Hauff

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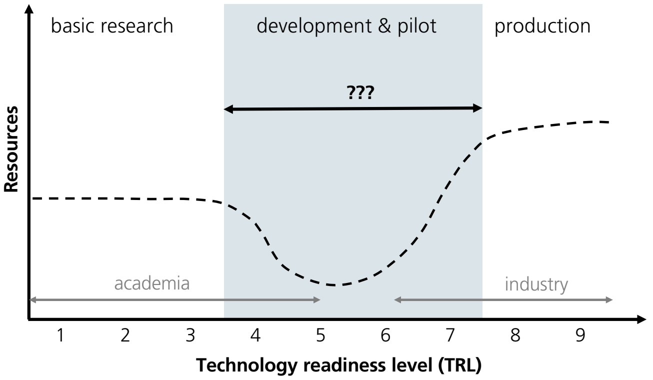
Bridging the technological *valley of death* for coating technologies



Requirements

- scaled technologies
- process components
- machine plattforms

for all relevant substrate materials and forms

In imitation of REHVA Journal 03/2015 p.58

Page 10 | Jörg Neidhardt | SVC 2025, Nashville | Flash Lamp Annealing - A new approach to surface engineering challenges | © Fraunhofer FEP | Fraunhofer FEP

Technologies

Electron beam technologies

Sputter technologies

Plasma surface technologies

Technological key components

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Fraunhofer FEP technologies

Large area, in-line configuration

- **Surface treatment**
  (plasma, ion, bias, electron beam, **flash lamp annealing**)
- **High-rate evaporation**
  (boat, inductive heating, electron beam, plasma assisted)
- **Magnetron sputtering**
  (DC, pulsed, hybrid, dual magnetron, reactive & non-reactive)
- **High-rate PECVD**
  (magPECVD, arcPECVD)
- **Non-vacuum processes**
  (slot die, electron beam)
- **Gas Phase Condensation**
  for nanoparticle generation
- **Process control**
  (in-line spectrometer, plasma emission, plasma impedance)

R&D → pilot → industrial

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Fraunhofer FEP substrate form factors

	Method	max. substrate size	Material	Thickness
Roll-to-roll	Sputtering Electron beam Evaporation Printing	300 – 600 mm width	Metals, Polymers, Flexible glass	7 µm … 200 µm
Sheet-to-sheet	Inline Sputtering (planar, tubular) magPECVD	600 x 1200 mm² 650 x 750 mm²	Metals, Polymers, Flexible glass, Ceramics, Glass	50 µm … 6 mm 120 mm
Sheets and strips	Electron beam evaporation	500 x 500 mm² 300 mm width	Metals, Polymers, Ceramics, Glass	15µm …1.5 mm
Wafer	Sputter deposition (high rate)	Up to 300 mm diameter	Metals, Polymers, Ceramics, Glass, Si	max. 20 mm
3D objects	Sputter deposition PECVD	500 x 500 x 500 mm³	Metals, Polymers, Ceramics, Glass	-

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Fraunhofer FEP substrate form factors

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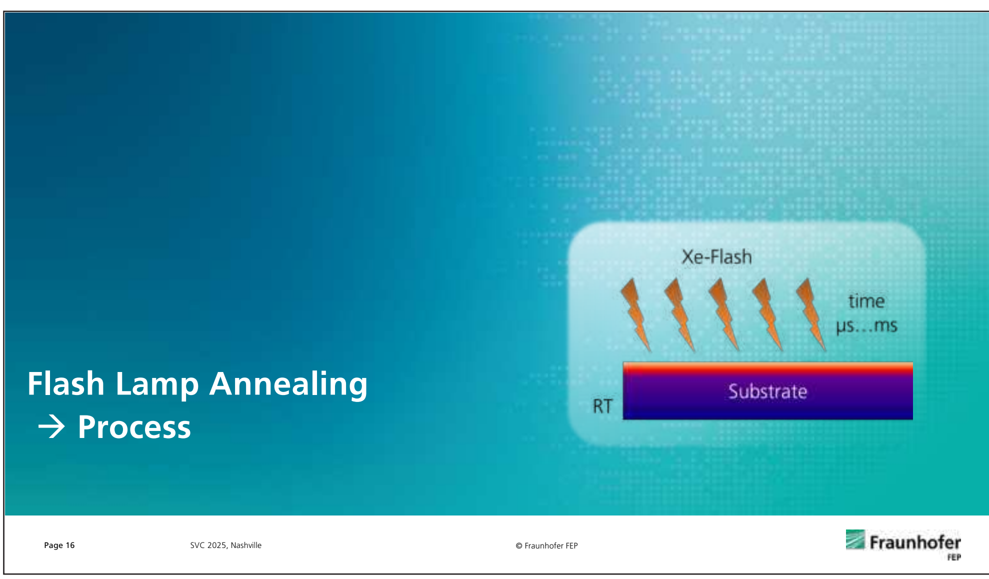

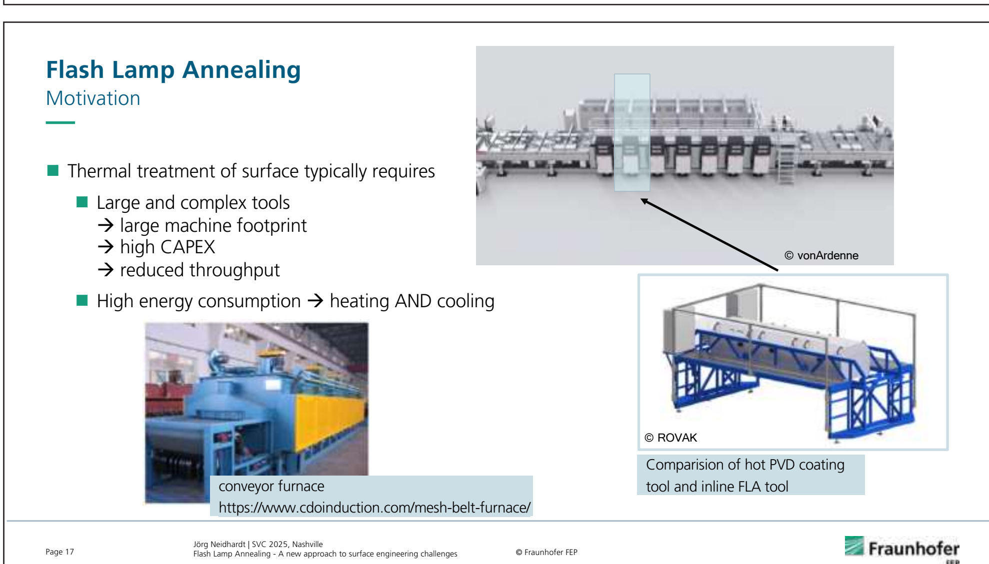

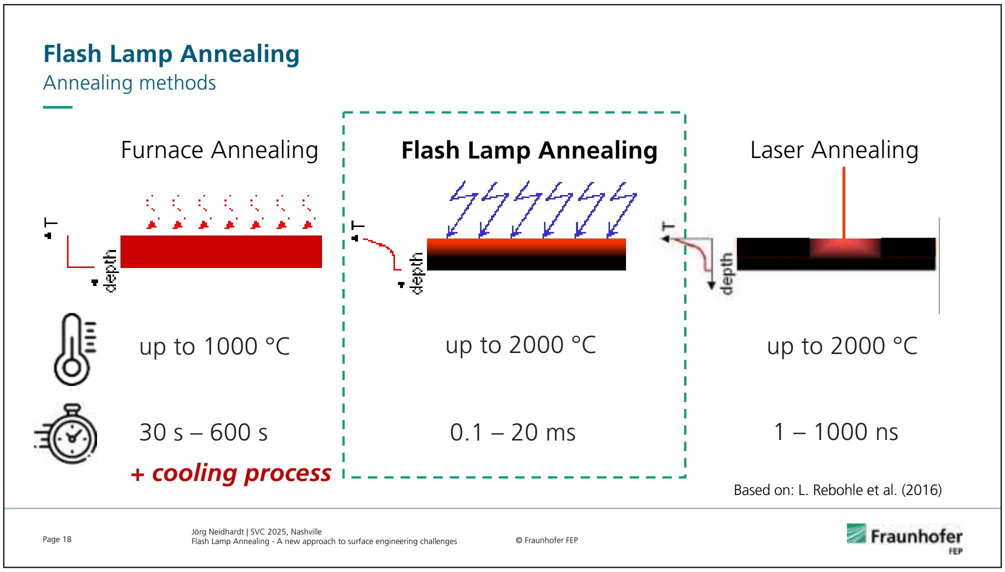
Flash Lamp Annealing
Annealing methods
Furnace Annealing
Flash Lamp Annealing
Laser Annealing
T
depth
up to 1000 °C
up to 2000 °C
up to 2000 °C
30 s – 600 s
0.1 – 20 ms
1 – 1000 ns
+ cooling process
Based on: L. Rebohle et al. (2016)
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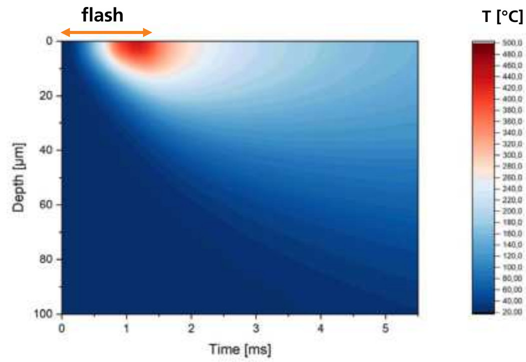
FLASH LAMP ANNEALING – A NEW APPROACH TO SURFACE ENGINEERING CHALLENGES

Flash Lamp Annealing

Treatment characteristics

- high intensity light pulse (250…1000 nm)
- Energy deposition in millisecond range

⇒ Surface selective heating
⇒ Low thermal load on substrate
⇒ Energy efficient



Simulation of a time-resolved thermal profile of a flashed thin film on a 100 µm PET polymer web

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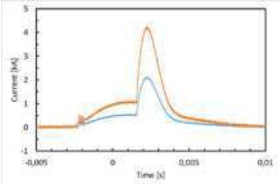
Flash Lamp Annealing

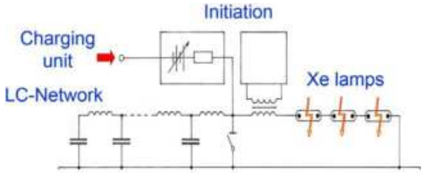
Mode of operation

FLA-Technology - compressed

- Energy provided by capacitor banks
- Ignition and/or switching of the flash lamp (array)
- Discharging the stored energy into the flash lamp
- Shape and duration of pulse adjusted by inductive network



Overview of FLA hardware working principle
top: installed hardware at FEP
bottom: schematic wiring diagram



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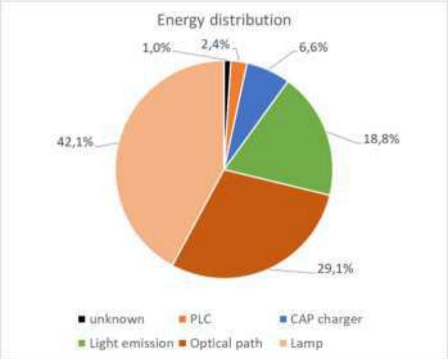
Flash Lamp Annealing

Energy efficiency

Determination of the efficiency of the FLA device

- Measurement of energy consumed from power grid
  → input = 100%
- Measurement of stand-by energy
  → PLC
- Measurement of energy loss via cooling water
  → calorimetry
  → Lamp + optical path + CAP charger
- Measurement of emitted light
  → calorimetry
- Averaging different measurement cycles



→ app. 20% of the primary energy arrives at the substrate

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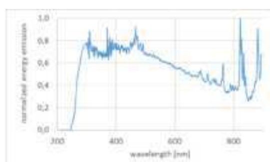
FLASH LAMP ANNEALING – A NEW APPROACH TO SURFACE ENGINEERING CHALLENGES

Flash Lamp Annealing
Process characteristics

Typical process parameters:

- Pulse duration
- Pulse energy density
- Number of pulses
- Lamp spectrum



Surface chemical effects

- Chemical activation
- Molecular bonding modification
- Surface de- / adsorption of molecules

Thermal effects

- Evaporation of materials
- Crystallization
- Sintering
- Drying

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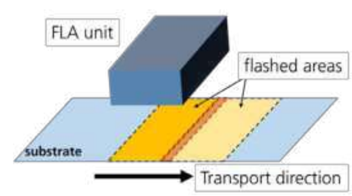
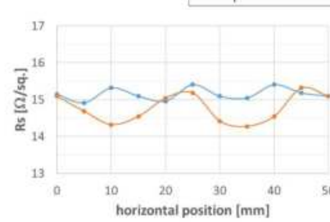
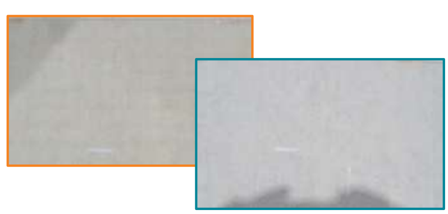
Flash Lamp Annealing
Large-area treatment

- Stitching of illuminated areas
- Multiple treatment in overlap regions muss be handled according to different annealing performances
  1) Saturation of treatment process
  2) Accumulation of treatment cycles







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InnoFlash
Grant No: 100349243
2018 – 2020

EFRE Fraunhofer FEP

Flash Lamp Annealing
→ Equipment

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EQUIPMENT: Inline In-vacuo Flash Lamp Annealing

Objectives	■ High throughput inline annealing of thin films ■ Combination with PVD processes (ILA900)
Features	■ 750 mm Xe-Flashlamp ■ Pulse duration: 0.9 – 9.5 ms ■ Pulse energy: max. 50 J/cm² ■ Atmospheres: vacuum, [air]


ILA900: vertical inline coater @FEP

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InnoFlash
Grant No: 100349243
2018 – 2020

Fraunhofer FEP

EQUIPMENT: Offline Flash Lamp Annealing

Objectives	■ Easy access to FLA for R&D studies ■ FLA process development
Features	■ 750, 360 mm Xe-Flashlamp ■ Pulse duration: 0.9 – 9.5 ms ■ Pulse energy: max. 50 J/cm² ■ Atmospheres: air, inert, reactive, vacuum


Inert FLA-box


Purged FLA-box

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InnoFlash
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EQUIPMENT: R2R and S2S for FLA and coating

Objectives	■ FLA in combination with wafer-leve and R2R PVD processes ■ R&D studies
Features	■ DC- and RF-sputtering, E-beam evaporation ■ Pulse energy: max. 40 J/cm²


S2S sputtering and FLA


R2R sputtering, e-beam evaporation and FLA

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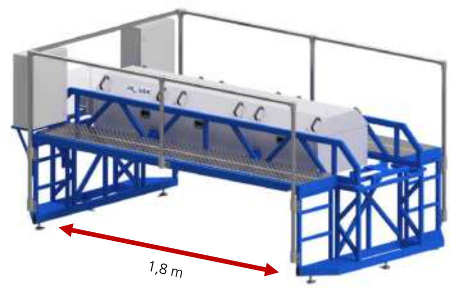
FLASH LAMP ANNEALING – A NEW APPROACH TO SURFACE ENGINEERING CHALLENGES

EQUIPMENT: Inline FLA post-treatment for large substrate areas

Objectives	FLA post treatment of large substrates R&D studies
Features	Substrate width: 1,80m Roller conveyor transport (not shown) High throughput



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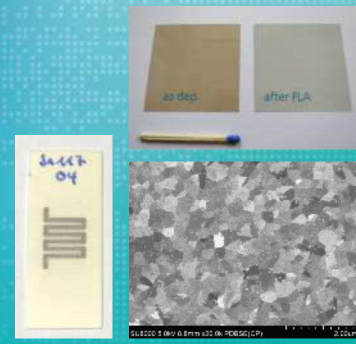
USE CASES for FLA



USE CASE: Surface selective annealing of coatings

TCO activation

Objectives	■ Annealing of transparent conductors ■ Enhancement of optical or electrical properties
Technology	■ Inline PVD coating of ITO thin films adapted to FLA ■ Inline flash lamp annealing ■ Substrates: glass, ultra-thin glass, polymer?

Inline FLA of ITO on glass sheet 600 x 1200 mm²

Inline FLA of ITO on ultra-thin glass sheet 200 x 300 mm²

InnoFlash
Grant No: 100349243
2018 – 2020

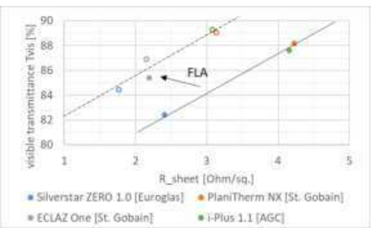
USE CASE: Annealing of multi-layer stacks

Treatment of low emissive coatings (lowE) by inline FLA

Objectives	■ High throughput inline process for large substrates areas ■ Increased transmittance and reduced emissivity (resistivity)
Technology	■ Inline flash lamp annealing of lowE coatings ■ Demonstration at commercially available products

FLA treated zone

- Reduction of resistivity by ~25%
- Increased transmittance by ~3%

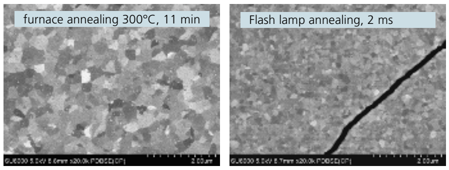


FLASH LAMP ANNEALING – A NEW APPROACH TO SURFACE ENGINEERING CHALLENGES

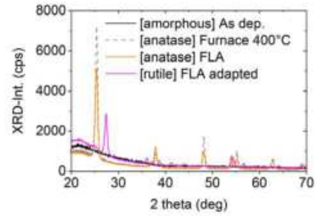
USE CASE: Surface selective annealing of coatings

Recrystallization of TiO_2

Objectives	■ Crystallization into anatase phase for photocatalytic surface properties ■ High throughput inline capable annealing process
Technology	■ Inline PVD coating of TiO_2 thin films adapted to flash lamp annealing ■ Inline flash lamp annealing



SEM images of crystalline anatase TiO_2 thin films on glass

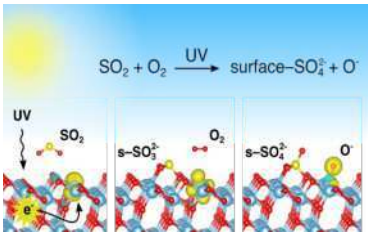


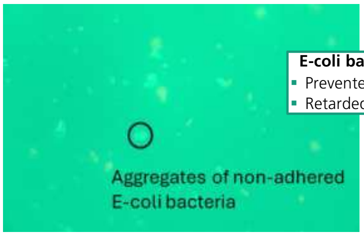
XRD measurement of TiO_2 thin films

Grant No: 862100

USE CASE: Surface Functionalization

Objectives	■ Creation of anti-pathogen surfaces on polymer film ■ Prevention of healthcare-associated infections
Technology	■ High-energy sputtering of oxides on polymer films ■ Photo-fixation of sulfur radicals by flash lamp annealing





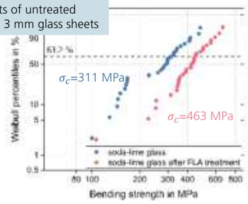
E-coli bacteria are:
- Prevented from adhesion
- Retarded in growth

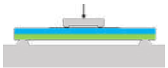
Grant No: 862100

USE CASE: Strength increase of glass

Objectives	■ I ■ Rapi mper
Technology	■ Fl - 12 J/cm² ■ Significant increase in glass strength as determined in a double-ring bending test

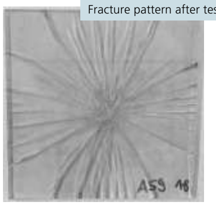
Weibull plots of untreated and treated 3 mm glass sheets





Double-ring bending test, according to DIN EN 1288-5:2000

Fracture pattern after testing



20th Annual

5K RUN/WALK

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SVCF

JOIN SVC TECHCON 2026 ATTENDEES FOR A

REWARDING EXPERIENCE

while supporting our goal to raise funds for vacuum coating student and practitioner scholarships and travel awards.

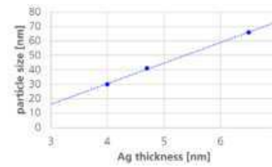
Long Beach Convention Center, Long Beach, CA		
APRIL 29, 2026	BIB PICKUP 5:30 AM	START 6:00 AM

- Participate solo or on a team
- Minimum four members/team
- Top team wins traveling trophy
- Fantastic prizes for top four of 1st-place team
- Medals for top three finishers
- Includes technical T-shirt
- $40/person; sign up when you register for TechCon or on the SVCF website: www.svcfoundation.org

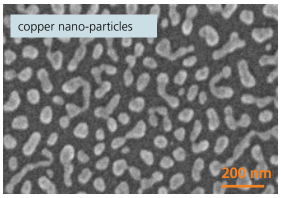
FLASH LAMP ANNEALING – A NEW APPROACH TO SURFACE ENGINEERING CHALLENGES

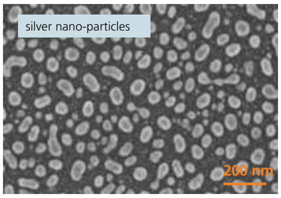
USE CASE: Highly productive low temperature nano-particle synthesis

Objectives	Synthesis of nano-particles ■ High throughput inline process ■ Low temperature process
Technology	■ PVD coating in combination with inline FLA in vacuo



- Substrate temperature < 120 °C
- NP size and distribution adjustable





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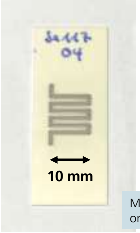
USE CASE: Printed sensors

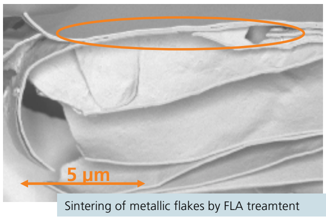
Sintering of inks and pastes

Objectives	■ Sintering of metallic flakes to decrease electrical resistivity ■ Improvement of sensor performance of magnetic field sensor (AMR)
Technology	■ Mag4Ink-Technoligy = Synthesis of special PVD produced powders ■ FLA treatment of printed metallic paste



Magnetic field sensor printed onto ceramic substrate

- Reduction of resistivity by factor 30



Sintering of metallic flakes by FLA treamtent

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Grant No: 03VP09093
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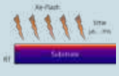
Summary

Flash Lamp Annealing (FLA)

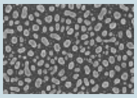
Fraunhofer and Fraunhofer FEP



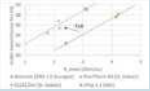
Introduction: What is FLA?

Pilotlab platforms for FLA

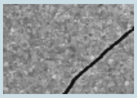
USE CASES



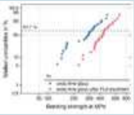
Formation of nanoparticles



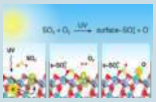
Thermal-insulation coatings



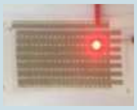
Crystallization of thin films (ITO, TiO_2, …)



Glass strengthening



Photoadsorption of molecules



Printed electronic and sensors

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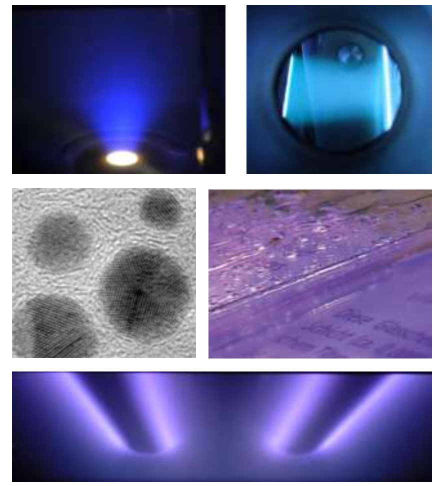
Summary

- Novel processing capabilities in place
- Use cases demonstrated
- Layer stack modeling & coating design
- Process setup, adjustment and optimization
- Up-scaling, sampling and technology transfer
- Key component development

➡ **Ready for your application!**



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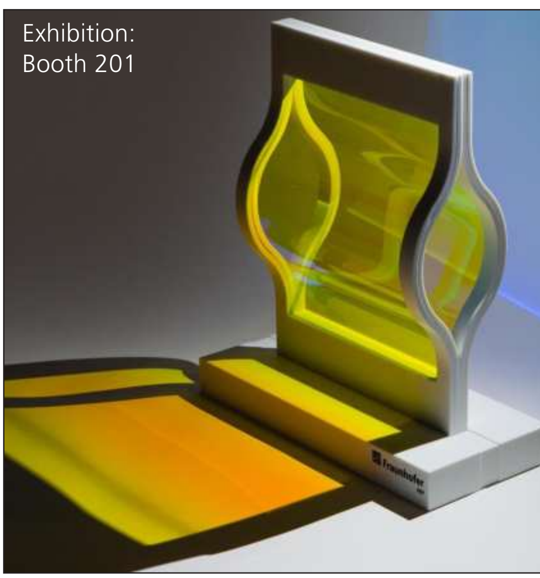
Exhibition:
Booth 201



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CONTRIBUTED ORIGINAL ARTICLE

Adapted from a manuscript that was presented at the 2025 68th SVC TechCon

Transforming Leak Detection in Vacuum Coating Systems with Remote Plasma Optical Emission Spectroscopy (RPOES)

By Marcus Law, Joseph Brindley, Benoit Daniel, Oisín Boyle
Gencoa Limited, Liverpool, United Kingdom

In this study, we introduce an alternative leak detection method based on **remote plasma optical emission spectroscopy (RPOES)**. The technique exploits plasma-induced light emission to detect leaks in ºreal time, enabling both detection and localisation using trace gases such as argon that are relatively inexpensive and readily available. Compared with mass-filter helium detectors, RPOES provides greater robustness, the ability to operate at higher pressures, and reduced maintenance demands. We outline the principles of RPOES, emphasise its advantages in detecting gases commonly linked to vacuum leaks (including water vapor and air), and assess its viability as a practical alternative to helium-based methods. Case studies are presented to demonstrate its effectiveness in identifying leaks across a range of coating applications, with ultimate aim to improved process stability, enhanced coating quality, and lower operational costs.

INTRODUCTION

Ensuring the integrity of vacuum systems prior to deposition and surface treatment is critical, as even small leaks can compromise coating quality, reduce process stability, and result in costly downtime. At present, helium leak detectors based on mass spectrometry and are regarded as the industry standard due to their exceptional sensitivity. However, reliance on helium as a tracer gas presents growing challenges: its cost continues to rise (price doubled over the past decade [1]), long-term availability is uncertain, and the instruments themselves are expensive to manufacture and maintain. Moreover, in many industrial contexts, the level of sensitivity provided is orders of magnitude higher than practically required.

Vacuum system integrity can also be compromised by a range of additional bottlenecks beyond simple physical leaks. These include virtual leaks, where trapped volumes, for example in screw threads or O-ring grooves release gas slowly into the chamber; permeation of gases through materials such as gas lines and seals; and the release of water vapor absorbed on surfaces. Other contributors include organic outgassing from contaminated parts and pumping issues such as oil backstreaming. Each of these factors can degrade vacuum quality, reduce coating performance, and increase the demand for effective leak detection methods to quantify leaks in vacuums.

Leak flow (Q) is defined as

$$Q = \frac{\Delta P \cdot V}{\Delta t} \quad (1)$$

Where ΔP is the change in pressure, V is the volume and Δt is the time taken for the pressure change. Q is typically expressed in mbar·L/s and in SI units Pa·m^3/s.

A number of conventional leak detection methods are employed in industry, but each presents limitations. Rate-of-rise testing (using equation (1)) cannot distinguish the cause of a leak, with leak rates strongly dependent on the initial pump-down conditions. Base pressure monitoring likewise fails to reveal the underlying cause and can take days to diagnose. Dedicated helium leak checkers, while highly sensitive, face rising helium costs and supply chain concerns, with filaments that degrade over time, are prone to contamination, and require regular maintenance and calibration. Residual gas analysers (RGA) based on mass spectrometry allow detailed analysis but require sampling of the vacuum system, involve complex and sensitive components, and are often overkill for the practical requirement. Furthermore, data interpretation can, in some circumstances be non-trivial, as contaminants can share the same mass-to-charge ratios.

To address these limitations, we introduce a leak detection approach based on **remote plasma optical emission spectroscopy (RPOES)**. An early demonstration of plasma-based optical emission for leak detection was reported by Mann [2], who developed a simple detector based on monitoring the light emitted from a Penning gauge plasma. In this configuration, the emission line at 391.4 nm, corresponding to the N_2^+ ion, was selectively filtered and detected, allowing air leaks within a vacuum chamber to be identified. This early work established the principle that plasma-induced optical emission could serve as a sensitive indicator of gas ingress, laying the foundation for more advanced remote plasma optical emission spectroscopy (RPOES) techniques.

Such a system is described in this publication to detect gases in real time, providing partial pressure information. It is well suited to identifying gases commonly linked to vacuum leaks, such as water vapor and air, and can be used in conjunction with a trace gas, making it a practical alternative to established methods.

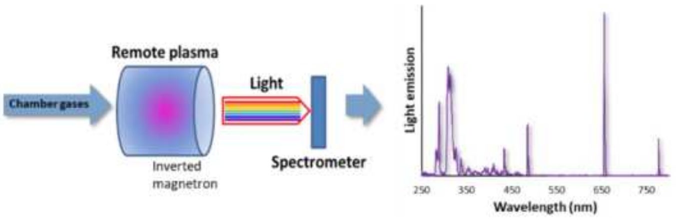

Fig. 1 – RPOES technique.

EXPERIMENTAL AND RESULTS

RPOES technique

The RPOES technique operates by generating a small remote plasma within a dedicated sensor mounted to the process vacuum chamber. In this configuration, species present in the chamber are ionised and excited within the sensor plasma, producing characteristic optical emission lines. The resulting light is transmitted to a spectrometer, where both the wavelength and intensity of the emission features are analysed. Identification of the emitting species is achieved by cross-referencing the observed lines with established reference data, including the NIST Atomic Spectra Database [3] and Pearse and Gaydon's *Identification of Molecular Spectra* [4]. By quantifying the intensity of the identified peaks, the partial pressures of the corresponding gases can be determined, enabling both qualitative and quantitative assessment of the vacuum composition.

The sensor used employed an inverted magnetron configuration to generate the plasma. A cylindrical cathode surrounded a rod anode biased up to 3 kV, while a surrounding ring magnet provided confinement of electrons close to the anode, sustaining a stable Penning discharge. The light emitted from the plasma was collected through a sapphire viewport and collimating optics, then directed into a compact broad band spectrometer. This configuration enabled analysis across a broad spectral range, from the ultraviolet to the near infrared, thereby capturing multiple emission peaks simultaneously rather than being limited to a single filtered wavelength. Its basic principle is shown in Fig. 1.

Current regulation of the discharge was used to maintain monotonic behaviour of plasma current (emission intensity) with respect to increasing partial pressure, providing a stable calibration basis. The operating range of the sensor was established from 10^{-6}mbar to 0.5 mbar, covering the regime relevant for industrial vacuum processes and leak detection. This is illustrated in Fig. 2.

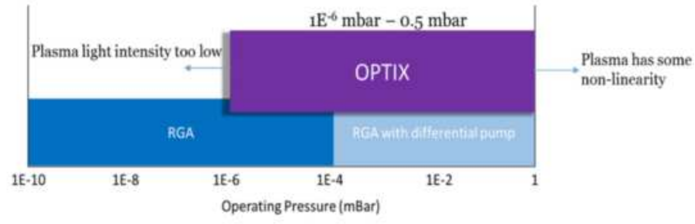

Fig. 2 – RPOES device operating pressure range.

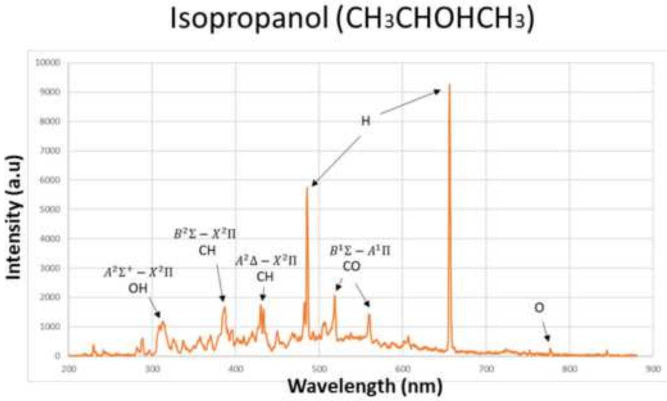

Fig. 3 – OES spectrum of Isopropanol.

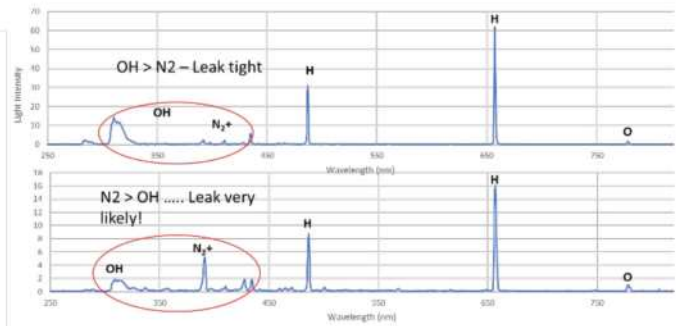

Fig. 4 – Water vapour and air leaks.

An important feature of the RPOES technique is that the plasma dissociates larger molecules into their smaller constituent fragments. These fragments emit light at well-defined wavelengths characteristic of their elemental or molecular identities. Consequently, the recorded spectrum contains a series of prominent and easily identifiable peaks, which can be used to infer the presence of the original parent molecule with high confidence. Shown in Fig. 3 is a spectrum of isopropanol.

Application Examples

The case studies reported in this work, had a measurement time (light acquisition) of 1 s unless stated otherwise. The device was operated in HDR mode, where the acquisition time was split into segments of differing lengths and reconstructed into one spectrum. This algorithm enhanced measurement quality, allowing small signals to be measured in detail. Since the limiting factor for measurements is the amount light accumulation, for some applications, an acquisition time of < 100 ms is sufficient.

Application examples are presented to demonstrate the capability of RPOES for real-time gas identification and quantification in vacuum systems. These results illustrate its effectiveness for leak detection, leak characterisation, and process monitoring.

Air leaks and water content

Fig. 4 shows representative RPOES spectra demonstrating the ability to distinguish between water vapour outgassing and atmospheric leakage. In a clean, leak-tight system, the spectrum is dominated by OH and H emission lines (water), with only a minor contribution from N_2^+. Under these conditions, the intensity ratio N_2^+/OH remains below one (N_2^+/OH < 1). A general rule of thumb is that below 10^{-2} mbar total pressure, nitrogen should not be present in significant quantities.

In contrast, spectra obtained during a leakage event exhibit a large N_2^+ proportion relative to OH, such that the N_2^+/OH ratio exceeds N_2^+/OH > 1. This shift provides a simple and robust diagnostic: systems where nitrogen emission exceeds that of OH can be classified as exhibiting an air leak, while those with OH-dominated spectra are indicative of water vapour outgassing and/or water leaks.

The utility of this ratio can be extended to quality control (QC). In this specific example, assessment of vacuum chambers leak tightness was quantified to a QC specification. The principle is show in Fig. 5 using partial pressure traces of OH and N_2, measured by RPOES in RGA mode. N2 sum in Fig. 5 is the combination of both N_2 and N_2^+ partial pressures, to give a full representation of the nitrogen concentration throughout the pumpdown as the ionisation levels of nitrogen change. The RPOES device was attached directly to the chambers.

An acceptable partial pressure of N2 sum (air) was established for QC purposes in manufacturing. Chambers passing QC, OH emission remains greater than N_2, with nitrogen sufficiently low (Fig. 5(a,b)), corresponding to acceptably leak-tight operation. In contrast, chambers falling outside the QC specification show spectra where N_2 exceeds OH. A small leak produces a gradual crossover between the traces (Fig. 5(c)), while a large leak results in persistently high nitrogen concentration dominating the signal (Fig. 5(d)).

Together, these results establish the N_2/OH signal balance as a rapid and quantitative diagnostic for vacuum integrity, pro-

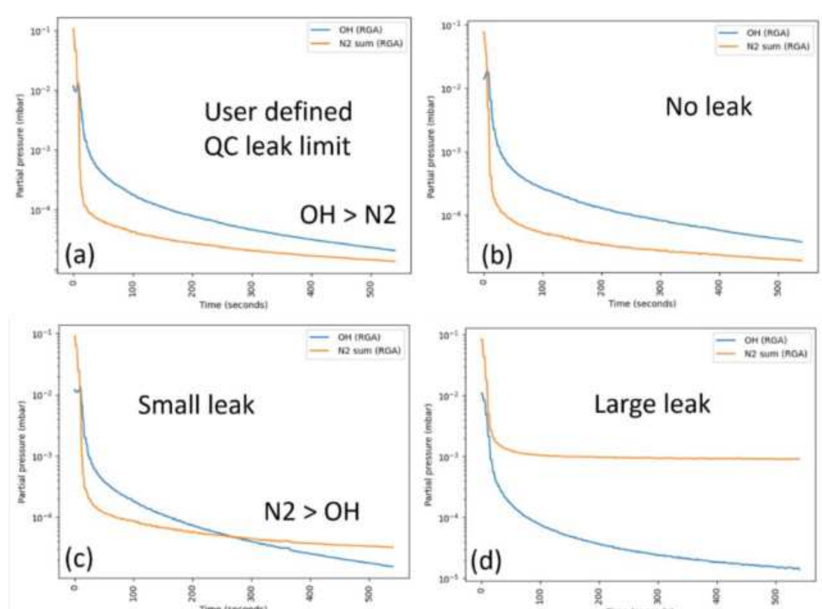

Fig. 5 – Vacuum chamber quality control partial pressures of Nitrogen and OH (water vapour)

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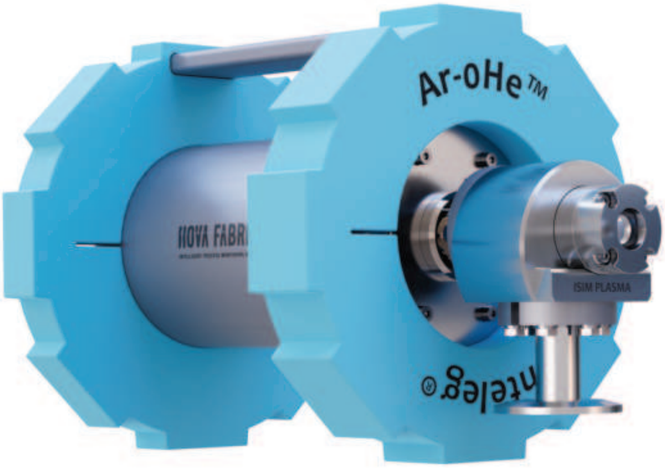
Zero Helium. Maximum Precision.



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Leak detection by OES

Revolutionising Leak Detection

	✓ Argon-spray mode	✗ Helium-spray mode
Leak finding process	Fast	Slow
Leak location accuracy	Precise	Inaccurate
Residence time	Ar, <10s	He, approx. 30 min.
Detector use complexity	Simple	Complex
False-positives	No	Yes
Detector set cost	$	$$$
Spray gas cost	$	$$$
Spray gas type	Ar	He
Spray gas availability	Readily available	Shortage

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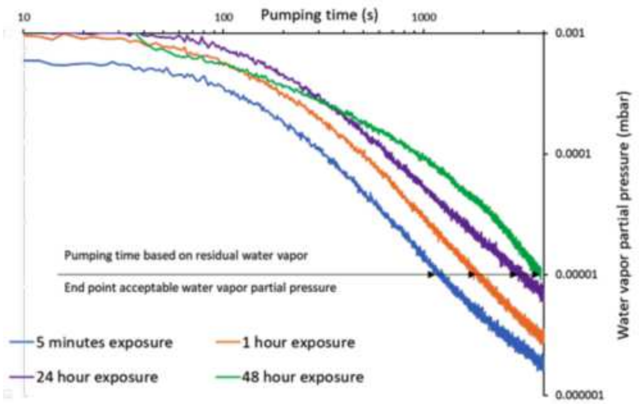

Fig. 6 – Water vapour partial pressures for differing levels of atmospheric exposure.

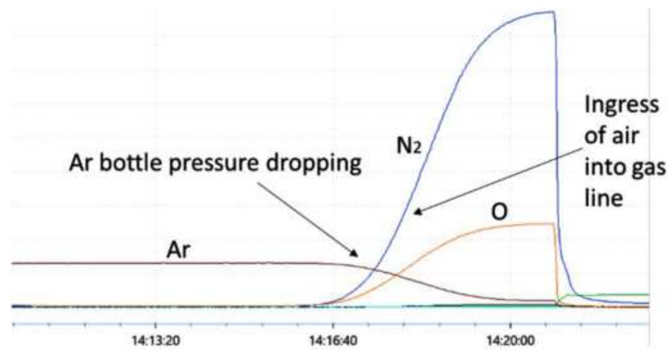

Fig. 7 – Argon, Nitrogen and Oxygen traces for an emptying argon gas line.

viding a straightforward pass/fail criterion for QC inspection of vacuum chambers, without a tracer gas or mass spectroscopy.

RPOES can also be applied to monitor water vapour desorption following atmospheric exposure, providing a means to optimise pump-down and degassing cycles. Fig. 6 shows the evolution of water vapour partial pressure during pump-down after a vacuum chamber was exposed to atmosphere for different durations ranging from 5 minutes to 48 hours. As expected, longer exposure times result in higher initial water vapour concentrations and extended degassing times before reaching an acceptable base level.

A key advantage of this approach is the ability to define a quantitative end-point criterion for residual water vapour. By monitoring the partial pressure directly, the pump-down stage can be terminated, and the process can be started, once the water concentration has reached the required threshold. This ensures that contaminant limits are met while avoiding unnecessarily long pumping cycles.

Such real-time end-point detection provides a practical route to reducing cycle times and improving process efficiency, while maintaining strict control over vacuum cleanliness

Contamination detection

In addition to system leak detection, RPOES enables the identification of contamination within a system, which cannot be diagnosed by conventional leak testing. Fig. 7 shows a case where an argon process gas line became contaminated with air as the supply bottle pressure dropped. Under these conditions, mass flow controller (MFC) feedback reported no anomalies, and pressure readings remained consistent.

The in situ RPOES spectra, however, revealed a clear ingress of nitrogen and oxygen into the gas line. As the argon supply declined, the N_2 and O emission signals increased in the same period as the argon signal decreased. This directly indicated the replacement of process gas with atmospheric air. Importantly, this situation does not correspond to a system leak, but rather a leak within the gas feed, meaning that in situ gas monitoring is the only way to observe the problem in real time.

RPOES can also be applied to monitor the outgassing behaviour of materials in vacuum environments. In this example the effectiveness of barrier coatings on polymers was quantified using this technique.

Fig. 8, compares the evolution of gas species released from A polymer with and without a silicon nitride (SiN) barrier layer during thermal exposure. In the uncoated polymer (Fig. 8(a)), significant outgassing of CO_2, OH, and N_2 is observed as the sample is heated, with peak concentrations occurring around 1500 s. By contrast, the SiN-coated polymer (Fig. 8(b)) shows a marked reduction in CO_2 and N_2 partial pressures, with overall gas release suppressed by over an order of magnitude compared to the uncoated sample. The OH signal remains the dominant feature but is also reduced in magnitude.

These example highlights a fundamental feature of RPOES: the ability to continuously monitor process gases and identify contamination events that would remain invisible to conventional diagnostic tools. This case study demonstrates how a quantitative, real-time method to assess barrier coating performance was performed using the technique, which allowed

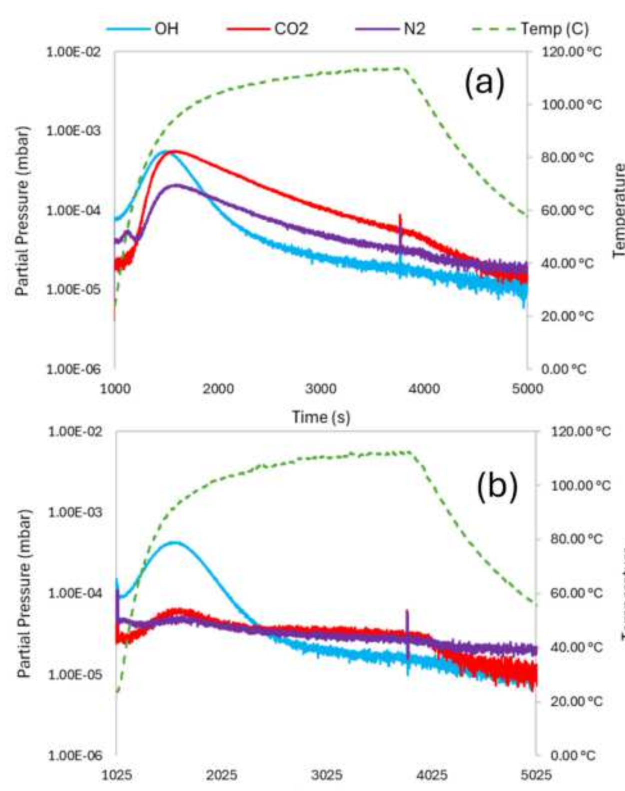

Fig. 8 – Outgassing of polymers with (b) and without a barrier coating (a).

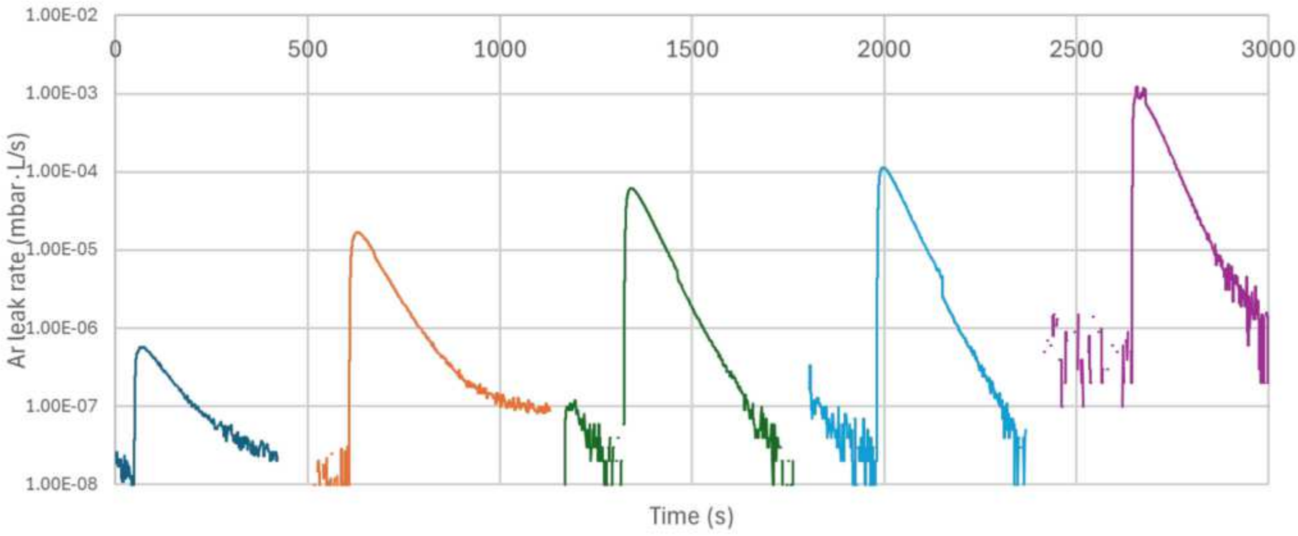

Fig. 9 – Example leak detection experiments using RPOES. All values are stated as the He equivalent.

differences in gas evolution between coated and uncoated polymers. The technique therefore offers a valuable diagnostic for evaluating and optimising materials in coating and packaging applications.

RPOES as an alternative to conventional mass filter-based helium leak checkers

Leak detection experiments were carried out using the RPOES system connected to a vacuum chamber. A dosing valve was fitted to the chamber to introduce controlled leaks under reproducible conditions. In addition, a calibrated reservoir leak (10^{-6} mbar·L/s) was used to provide a reference, enabling conversion of the measured argon signal into quantitative leak rates.

For test measurements, argon was introduced at the chamber opening to simulate leak events. The resulting optical emission signals were recorded by the RPOES device, and data were collected under varying leak conditions to evaluate sensitivity, response time, and repeatability. Fig. 9 shows these results.

Comparisons were made between different leak magnitudes, with emphasis on the system's ability to resolve small leaks and distinguish between signal levels. This approach allowed direct correlation between leak rate and the optical emission response, thereby establishing the calibration basis for quantitative leak detection using RPOES.

Leaks in the range of 10^{-3} – 10^{-7} mbar·L/s were recorded in this example. Further work is needed for full calibrated measurements.

DISCUSSION

The results and case studies demonstrate that remote plasma optical emission spectroscopy (RPOES) offers several clear advantages compared with established helium-based and mass-spectrometric leak detection methods. A primary benefit is lower operational cost. Unlike helium leak detectors, RPOES requires no dedicated pumping or sampling system and avoids reliance on increasingly expensive and supply-constrained helium. The use of inexpensive and widely available gases, such as argon makes the technique particularly attractive for industrial settings where routine leak checking is required.

Another key advantage is measurement speed. Because the RPOES device is in contact with the vacuum environment, there is no lag associated with sample extraction or transfer. Spectral information is delivered to the detector at the "speed of light," enabling rapid identification of leaks and near real-time response during process monitoring.

The technique also provides reduced maintenance demands compared with conventional systems. Helium leak checkers and residual gas analysers (RGA) often rely on fragile filaments or complex ion optics that degrade over time, requiring frequent calibration and servicing. In contrast, the RPOES technique described in this work employs a robust plasma generation with minimal consumable components, ensuring stable long-term operation.

Portability is another strength of the method. The compact design of the RPOES device implementation allows the device to be easily hand-carried and positioned at different points on a vacuum system, in contrast to bulky helium leak detectors that require pumps, carts and storage.

Importantly, RPOES provides a reliable measurement of true gas concentrations within the chamber. Because gases are excited and detected directly in situ, the measurement is not influenced by sampling artefacts. This results in faster signals, more accurate identification of the leaking gas, and the ability to capture subtle features such as virtual leaks or slow outgassing phenomena that might otherwise be masked.

Taken together, these advantages position RPOES as a practical and scalable alternative to helium-based leak detection, particularly for industrial coating and surface treatment processes where ultimate sensitivity is less critical than cost, speed, and robustness.

CONCLUSIONS

This work highlights the potential of remote plasma optical emission spectroscopy (RPOES) as a powerful tool for quantifying vacuum integrity in real time. The technique is inherently non-invasive, relying on the detection of characteristic optical emissions from gases directly within the vacuum environment, and is capable of operating across a wide pressure range from 0.5 mbar down to 10^{-6} mbar. Data collection speeds of under 100 milliseconds enable rapid results and near-instantaneous feedback during leak testing and process monitoring.

Importantly, RPOES can be employed as a standalone leak detection solution, removing the dependence on helium tracer gas and its associated costs and supply chain challenges. Preliminary studies indicate that leak rates as low as 10^{-8} mbar·L/s are within reach using argon, with further optimisation ongoing. Combined with its compact, robust design and reduced maintenance demands, RPOES offers a scalable alternative to conventional methods for industrial applications.

Overall, RPOES provides a versatile, cost-effective, and rapid approach for maintaining vacuum integrity, with clear advantages for coating, deposition, and other vacuum-based processes where both reliability and operational efficiency are critical.

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Marcus Law MPhys, PhD is an Applications Development Engineer at Gencoa, working within the R&D department. He holds a PhD from the Fusion Centre for Doctoral Training at the University of Liverpool, awarded in 2024. In his role, he is responsible for the experimental performance characterisation and data collection for sensing products, leading industry trials, and product demonstrations, and providing customer support, including training and troubleshooting.

Joe Brindley completed his PhD in feedback control algorithm design at the University of Strathclyde in 2011. Joe joined Gencoa Limited in 2012 and has had responsibility for development of their vacuum sensing and control products. Since 2025 he has held the role of Technical Director with overall responsibility for the company's R&D and product design activities.

Benoit Daniel MSc and BSc(Hons) from St Joseph College, Dijon (France) and Hogeschool Brabant, Breda (Holland) in 2000-2003 in International Project Management in Computer Science and Networking and Software Engineering. He joined Gencoa in 2003 and is currently responsible for the development and production of control & sensing solutions.

Dr Oisín Boyle is a data scientist working at Gencoa to produce AI tools for propelling the vacuum coating sector towards industry 4.0. Having completed his BSc Physics and Music degree with First Class Honours in 2019 at Cardiff University and MSc in Applied Mathematics at Imperial College London in 2020, Dr Boyle completed his PhD in 2025 at the University of Liverpool with a thesis entitled "Block Sparse Bayesian Learning with Applications to Spectral Unmixing for Plasma Optical Emission Spectra". The research of this PhD comprised analysis of the spectra produced by the Gencoa Optix. Dr Boyle also has experience in high-performance computing, having undertaken training at Hartree STFC and used the University of Liverpool's supercomputer. Dr Boyle was also a finalist for the Siemens' AI Challenge in 2021, and a recipient of the Society of Vacuum Coaters Foundation Jim Colbridge Memorial Scholarship.

EXECUTIVE DIRECTOR'S MESSAGE

Frank Zimone
SVC Executive Director

A quest for relevance through excellence…

Today is February 5, 2026. My editorial column for the Bulletin must be written months in advance so we can publish in March; we are currently 81 days away from the start of the 2026 TechCon.

We are heavy in the preparations for the 2026 event. The 2026 TechCon will be held, for the third time, at the Long Beach Convention Center (LBCC) in Long Beach, CA USA. The LBCC is an ideal venue for the SVC as the intrinsic intimacy of the site is ideal to support the networking ethos that is the very DNA of the SVC. The weather promises to be great and for most of us still trapped indoors by a usually cold and snowy winter, the warm sun and smiling faces of our colleagues will come as a welcome respite. We have secured an extremely attractive conference

lodging rate at the Hyatt's two adjacent properties and have expanded many of our meetings and tutorials into the Hyatt as well. The SVC policy of securing venue contracts years in advance has really paid off for us as we have been protected from price inflation, which has affected all aspects of the economy, including the hotel industry. We continue to enjoy the fruits of solid advance planning and fearsome negotiating!

2026 represents the culmination of years of advance planning and professionalization. The SVC has become the home for key technologists and thought leaders; the strength of the conference, and the tutorial programs reflect their contributions and commitment. Never forget that you are only as strong as your team (gosh, where have I heard that before???) and when you consider the 100+ members of the SVC organizers, volunteers, and instructors, that fact becomes immediately apparent.

As in previous years, registration to the 2026 TechCon for all our stakeholders is through an intuitively dedicated website. Our investment a few years ago in the Swoogo registration platform (many thanks to our colleagues at the AVS for pointing us in this direction) has allowed us to offer a seamless registration experience and ability to convey pertinent conference information, in real time, to our attendees.

Conference registration fees and tutorial fees are unchanged for 2026. Continuing the successful innovation started in 2023 we are offering a complimentary tutorial to ***all paid conference registrants*** and adding a significant discount on any additional tutorials (30%) that a conference registrant may elect to take.

The SVC Program leadership has secured a roster of exciting keynote and invited speakers; we will be offering a record number of Technical Forum Breakfasts and will be repeating our hugely popular Colloquium at the Techcon forums. The TFB's are so popular that for 2026 we will be expanding the program and offering additional "Sunset Sessions" on Monday and Thursday during the event. The Technical Program has been expanded yet again and for 2026 we are offering 22 sessions! In fact, the number of sessions has expanded to the point where we needed to add a fifth parallel session, a first in SVC history.

For us to secure meeting and exhibition space of this quality, we are required to make commitments years in advance and commit to booking a specific number of room nights. Our commitment for 2026 is approximately 1900 room nights. If we come up "short" we are contractually obligated to pay for every unused room night! As you can imagine, that is an incredible financial commitment, one that we are happy to make in order to provide the experience that everyone expects from an SVC TechCon.

This year, we are continuing a proactive protocol designed to put us into a situation where we are not paying for unused rooms from our block. In 2022 we narrowly averted, through skillful negotiation, an attrition penalty that would have bankrupted the SVC. Meeting space is not "free" and to support an event of the caliber that everyone expects of the SVC we need to ensure that we meet our contractual obligations and motivate everyone to stay in the show hotel. It is actually pretty simple once you think it through.

When you access the TechCon registration site you are first directed to the hotel reservation page. When your reservation is completed, you are issued a hotel confirmation code. During the conference registration, you will be asked for the code. If you have a valid hotel registration you will be presented with the normal conference pricing structure. If you are not staying at one of the two Hyatt "partner properties" (an obvious exception is available during the registration process for locals/commuters who do not require a hotel!), you will be directed to a conference fee that is $619.00 USD higher. This allows us the opportunity to develop a reserve in the event our room block is not fully utilized. This policy does not apply to those who register as exhibit visitors or tutorial-only attendees. This policy will apply to all exhibit booth personnel registering to attend/work the exhibition.

If you register for the conference at a higher rate and subsequently make your hotel reservations at the Hyatt, then we will be delighted to immediately refund the difference directly to you! Just let Jacque Matanis (jacque.matanis@svc.org) know by email, provide her with your Hyatt registration details and the refund will be promptly issued.

To our many ***new*** TechCon visitors and exhibitors let me reshare some solid advice on how to make the most of our event. I can assure you that if all you do is sit in on a few papers or set up a booth at the show and wait for people to visit you, the show ***will*** be a huge disappointment. Some specific ideas to consider are as follows:

Plan:

- The TechCon is a "dense" event. There is something going on every minute of the day and as far as the conference is concerned there are always multiple parallel sessions in progress. Plan your day ahead of time; decide what you want to do in advance. Arrive early and if possible, stay at a show hotel so you are not spending too much time "commuting."
- Recognize that the Exhibition and the Conference are just components of a much larger event. You need to look at the entire event and plan out what events and/or networking opportunities you want to participate in. This means that understanding the TechCon program in advance of travelling to the show is critical.
- As an exhibitor, recognize that many of your potential customers will be presenting in the technical sessions. It is a clever idea to attend those presentations where the technology presented either falls into your current product offerings or is in an area you want to move into.
- Many companies exhibiting at the show could be part of your

potential supply chain or even a future employer; their time at the show will be busy (after all, they are there to conduct business!) and you will want to plan precisely who you want to visit (use the interactive floorplan guide on our website) to see where each exhibiting company will be located.

Visibility:

- Establish visibility before the show and on an ongoing basis throughout the year. Become a Corporate Sponsor which not only gives you and SVC membership and a permanent presence on the SVC website but also gives you the opportunity to post a corporate update to the entire SVC data base on a quarterly basis through our TECHTalk and SVConnections electronic newsletters.
- Consider advertising in the SVC's Bulletin, the flagship magazine that highlights relevant technology and SVC events.
- Become a TechCon Sponsor: TechCon sponsorship (there are many levels) will provide an opportunity to get your name and company logo in front of many people and associated with many events at the TechCon. Level sponsorships are the most popular as they include advertising in the Exhibit Guide which is provided to everyone who attends the Technical Conference and the Exhibition. Specialty sponsorships allow companies to "brand" an event during the show. Depending on your budget you may want to consider at least a "Level" and a specialty sponsorship. Going above the noise level associated with 150 exhibitors may be a worthwhile and productive exercise.

Participate:

- For our Technologists, submit an abstract and make a presentation to share with the world your significant developments in the field. Use the TechCon as an opportunity to build your personal brand.
- For our Exhibitors, make a presentation at the Exhibitor Innovator Showcase (EIS). The Exhibitor Innovator Showcase is a forum where you are given 20 minutes to make a commercial presentation on any subject that you like! It can be a company overview. It could be a new product introduction. It can be on some services you provide. Remember that all presentations in the Exhibitor Innovator Showcase are eligible for publication in the SVC Conference Proceedings.
- All presenters at the TechCon will have the opportunity to submit a narrated video of their presentation for inclusion in

the new SVC On-Demand Video Proceedings that is hosted on the SVC's YouTube channel.

Network:

- Make sure you attend as many of the Networking events as possible. You may want to attend the morning Technical Forum Breakfasts (Monday, Tuesday, and Thursday mornings of the conference as well as the awards ceremony/welcome reception, the SVC Foundation Casino Night Fundraiser, and the SVC Foundation 5K Fun Run/Walk. Do not be intimidated by the language barrier! We all speak the same technical language regardless of our country of origin. People partner with those that they trust. To trust someone, they must get to know you. And to get to know you, someone needs to first extend their hand in friendship and say hello!
- Get to know your competitors who will be at the show too. This is an interesting world we live in. Your competitors today can be your collaborators or even employers of tomorrow!

Follow-up:

- If you have made a presentation do not forget to submit your manuscripts and PowerPoint Presentations (along with the required copyright transfers/releases) so there is no chance they will not be included in the Conference Proceedings. Remember that all Proceedings contributions are assimilated into mAIke, the SVC's new artificial intelligent assistant. Can you imagine a better way to ensure that your contributions get in front of all our stakeholders?
- Plan to submit a video version of your presentation (along with the appropriate release) for inclusion in the SVC On-Demand Video Proceedings.
- Follow-up with email and "heaven forbid," a telephone call to contacts that you made at the TechCon. Stand out both personally and professionally.

Honestly, it is not that hard to be successful; get up early, stay late and take advantage of all the opportunities we "bake into" the TechCon. And don't forget to have fun!

So, how does the tag line factor into any of this?

This year has seen political, social, and economic uncertainty which rivals the COVID pandemic! The jury is still out on whether 2026 will be a financially successful year for the SVC. What we can say is that our plan to broaden the depth and breadth of the conference and the tutorial program is an ongoing process that will yield future benefits to our stakeholders and by association, the SVC. We will continue these efforts, broadening the tent for subsequent years and to do so, we need the assistance and engagement of each of you! Come join us, get involved, own a piece and I promise you will not regret it.

Stay safe and see you all soon!

— Frank Zimone
SVC Executive Director
frank.zimone@svc.org

SVC FOUNDATION NEWS

Greetings, SVC Members!

While many of us in the North are still in the throes of Winter, preparations have started for the 2026 TechCon in Long Beach, California, with the Foundation's Casino Night and 5K Run/Walk events.

These signature events are the financial backbone of our scholarship program. We are incredibly fortunate to have the support of our corporate partners who drive this success. In 2026, we anticipate giving a record amount ($60K) to young members and students through one of our three programs – Academic Scholarships, Industry "Trade" Scholarships, and Supported Travel to the SVC TechCon.

We can always use your help to increase our endowment and ensure future giving. Available sponsorships for both the Casino Night and 5K Race can be reviewed and purchased at our website: **www.svcfoundation.org**. These events are great ways to meet the movers and shakers in our industry, spend time with our technical experts, and have fun. So, shovel the snow off your sidewalks and set your sights and sneakers for sunny California this April.

In other Foundation news, Christopher Johnson and Jason Rogers have left the Board of Trustees. We thank them both for their service and wish both of them well in the future. Patrick Morse has been re-elected and has taken on the role of Vice Chair, which we are all very excited about.

— With kind regards,
Gary Vergason
SVC Foundation Chair

Promote – Participate - Support

Congratulations to the latest class of Academic Scholarship awardees as listed below:

Alex Bordovalos
(University of Toledo)
Clark & Karen Bright Endowed Scholarship Honoring Angus Macleod

Michal Nowak
(Military University of Technology)
J.A. Woollam Company Scholarship

Chang Huai
(University of Buffalo)
Bernard Henry AIMCAL-SVC Scholarship

Karthik Pagadala
(Purdue University)
John Fenn Sr. Endowed Scholarship

Md Mehedi Hasan Tanim
(University of Michigan)
J.A. Woollam Company Scholarship

Isaac Ogunniranye
(University of Toledo)
J.A. Woollam Company Scholarship

Sanuthmi Dunuwila
(University of Delaware)
J.A. Woollam Company Scholarship

Yuheng Chen
(Purdue University)
Kathe and Gary Vergason Endowed Scholarship Honoring Michael Andreasen

Aesha Patel
(University of Toledo)
David Glocker Endowed Scholarship

Ian Hoffman
(Purdue University)
Helen & Rolf Illsley Scholarship

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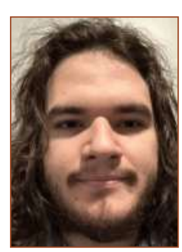

Kevin Euscher
(State University of New York – Buffalo)
SVCF Scholarship

Marta Di Girolamo
(Imperial College London)
SVCF Scholarship

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