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SVC™ Society of Vacuum Coaters

News Bulletin

A Publication for the Vacuum Coating Industry

What's Inside:

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• TVP Water Vapor Cryotraps
• Cryotrap Service and Gas Blends

Telemark's TVP series water vapor cryotraps have fast cool and defrost times, digital communications, heat load management up to 3500 watts, a small footprint, environmentally compliant refrigerant blends, easy access and usability.

In addition to these water vapor cryotraps, Telemark now offers service, spare parts, and mixed refrigerant gas blends for other brands of cryotraps through our expanded 'cryo-refrigeration' service group. Based in our new Cryotrap manufacturing plant in California, and in our east coast service office, this capability will bring a deep level of experience and capability to maintaining, repairing, and re-charging your existing equipment. Contact us for service or to determine if your specific (non-patented) gas blend is available.

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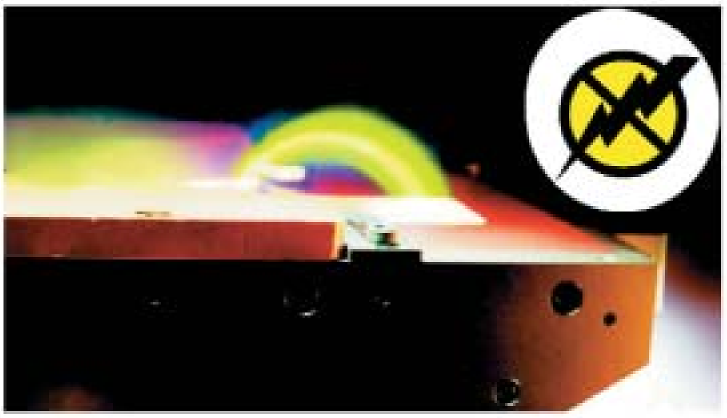

ARC SUPPRESSION FEATURES:

- Operates in hostile particulate laden environments.
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- Operates at pressures >5 X10^{-3} torr
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The Model 880 Controller is based on a multi-microprocessor design, which enables rapid measurement updates with superior resolution, as well as modular architecture. The unit has four slots for I/O cards; each slot can house either an input card (8 optically isolated inputs) or an output card (8 form-C SPDT relays). The sensor-head/source-control modules provide two channels each for crystal frequency measurement and two separate, isolated, analog 0-10 volt (plus and minus) outputs for source control. The 880 can house four such modules, supporting up to eight channels of sensor input and 8 analog outputs, and enabling averaging and co-deposition functions.

Model TT-8

E-Beam Power Supply

- Maximum power 8 kW
- 5 kW tetrode tube for superior instantaneous arc-down recovery with +/- 2% voltage regulation
- 19 Inch rack mountable 15.75" (9U) high & Controller, 1.75" (1U) high
- Adjustable constant voltage maintains stable beam position
- Full remote operation from PLC
- Constant emission current regulation +/- 2%
- Standard sweep includes sawtooth & spiral (oscillating circle) patterns, four pattern memory module, and handheld joystick sweep control.
- Optional programmable sweep

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Letter from the President

First, a big thank you to the membership for attending the 47th Annual Society of Vacuum Coaters (SVC) Technical Conference (TechCon) held at the Adam's Mark Hotel in Dallas, TX. You made it a huge success!

Next, I want to thank the people who worked so hard to put on the TechCon: our management organization (MPI) led by Vivienne and Don Mattox, the Technical Program Committee chaired by Ric Shimshock and Ludvik Martinu, and all the members of the Technical Advisory Committees (TACs). This year for the first time our conference ran for four days due to the addition of the Smart Materials Symposium, jointly sponsored by SVC and Elsevier Publications. This Symposium was very well attended, and we plan to continue the four-day format at the 2005 TechCon in Denver.

The TechCon opened with the Keynote Lecture by Dr. Chikara Hayashi of ULVAC speaking on UHV processing and applications. Outstanding technical sessions followed and are discussed later in this issue by the TAC Chairs. Other TechCon program highlights included the Technology Forum Breakfasts, the Heuréka! Sessions for post-deadline developments, and The Donald M. Mattox Tutorial Program. As always, we offered a wide variety of excellent short courses, providing training at all knowledge levels and taught by industry and academic experts in the various fields. The TechCon also featured, I believe, the best array of exhibitors in our industry.

Sunday evening, Nobel Prize winner, Dr. John B. Fenn, gave the Plenary talk, which was simply delightful. Professor Fenn told the entertaining human side of the struggles in the developments of electrospray, the vacuum techniques used to ionize large organic molecules.

Preceding the Plenary talk, election results were announced at our annual business meeting. We welcomed two new SVC Board of Directors members: Doug Smith and Michael Andreasen. On behalf of the Society, I want to thank outgoing Board members, Angus Macleod, Don McClure, and Tony Broomfield for their many years of valuable service. Don McClure left the Board after serving admirably as Secretary of the Society (and Director) for several years. Your new SVC Officers include Dave Glocker, Secretary; Peter Martin, Vice President; and Clark Bright, President. John Felts became immediate Past President succeeding Tony Broomfield.

At the Awards Ceremony, we honored our 2004 SVC Mentors (Russ Hill, Harold Gadon, and Richard Swisher) for their major contributions to the vacuum coating industry. Please join with me in congratulating them for their outstanding careers and thanking them for their willingness to share their knowledge with others. The 2004 SVC Sugerman Award recipient is Don McClure. Don has contributed greatly to our industry, especially in web coating technology, and to the SVC in a multitude of areas. A special award was also presented to our SVC Technical Director, Don Mattox. In recognition of his major technical contributions and SVC service, we have officially named the tutorials at the TechCon, the Donald M. Mattox Tutorials.

The above is just a sampling of the activities at the 2004 TechCon. I hope you didn't miss it! Mark your calendar now for next year; the TechCon is April 23–28, 2005, in Denver, Colorado!

Looking forward, your new Board and Officers will attend the SVC summer Board meeting in mid June at the site of the TechCon in 2005. In addition to our regular business meeting, we also will have a training session the prior evening to orient and focus the new Board and Officers on strategic SVC topics. We are challenged with many strategic issues, including growing the Society while ensuring that we retain the friendly spirit and industry focus that has made us successful. Please help us to be successful in these tasks by providing your opinions and feedback. You may contact me (cibright@mmm.com), Vivienne Mattox (viviennemattox@svc.org), or any member of the Board. And, if you really are interested in further influencing the course of SVC, join a TAC, run for the Board, and become an Officer. We need your ideas, your help, and your support. Remember, this is YOUR Society.

Clark Bright, 3M Company (cibright@mmm.com), is the SVC President.

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Cover Photo: *Triode Sputtering System, R.D. Mathis Company, 1967.*

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TechCon Perspectives from the Program Chairs

The Dallas TechCon was a success! Feedback from the many attendees was overwhelmingly positive, and the internal metrics we keep on the TechCon are also good. We certainly hope you were able to make it to the 47th Society of Vacuum Coaters (SVC) TechCon held April 24–29th at the Dallas Adam's Mark Hotel and participate in some of the many networking opportunities, partake in some of the educational offerings, spend some time in the exhibit hall with some of the many vendors who make the TechCon their conference of choice, listen and dialogue with the many interesting TechCon lectures and presentations, and catch up with old friends. For those who did participate, we appreciate your investment in time and talents in keeping the SVC TechCon strong and vital. We also appreciate that many of you did take advantage of the good lodging rates at the Adam's Mark Hotel. By electing to stay at the conference hotel, our attendees help keep the cost of TechCon reasonable.

The time invested by the Program and TAC Committees and the MPI team paid off handsomely for the attendees during the four full days of this well-run event. Even with the addition of an extra day, the days were still full! One of our goals was to increase the time for networking, and secondly, to create more time in the program that would allow a trip to the exhibits that did not compete with the many interesting oral presentations at the TechCon. Convening the SVC/Elsevier Smart Materials Symposium at our TechCon allowed us to adjust the TechCon sessions over four days. While we intend to tweak this format slightly for the upcoming TechCon in Denver, judging by the number of side meetings that took place in Dallas and the traffic in the exhibit hall, we think we made good progress on achieving both goals.

The TechCon ran smoothly over the course of the four days. The days were filled with interesting events running from breakfast to late in the evening. The Program Committee and the TACs assembled a strong program. The sessions were full and the addition of the Smart Materials Symposium brought some new faces to the TechCon. Based on the success in Dallas we have decided to continue a similar forum and format next year. The Program Committee is already at work lining up interesting speakers for next year. We will also run the Denver TechCon over fours days as we did in Dallas.

The venue at the Adam's Mark Hotel worked extremely well. It provided ample space for a sit-down meeting with friends and colleagues and for making new acquaintances. We will maintain our approach of co-locating the hotel and meeting rooms for the Denver TechCon. If you have opinions on this—positive or negative—please share these with our SVC Future Sites Committee Chair Pamela Diesing (pdiesing@aol.com) and Vivienne Mattox, our Executive Director and Meeting Planner (viviennemattox@svc.org).

The Plenary talk on Sunday evening by the Nobel Prize winner, Dr. John B. Fenn (father of our own Nat Sugerman Award winner and Past President Dr. John B. Fenn, Jr.), was well attended and was very enlightening and entertaining. The topic of "Electrospray Wings for Molecular Elephants" told the story of the many struggles and developments needed to establish the vacuum techniques necessary to ionize large organic molecules. This technique is used widely now, and will have many future impacts on the characterization of biological molecules. Professor Fenn gave us a very human view of the developments in this exciting field.

The Plenary talk was preceded by the Awards Ceremony, which highlighted the contributions made by our 2004 SVC Mentors, Russ Hill, Harold Gadon, and Richard Swisher, and the 2004 Sugerman Award Winner, Don McClure. A special award was made to our SVC Technical Director, Don Mattox by henceforth renaming the Lunchtime Tutorials as The Donald M. Mattox Tutorial Program.

We were honored this year to have Dr. Chikara Hayashi of ULVAC present the Keynote TechCon Lecture on the many applications of UHV Processing. Dr. Hayashi provided us with an overview of the many implementations that this powerful technology has played in enabling many materials processing applications such as the preparation of specific nanoparticles. He also reviewed some of the many innovations that the researchers at ULVAC developed over the decades and showed some very interesting results from their collaborations with researchers.

The tutorials by Charlie Bishop, Don Mattox, and Don McClure continued to be a great success. Traditionally, these tutorials are well attended and very stimulating. Once again the turnout was high, and the discussions carried on past the allotted time and continued over the course of the TechCon. We look forward to further stimulating tutorials in Denver.

Because we had more room in the TechCon program for extended Technology Forum Breakfasts, we increased both the number of topics and convened them on Tuesday and Wednesday. They were well attended; in fact, they were so well attended that we will need to refine the format so that a general discussion could be held with so many participants. The "Meet the Experts" sessions went well and were extended to a three-day offering.

The success of the Heuréka! session continued, and the format was extended this year to include two full sessions. The attendance was high, and the contributions were interesting. We look forward to the continued success of this forum. The Joint Sessions also worked out well in Dallas, and we look to more use of the Joint Sessions in our future TechCons. We also had a good collection of posters this year and excellent student participation at the TechCon.

Look to the summaries by the TAC chairs of the highlights of their sessions later in this bulletin. I will mention one item here that is of considerable interest and that is that we intend to hold a special session on high-power impulse magnetron sputtering (HIPIMS) as a highlighted topic in a Plasma Processing Session in Denver. Save your presentations and be sure to mark your calendar.

In summary, it was a very successful TechCon. Many people worked very hard to pull off this event, and it paid off. We made some changes, and they seemed to get a positive response. However, we are always looking for your input on the program. Finally, think about joining a TAC, and more importantly, think about making a presentation. We look forward to reviewing your abstracts for Denver this coming October.

Ric Shimshock, MLD Technologies LLC (rshimshock@mldtech.com), and Ludvik Martinu, École Polytechnique, Montreal, Canada (ludvik.martinu@polymtl.ca), are the 2004 and 2005 SVC Program Chairs.

Emerging Technologies

The Monday afternoon Emerging Technologies session of SVC's TechCon 2004 opened with an invited presentation by Gerhard Pfaff from Merck KGaA on special-effect pigments. Most of these optical and functional coatings consist of nanostructured metal oxides on thin mica platelets or on silica, alumina and metal flakes, or are based on liquid crystal polymers (LCP). Aims of new developments are new effects and colors, increased stability, improved dispersibility, and functional properties. Uwe Beck of BAM Berlin introduced a versatile cluster system consisting of three clusters: PECVD cluster, ion-assisted electron beam evaporation, and sputter clusters. The effect of process parameters on layer quality was shown for optical multilayers. Lad Bárdos of Uppsala University followed with a presentation on hot hollow cathode arc deposition of highly oriented Cr and CrN. Reactive PVD rates for highly oriented, dense CrN on steel and silicon reach values as high as 4.5 µm/min. Bill Sproul from Advanced Energy Industries, Inc., reported on the reactive sputter deposition of dielectric Al_2O_3 coatings using high-power pulsed magnetron sputtering (HPPMS) with oxygen partial pressure control and arc handling capabilities in the power supply. Comparison with pulsed DC power sputter deposition was given.

Peter Siemroth of Arc Precision GmbH kicked off the Emerging Technologies session on Tuesday afternoon with the invited presentation on industrial precision deposition by filtered high curent pulsed arc. Ultrathin coatings deposited by filtered high current pulsed arc exhibit enhanced hardness, mass density, and scratch resistance compared to PECVD or magnetron sputtering. Hynek Biederman from Charles University, Prague, reported on RF magnetron sputtering from polymeric targets. Emission of ions from the discharge and ion flux effect on the deposition process were investigated. David Christie from Advanced Energy Industries, Inc., presented a design of a new pulsed-power supply for HPPMS. The power supply has pulse leading-edge control and arc suppression capability, enabling deposition from materials as carbon and aluminum. Wilfred Kittler of Gnomic Enterprises devoted his presentation to a novel method for the continuous production of unsupported

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nanoparticles and nanosheets. Substrateless deposition methods simplify the production process of "thin film particles". The final presentation by Tal David from Tel Aviv University featured p-type Sb-doped ZnO growth by filtered vacuum arc deposition.

Hana Baránková, Uppsala University (hana.barankova@angstrom.uu.se), and Lad Bárdos, Uppsala University (ladislav.bardos@angstrom.uu.se), are the Emerging Technologies TAC Co-Chairs.

Heuréka! Post-Deadline Recent Developments

The "Heuréka!" session is a very important and prestigious forum for important late-breaking results at the SVC TechCon. After its premiere in 2003, the program at the 2004 TechCon in Dallas expanded considerably into two very interesting evening sessions.

The Monday evening session began with the presentation by Jay Lewis from MCNC R&D Institute on electromechanics of highly flexible transparent conductors for display applications. Thin film stacks of ITO/Ag/ITO were described to have favorable properties over single ITO films. Klaus Nauenburg from Leybold Optics GmbH discussed the quality of plasma-polymerized corrosion-resistant layers of new materials in large-scale coating machines for production of car reflectors. He introduced new siloxanes and their mixtures with gases for higher PECVD rates and better corrosion resistance of polymer-based films. Tansel Karabacak from Polytechnic Institute introduced a new strategy in stress reduction in sputter-deposited thin films that use physically self-assembled nanostructures as compliant layers. Decrease of stress (e.g., in sputtered W films) allows much better adhesion and a higher limiting film thickness. David Glocker from Isoflux Incorporated presented results of joint work with Advanced Energy Industries, Inc., on high-power pulsed reactive sputtering of zirconium oxide and tantalum oxide. This novel approach offers very encouraging improvements to the reactive sputtering process. Corinne Nouvellon from Materia Nova described a novel hybrid plasma system based on internal inductively coupled plasma combined with magnetron sputtering for fast deposition of Ti and TiO_2 films at low pressure (10^{-4} mbar range) in a semi-industrial coating chamber (0.5 m^3). The last presentation on Monday evening was given by Nicola Magriotis from the Arcotronics Nissei Group with co-authors from the University of Udine about the vacuum deposition of thick multi-layers on thin flexible polymer substrates. Solving thermal load problems in the fast coating of Cu and Al thick layers on thin web was discussed.

The Tuesday evening session began with the presentation of Bernd Szyszka from Fraunhofer Institute for Surface Engineering and Thin Films (IST) on modeling the reactive sputter process in in-line coaters for architectural glass and its experimental verification. A sophisticated computer simulation model can generate detailed data on the overall process and could allow complete computer control of the real production systems. Hallgeir Klette from Sintef Materials Technology described sputtering of very thin Pd-alloy hydrogen separation membranes. The free-standing Pd foils have diverse applications in hydrogen-related processes. Holger Nörenberg from Technolox Ltd. presented results of work with the University of Oxford on recent developments in measuring permeation through barrier films and an understanding of permeation processes. The work is of interest for testing barrier films (e.g., in the food industry). Gail Ludtka from Oak Ridge National Laboratory presented jointly with individuals from the HY-Tech Research Corporation on aluminum soldering performance testing of H13 steel coated with boron by the cathodic arc technique. Boron has unique properties due to its highly attractive interaction for steel and a repulsive chemical interaction for aluminum. Reiner Kukla from Applied Films GmbH & Co. KG described a new modular roll-to-roll PVD web coater for cleanroom production. Construction details of this novel system were discussed with the audience.

The session was closed by the presentation of W. Klug from Leybold Optics GmbH about the innovative production of high-quality optical coatings for applications in optics and optoelectronics. A sophisticated system with optical monitoring and inductively coupled plasma combined with dual magnetron sputtering in a device with load lock and cassette substrate handling was proved to produce optical multilayer coatings with outstanding properties.

The "Heuréka!" sessions in Dallas were a big success, reflected by a record interest of conference participants and stimulating questions and discussions from the audience. The sessions were a great forum for exciting "hot-off-the-press" developments at the TechCon.

Lad Bárdos, Uppsala University (ladislav.bardos@angstrom.uu.se), and Hana Báránková, Uppsala University (hana.barankova@angstrom.uu.se), are the Heuréka! Session Chairs.

Innovators Showcase

The 2004 Innovators Showcase once again raised the bar in terms of quality and relevance of the subject matter. Special thanks go out to all the participants who took the time and energy to craft a fascinating roster of presentations. The Adam's Mark hotel afforded us ample room and, once again, the SVC staff did a fabulous job ensuring that everything ran smoothly.

Extending the conference for a day and reducing the number of parallel conference sessions from four to three had a dramatic impact on attendance at the Innovators Showcase. This is quite a change from the days (which were not all that long ago) where the majority of the attendees were "booth mates" and competitors! We're on a roll. Let's continue our success in Denver next year!

Frank Zimone, Denton Vacuum LLC, (fzimone@dentonvacuum.com) is the SVC Innovators Showcase organizer.

Joint Session

This was the third consecutive year of the Special Joint Session focusing on Display Technologies. This continues to be the hot topic within the SVC community. Again, this session was organized by the Chairs of the Optical Coating, Web Coating, and Large Area Coating TACs. The Tuesday morning session was moderated by Ludvik Martinu of École Polytechnique and Peter Moulds of Ursa International. The session was kicked off when Martinu introduced the invited presentation, Mechanisms of Vapor Permeation through Multilayer Barrier Films, by Gordon Graff of Pacific Northwest Laboratory. This presentation discussed a thin film of organic/inorganic composite layers on PET that can achieve excellent water vapor permeation rates; further improvements of flexible thin film vapor barriers were discussed. Influence of DC and MF-Sputter Technology on the Qualities of ITO Layers on PET Film and Glass was the second presentation of the Joint Session and was made by Hans-Georg Lotz of Applied Films GmbH. This presentation described the work, tests, and results of comparing conventional DC and MF sputtering of ITO layers. The pros and cons of both methods were discussed. The third presentation of the session was Control of Transparent Conductive and Antireflection Coatings Deposition Process by Viktor Kozlov of Sidrabe, Inc. The presentation dealt with criteria for estimation of the overall performance of magnetron sputtering systems for the deposition of oxide coatings in the reactive process. Osamu Sakakura of Dia Nippon Printing Company gave the next presentation entitled, Anti-Reflection Coating by PECVD on Flexible Substrate. This presentation discussed the increasing need for antireflective films brought about by the display market and the use of PECVD as a temperature and cost advantage for deposition. Paul Hambourger of Cleveland Sate University presented a very interesting discussion, Slightly Conductive Transparent Films for Space Applications: Manufacturing and Durability. Solar panels and other spacecraft surfaces need protection due to charging by particles emitted from the Sun. Vacuum coating of highly transparent, slightly conductive films may be the solution.

The final activity for the Joint Session was the Workshop on Vacuum Coated Flexible Webs for Use in Displays. Again, a special thank you to John B. Fenn, Jr., for coordinating this panel discussion and to those who participated in this well-attended event. The panel members were:

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Johannes Strümpfel of VON ARDENNE ANLAGENTECHNIK GmbH; Hans-Georg Lotz of Applied Films GmbH; Mohtashim Saif of CPFilms, Inc.; Steve Sargeant of Toray Plastics America; Robert Rustin of DuPont Teijin; Charles A. Bishop of C.A. Bishop Consulting Ltd.; and Don McClure of the 3M Corporate Research Materials Laboratory. After an overview by John B. Fenn, Jr., each panel member presented a brief summary of their company's developments, concerns, plans, and progress toward a truly functional flexible display. A brief audience discussion followed.

The panel members represented many aspects of the market for the use of vacuum coated flexible webs in the display industry, both present and future. Even though they came from diverse backgrounds such as the vacuum equipment manufacturers, the substrate producers, the vacuum converts, and end users, there was a definite consensus reached on several important points during the discussion. The following is a summary of the critical points that were raised.

• The substrate itself was identified as one of the keys to a successful entry into the display market. It was obvious that "standard" polymer films off the shelf do not have the properties of surface smoothness, low debris contamination, and process temperature compatibles that current designs of flexible displays require. However, the issue of the cost of engineering and making acceptable flexible substrates kept coming up. The general feeling was that unless there was a "killer application" that could only use plastic materials, glass substrates would remain competitive.

• It was pointed out several times that the sheet resistivity of the transparent conductive coatings was currently not low enough for OLEDs and other applications. Also, the rising cost of indium is causing concerns in this market that is now based on using indium tin oxide as the TCO of choice.

• Substrate handling and processing these materials in a suitable cleanroom environment, estimated to be at least class 100, were also mentioned by many of the panel members. Also, the yield factors involved with every processing step were stressed as well.

• The ever-present issue of suitable vapor barrier layers was raised continuously. It is still not clear that a cost-effective and robust barrier material exists for use with plastic-based OLEDs. However, there were many other flexible display designs, such as e-paper and lids that do not have as stringent requirements as the OLED materials do.

• The last issue consistently mentioned was the question, "Is there enough marketing information available now that could help guide potential manufacturers in decisions of where to invest the capital and development effort?" Right now there are many opportunities, but will all of them succeed?

In spite of the concerns enumerated, the overall feeling presented by the panel was one of optimism. Almost everyone on the panel felt that there were good opportunities valuable to members of the flexible vacuum coating community to participate in this opportunity, even if it is not clear yet where the best bet lies.

Peter J. Moulds, Ursa International Corporation (ursaintL@earthlink.net), Ludvik Martinu, École Polytechnique (ludvik.martinu@polymtl.ca), and Michael Andreasen, VON ARDENNE Coating Technology (michael.andreasen@vact.com), worked jointly to develop this session.

Large Area Coating

Thanks to all of the presenters who, during the two Large Area Coating Sessions of the 2004 SVC TechCon, covered a broad range of applications, processes, equipment, and basic improvements in technology of interest to the Large Area Coatings community.

Highlights of the first session included the following. Steve Selkowitz, Lawrence Berkeley National Laboratories, led off the session on Tuesday morning, presenting an invited talk titled, Saving $40B per year: Performance Needs for Energy-Efficient Coated Glazings in Buildings. Selkowitz showed that buildings account for one-third of all energy use in the United States and showed ways that coatings can help meet the U.S. Department of Energy goal of "Zero Energy Buildings" by 2025. Data were presented on the costs and impacts that solar control, low emissivity, and active coatings have had and can have on HVAC load in buildings in different climate areas—enough to meet the DOE goal if combined with innovative fenestration technologies to reach U values under 0.15. In fact, one low-E coater capable of producing 200 million square feet per year of low-emissivity coatings can save the equivalent of 36 million gallons of oil—and that equals the production of one off-shore oil platform. This presentation was followed by three discussions in the area of reactive sputtering of SiO_2 and TiO_2, two of the most important materials for large area coatings.

Roman Nyderle of Fraunhofer presented Reactive Pulsed-Magnetron Sputtering of SiO_2: Influence of Process Parameters on Layer Properties. This presentation explained using pulse-packet mode deposition as a means to adjust layer properties in SiO_2 and other reacted materials. Deposition rate, residual stress, and surface roughness were shown to be conjointly influenced by changing the pulse parameters while holding other deposition conditions constant.

John Davis of Applied Films presented High-Power Pulse Reactive Sputtering of TiO_2 in which he showed that the deposition rate using HPPMS with a rotary magnetron is less for comparable power than DC sputtering; but, there is an increase in the index of refraction, possibly due to increased density of the deposited films. Phil Greene of VON ARDENNE presented Plasma Emission Monitoring of Low-Rate Materials on Rotating Cylindrical Magnetrons. Greene showed new data on the PEM closed-loop control system operating high on the transition curve with SiO_2 and TiO_2. For TiO_2, stable deposition rates of up to six times the 100% O_2 rate with +/- 2% cross-coater thickness uniformity with on-average operator intervention only every four hours were attained. For SiO_2, deposition rates of five times the 100% O_2 rate with +/- 2% uniformity were achieved.

Dermot Monaghan of Gencoa then presented Principles and Techniques for

Thickness Uniformity Control in Planar Magnetron Sputtering. Monaghan showed how to use variables of target size, target-to-substrate separation, substrate motion, magnetic field design, materials, and gas pressure to simulate the coating distribution. We then had three presentations discussing improvements to sputtering equipment.

Jim Rietzel of VON ARDENNE led off with Enhancements to Rotating Cylindrical Magnetrons in which he discussed recent improvements to rotating cylindrical magnetrons for higher quality and lower cost. Rietzel showed the operating principles of a new AC (or DC) end block designed to run at up to 400 amps and an improved magnet bar incorporating a center support for improved cross-coater uniformity. Data were shown from full-width industrial coaters supporting +/-2% thickness uniformity or better at high rates for all of the normally used reacted materials. Rietzel also showed the results of experiments with slow-sputtering metal rings at the ends of the targets that allow target utilization into the 90+ % range.

Michael Geisler of Applied Films presented Latest Developments and Applications of Large Area Coaters. Geisler showed recent progress on an architectural glass horizontal coater design with respect to chamber configuration, process tooling, and process control technology. Geisler discussed flexible bays (pump/cathode), tooling for uniformity, closed-loop process control, and their impact on improving cross-coater and lead-to-trail thickness uniformity. Examples of use for heat-treatable coatings were provided.

Thomas Rettich of Huettinger presented Arc Management in DC and MF Generators for Large Area Coating Systems, a favorite topic for large area coaters. Rettich showed how Huettinger's digital signal processor (DSP) based arc suppression system with adaptable (user-configurable) parameters can be configured to stabilize deposition at optimum deposition rate, film quality, homogeneity, and optical properties. Examples from production coating systems were provided.

The final presentation of the first session was made by Johan Zijp, TNO TPD, on the topic High Rate Evaporation of Alloys, which explained the use of choked orifices in the vapor streams that, when properly disposed, can independently control the vapor flow for mixing and compositional control on the substrate. Zijp showed results from the deposition of Zn-Mg on a coiled metal strip where the deposition rate could be predicted from the temperature of the vapor generator.

Highlights of the second session on Large Area Coating included the following. The first four papers constituted a mini-conference on targets and target technology. James Finley of PPG led off with an invited presentation, Effects of Methods of Manufacturing Sputtering Targets on Characteristics of Coatings. Finley discovered that starting with the same composition of pre-alloyed TiAl powders, hot isostatic pressed targets showed a very fine grain microstructure with no porosity versus cast targets, which showed shrinkage porosity and a variation in grain size ranging from fine near the edges to very course in the center. Even so, there was essentially no difference in DC sputtered film properties, deposition rates, or arcing rates.

Frank Jürgens of Fremat followed with Rotatable ZnO Targets: a New Generation of Ceramic Targets. Jürgens showed a capability to manufacture homogeneous ZnO targets with 95% theoretical density. These are made by mixing the materials at high energy, pressing and sintering up to 25 mm thick tube segments, then joining the tube segments onto a steel cylindrical backing tube. Such targets have been successfully tested in a large area coater for about six months.

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The next presentation was by Falk Milde of VON ARDENNE on Sputtering of Conductive ZAO Films from Metallic and Ceramic Targets Using Planar and Cylindrical Magnetrons. The reactive cylindrical magnetron ZAO deposition process was investigated and compared to planar reactive and ceramic target deposition processes. Good layer properties were obtained with both planar cathodes and cylindrical magnetrons, using DC, pulsed-DC, and AC power in the transition mode. With thick layers, layer properties close to the theoretical limit were obtained as shown by SEM micrographs, XRD data, and optical modeling. The AC cylindrical magnetron reactive ZAO deposition seems to be very promising, especially with regard to lack of nodule growth, which can limit production when using planar cathode processes.

The last presentation in the target mini-conference was presented by Jocelyne McGeever of Technology Assessment International on the topic New Sputtering Targets: to Test or Not to Test? Using the example of silicon aluminum targets, McGeever showed how a sensitivity analysis of the cost versus potential benefit prior to committing to testing can help make the decision about whether or not to spend resources on testing.

The next presentation, by Guy Buyle of Ghent University, discussed Characterization of the Electron Movement in Varying Magnetic Fields and the Resulting Anomalous Erosion. Anyone interested in improving magnetron performance will be interested in reviewing this presentation that shows, for example, that the height of ionization above a target surface can decrease when the electrons go from a strong to a relatively weak magnetic field.

Russ Pylkki of Aspen Research then gave a rare glimpse into the requirements of end users in his presentation, Glass Coating: What Window Manufacturers Want. Pylkki provided numerous data on the residential window market, discussing how it has grown and the conditions for further growth of coatings. For example, Pylkki showed that of the 100 million residences in the United States, approximately 10% have low emissivity coatings, due to the preponderance of older homes. This means there is still a great opportunity for low emissivity coatings in the United States. Windows are being replaced at about 2 to 3% per year now and 50% or better of these have low emissivity coatings. According to Pylkki, going forward, window manufacturers want temperable, low-emissivity coatings with high selectivity, antireflective, and self-cleaning properties, as well as dynamic coatings for shading and privacy. Pylkki states that consumers would be willing to pay $5,000 to save $1,000 per year in energy costs.

Soren Berg of Upsalla University followed with a presentation on The Influence of Rotating Magnets on Hysteresis in Reactive Sputtering. In this presentation, Berg discussed the case of the rotating cylindrical magnetron where the target is rotating through a fixed magnetic field and when not in the field itself is subject to overcoating and chemical reaction with reactive gases to produce slow sputtering compounds. A mathematical model of the dynamic system was presented and validated with experimental observations, one of which is that the speed of target rotation influences the reactive sputtering process so that the hysteresis region is shifted.

Anja Blondeel of Bekaert followed with Optimizing AC Switching Parameters for Rotating Cylindrical Magnetron Sputtering in which some surprising results were presented. Blondeel showed that there is a loss of power with increasing power supply frequency, which is partially dependent on the sputter gas (oxygen, -12%) having twice the loss of argon or nitrogen. The experimental setup used a commercially available variable frequency-switching unit in combination with a DC power supply.

Also shown was that process parameters such as plasma restoration time, anode voltage, arc rates, cross-coater uniformity, and deposition rate are also frequency- and sputter-gas dependent, with arc rate decreasing at higher frequencies, and uniformity and deposition rate increasing at lower frequencies.

The final presentation of the session was Cylindrical Magnetron Sputter Deposition of Chromium Coatings for Erosion- and Wear-Resistant Application made by Krystyna Truszkowska of Benet Laboratories. This interesting presentation discussed sputter coating as an environmentally friendly way to coat a chromium hardcoat on the bore (inner) surface of long gun tubes. Data on the resultant coating hardness, adhesion, fracture, etc. were presented and thoughts on how to improve hardness were proposed.

All in all the Large Area sessions provided a wide assortment of technology updates to challenge our thinking processes and stimulate further advances in the field.

Michael Andreasen, VON ARDENNE Coating Technology (michael.andreasen@vact.com), is the Large Area Coating TAC Chair, and Johannes Strümpfel, VON ARDENNE ANLAGENTECHNIK GMBH (struempfel.johannes@ardenne-at.de), is the Assistant TAC Chair.

Optical Coating

From the point of view of those interested in Optical Coatings, the 2004 Technical Conference of the SVC was again very successful. The three half-day sessions attracted three invited speakers, two student presentations, 14 contributed talks, and four poster presentations. This does not include the optical coating presentations that were made during the Special Joint Session on Display Technologies and Control of Energy. This number of presentations is somewhat smaller than at last year's Technical Conference, but it is still very impressive considering the unusually large number of competing thin film conferences that will be held this year. As in previous years, the sessions provided a good overview of current developments in our field.

The first Optical Coating session on Monday morning was devoted to the topic of Processes for Advanced Optical Coatings. It was opened by an invited presentation on the Interface Engineering and Growth Control for High Reflectance Soft X-Ray Multilayer Mirror Coatings by Jens Birch, Linkoping University. This talk was followed by five contributed presentations: Advanced TCO and CIS Coatings through the Pulsed-Magnetron Sputtering of Powder Targets (Peter Kelly, University of Salford), Flexible and High-Throughput Deposition of Multilayer Optical Coatings Using Closed-Field Magnetron Sputtering (Des Gibson, Applied Multilayers Ltd.), Reactive Low-Voltage Ion Plating Plasma-Assisted Deposition: A New Perspective for Optical Coatings (Carlo Misiano, Romano Film Sottili SRL), Multilayer Protective Coatings for Polycarbonates Prepared by Plasma-Enhanced CVD (Zuzana Kucerova, Masaryk University, Czech Republic, a student presentation), and Improving Rate Control in Electron Beam-Evaporated Optical Coatings: the Role of Arcing and Controller Tuning (Michael Gevelber, Boston University).

The Tuesday afternoon session on Optical Filters and Thin Film Systems opened with an invited talk by Jerzy (George) Dobrowolski, National Research Council of Canada (retired), entitled, Developments in Materials and Processes: Key to Advances in Thin Film Design. This was followed by four contributed presentations: Broad-Band Antireflection Coating Design Recommendations (Ron Willey, Willey Optical, Consultants), The Production of Ultra-Low-Loss AR Coatings (Ian Stevenson, Denton Vacuum LLC), Application of Ion Beam-Assisted Thin Film-Deposition Techniques to the Fabrication of a Biosensor Chip with Fieldability Potential for Important Biohazard Detection Applications (Dale Morton, Denton Vacuum LLC), and Manufacturable Filter for CWDMs (David Cushing, 3M Precision Optics, Inc.)

The Wednesday afternoon session was devoted to Optical Metrology and New Photonics Materials. The invited talk that introduced the session was presented by Claude Amra, Institut Fresnel Marseille, and was entitled, Light Scattering, Photothermal Microscopy, and Laser Damage of Optical Interference Coatings. It was followed by seven contributed presentations: Optical Response from Single- and Multilayer Metal/Dielectric Nanocomposite Thin Film Systems (Jean-Michel Lamarre, École

Polytechnique, a student presentation), Structural Characterization of Wurtzite AI_{1-x} In_xN $(0.1<x<0.9)$ Grown by Dual Reactive DC Magnetron Sputter Deposition (Timo Seppänen, Linkoping University), Versatile Reactive Sputtering Batch Drum Coater with Auxiliary Plasma (Mark George, Deposition Sciences, Inc.), High Reflectivity Protected Silver Coatings on Stainless Steel and Aluminum (Frederic Sabary, CEA Le Ripault), Optical and Structural Analysis of Annealed SiO_x Thin Films Deposited by ECR-PECVD (Tyler Roschuk, McMaster University), How to Have Clean Surfaces in an Unclean World (David Allred, Brigham Young University) and finally, the last talk of the optical thin film sessions, Interface Engineering of Porous/Dense Multilayers of Silicon Nitride: In Situ Real Time Spectroscopic Ellipsometry Study (Ludvik Martinu, École Polytechnique). Once again, it appeared that the audience was well satisfied with the offered program.

Ludvik Martinu, École Polytechnique, Montreal, Canada (lmartinu@polymtl.ca), is the Optical Coating TAC Chair, and George Dobrowolski, NRC, Ottawa, Canada (dobrowolski@magma.ca), is the Optical Coating TAC Assistant Chair.

Plasma Processing

This year's Plasma Processing sessions were very successful in attracting a diverse selection of exciting and engaging technical presentations. Our first invited speaker was Mark Sobolewski of the National Institute for Standard and Technology (NIST) who demonstrated an experimental and theoretical formalism for extracting detailed and sometimes elusive information pertaining to the ion energy distribution and the ion flux to a surface under plasma from rather well-characterized and careful current and voltage measurements. Richard Van de Sanden of Eindhoven University of Technology showed us a novel plasma source, the expanding thermal plasma (ETP) and the exciting surface deposition possibilities it can provide due to the unique fundamental properties of the source. Both sessions were well attended and the invited talks generated a great deal of post-session discussions.

In addition to our invited speakers, our talks emanated from academic, government, and industrial laboratories. We were intrigued by innovative applications of electron beam-generated plasmas to nitride steels for hardcoating. We heard talks that sought to employ innovative two-dimensional magnetic modeling to optimize the design of magnetrons. We were impressed by the efforts made to innovate, scale, and implement a chromium coating tool and process for the interior of canon barrels! Four talks centered on the fundamental understanding and application of high-power impulse magnetron sputtering (HIPIMS). We were delighted by a "real-world" application of PECVD coating of SiOx and hard carbon films as for diffusion barriers as a means to extend shelf life for soft drink and beer containers. The speaker even brought the bottles to the talk! We heard many excellent plasma diagnostics presentations consisting of pulsed absorption spectroscopy; ion energy resolved in situ mass spectrometry, and semi-quantitative optical emission spectroscopy. Finally, our sessions always enjoy being a forum for the debut of a new or novel plasma source or process, and this year was no exception. We were treated to at least three presentations that introduced an atmospheric pressure source for cleaning wires, a large area source for CVD diamond deposition, and a scaleable, modular ion source for surface modification.

Next year we hope to continue our tradition of bringing the highest-quality technical presentations to the Society with the introduction of the latest sources, diagnostic techniques, processes, and plasma science in the community. In fact, there was so much interest in HIPIMS that we will have a special session devoted to this promising and burgeoning processing technology (see announcement on page 12).

Finally, in addition to our growing areas of technical interest, we have three new members of the Plasma Processing TAC. This TAC is the perfect vehicle for members who wish to contribute to the manner and direction in which SVC addresses plasma science and technology.

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If you are interested in joining the SVC Plasma Processing TAC, please do not hesitate to call upon any of the members!

Vasgen A. Shamamian, Dow Corning Corporation (v.shamamian@dowcorning.com), is the Plasma Processing TAC Chair, and Scott G. Walton, Naval Research Laboratory (sgwalton@ccs.nrl.navy.mil), and Falk Milde, VON ARDENNE ANLAGENTECHNIK GmbH (milde@ardenne-at.de), are the Assistant TAC Chairs.

Process Control & Instrumentation

The SVC Process Control & Instrumentation TAC focuses on the instruments, controls, and methods that make thin film coatings possible. This year's TechCon session proved both interesting and informative in presenting some new approaches to controlling thin film deposition processes.

The session started with our invited presentation, Modeling of Sputtering Equipment, Process, and Film Growth as an Engineering Tool: Building a Virtual Sputter Tool, by Jacques Kools of Veeco Instruments. The presentation described the use of computer modeling to simulate the thin film process to reduce the trial and error, guesswork, and costs that often accompany the development of thin film production tools and processes. Modeling techniques were applied to the deposition equipment, the process, and film growth to create a virtual sputter tool. This tool then becomes a practical and cost-effective way to develop new thin films. As the cost of computing power continues to come down, these modeling techniques are expected to become more widely used in thin film development.

The second presentation was Effective Closed-Loop Control for Reactive Sputtering Using Two Reactive Gases, by Dan Carter of Advanced Energy Industries. Two-reactive-gas sputtering is useful in producing binary compound thin films, which are increasingly used for electrical, optical, wear-resistant, and many other functional coatings. But, the presence of two reactive gases adds significant complexity to the process control because of competing reactions. The presentation reviewed the difficulties associated with controlling these processes and offered a solution based on partial pressure signals to control the process and the resulting complex compound materials.

Our third presentation described reactive sputtering control from a different perspective. Victor Bellido-Gonzalez, of Gencoa Ltd., presented Flexible Reactive Gas Sputtering Process Control. He described a high-speed control algorithm for gas input control, using plasma emission monitoring or target voltage monitoring as the control input. Several alternative process control structures were illustrated.

Our fourth presentation was Stabilizing RF Generator and Plasma Interactions, by Victor Brouk of Advanced Energy Industries. This presentation investigated how the characteristics of the plasma process system interact with the RF delivery system to influence the stability of the plasma. A means for quantifying the stability factor for the system was described, and some methods were presented for configuring the RF delivery and plasma process systems for optimum and stable operation.

Our fifth presentation, Fundamentals of Feedback Control for Batch Coating Reactive Sputtering Processes, was made by Mark George of Deposition Sciences. The presentation characterized the non-linear hysteresis involved in controlling a reactive sputtering process and the various methods employed to overcome these challenges. The presentation discussed control system hardware and some control algorithms that achieve steady-state operating points in less than 500 msec on some drum coaters.

Our next presentation, by Werner Klug of Leybold Optics, was High Accurate In-Situ Optical Monitoring for Multilayer Coatings. The presentation described a single-wavelength optical monitor used to improve the accuracy of layer thickness in a batch coater, resulting in improved production yields. The device has application in plasma-assisted evaporation and magnetron sputtering and is useful for

Nobel Prize winner Dr. John B. Fenn (left), and Ric Shimshock, SVC Program Chair. Dr. Fenn presented the Plenary Speech at the Opening Ceremonies during the TechCon in Dallas.

John B. Fenn's Plenary Speech a Highlight of the 2004 TechCon

One of the highlights of this year's SVC Technical Conference held in Dallas, TX, was the Plenary Speech given by Dr. John B. Fenn of Virginia Commonwealth University. Dr. Fenn won the Nobel Prize in Chemistry in 2002 for his pioneering work in the development of an analytical tool, called electro spray, that allows for the accurate measurement of masses for large complex molecules such as proteins. This technology, in combination with mass spectrometers, has helped to revolutionize the biochemical and biomedical industries.

The electro spray concept, which Dr. Fenn describes as helping molecular elephants to fly, allows for a single large molecule to be put in the vapor state by evaporating the solvent off an ionically charged liquid droplet. This concept evolved from his efforts in characterizing molecular beams while working at Princeton and Yale Universities. Once in the vapor state the mass of the molecule can then be accurately determined by using a mass spectrometer. In his speech, Dr. Fenn reviewed the history of molecular beams, which are basically generated by using a small hole, called a gas nozzle, to emit gases into a large vacuum chamber. In total, 12 Nobel Prizes have been awarded to people involved in the science of molecular beams. He peppered the technical aspects of his presentation with personal stories and tales of his own experiences in the field. All in all, it was a speech that appealed to the entire audience, and an interesting and enjoyable way to kick off the 47th Annual SVC TechCon.

First Call For Papers for the 2005 TechCon

Special Session on High-Power Impulse Magnetron Sputtering (HIPIMS)

High-power impulse magnetron sputtering (HIPIMS) is a subject of growing interest that has found its first applications in hard coatings, substrate pretreatment, low friction, and optical layers. The high ionization of the HIPIMS plasma provides opportunities to develop novel and improved materials with unique microstructure and macroscopic properties. HIPIMS processing requires a fundamental understanding of the dynamics in the plasma, on the target and the substrate surface as well as strong development of the hardware. The SVC's Plasma Processing TAC is proud to invite you to discuss and hear about all these topics and more in a special session devoted to the HIPIMS technique. Please plan to attend what should prove to be an engaging and informative technical session devoted to the burgeoning field. For information please contact the Plasma Processing TAC Chair, Dr. Vasgen A. Shamamian (v.shamamian@dowcorning.com) or Dr. Artutiun P. Ehiasarian (a.ehiasarian@shu.ac.uk).

multilayer optical devices such as band pass filters, steep edge filters, and AR coatings.

The next presentation, Computer-Aided Design and Analysis of Optical Transmittance and Electromagnetic Shielding Efficiency on Conductive Antireflective Coatings, was made by Jen-chieh Yang of National Cheng Kung University. A computer-aided design model was described for analyzing thin film composition from sputtering or evaporation,and predicting optical and electromagnetic shielding properties.

Our final presentation, Combination Gauges: Responding to the Technological Challenges, was made by Steve Smith of Helix Technology. The presentation described some of the difficult challenges faced in making vacuum measurements over the wide range of pressures found in thin film processes and described some of the novel solutions used to meet those requirements.

J. Grant Armstrong, Carberry Technologies (JGrantA@carberrytech.com), and David Chamberlain, MKS Instruments, Inc. (dave_chamberlain@mksinst.com), are the Process Control & Instrumentation TAC Co-Chairs:

Photo by Jowdy Photography

Don McClure's Lunchtime Tutorial entitled, "Web Coating for Fun and profit - Lessons from Two Decades of Making it Happen," was one of the many popular seminars at the 2004 TechCon. Don McClure was also honored this year as the winner of the 2004 Nathaniel H. Sugerman Memorial Award (see page 17).

Tribological & Decorative Coating

The Tribological & Decorative Coating sessions consisted of 11 contributed and 4 invited presentations. Professor John Moore from the Colorado School of Mines delivered an invited presentation on the development of a functional surface for die casting operations. The development of the functional surface included optimization of the substrate metallurgy and the deposition of nanostructured coatings by pulsed-plasma reactive magnetron sputtering. The microstructure and properties of the coatings were correlated with characteristics of the plasma produced during the deposition process.

Mahmoud Taher of Caterpillar Inc. presented results of studies on metal-carbide reinforced diamond-like carbon coatings for gear applications performed as part of a joint

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program between Caterpillar, United Technologies, and the J. A. Woollam Company.

One focus of this program is to determine the criticality of coating deposition parameters and to develop in situ means of monitoring those process parameters. Taher presented findings correlating in situ plasma diagnostics and spectroscopic ellipsometry with each other and with the chemical composition of the diamond-like carbon matrix of the coatings.

Herb Gabriel from Plasma und Vakuum Technik presented an overview of refinements and developments that have occurred in the area of cathodic arc evaporation processes for the deposition of hard, wear-resistant coatings. In particular, Gabriel discussed how developments in cathodic arc evaporation have spawned the creation of coating deposition systems so large that building structures are designed and erected around the deposition systems.

In his invited presentation, Roughua Wei from Southwest Research Institute described the conceptualization and development of a metal plasma source to be used for metal plasma immersion ion implantation and deposition in the same chamber. With this technology, a seamless transition between ion implantation and coating deposition can occur, offering the benefits of enhanced corrosion resistance, enhanced coating adhesion, and functionally graded substrate and coating microstructures.

One highlight from the contributed talks was Hans-Joachim Scheibe's (Fraunhofer Institute) presentation of novel concepts in the area of laser arc deposition of tetrahedrally bonded amorphous carbon for wear-resistance applications. Scheibe's novel process seems to be the first commercially viable process capable of making these technologically valued coatings with minimum particulates. His presentation included brilliantly devised computer generated animations of the process that provided the audience a better grasp of the novelty of the process.

Papken Hovsepian from Sheffield Hallam University presented methods in which Ti and Nb deposited by PVD processes, then subsequently treated with anodic oxidation can be made virtually any color desired. Many of these surface treatments were corrosion and wear resistant.

Ales Kolouch of the Technical University of Liberec gave one of this year's student presentations. Kolouch discussed a comparison of the deposition and characterization of titanium oxide thin films produced by PVD and plasma enhanced CVD processes.

Dale McIntyre, Vapor Technologies, Inc. (dmcintyre@vaportech.com), is the Tribological & Decorative Coating TAC Chair, and Gary Doll, Timken Research (gary.doll@timken.com), and Roel Tietema, Hauzer Techno Coating BV (rtietema@hauzer.nl), are the Assistant TAC Chairs.

Vacuum Web Coating

The Vacuum Web Coating Technical Advisory Committee (Web TAC) put together two sessions for the 2004 TechCon, along with a joint session in cooperation with the Optical TAC and the Large Area TAC. Thank you to the members of this committee who actively worked to make this year's Vacuum Web Coating sessions a great success. A special thanks to John Fenn, Jr., for coordinating the Panel Workshop and Discussion on Vacuum Coated Flexible Webs for Use in Displays.

The opening session, Substrates, Coating Materials, and Applications, was moderated by Peter Moulds of Ursa International Corporation and Craig Outten of Outten Technical Consulting. John Affinito of Helicon Research led off this year's session with his invited presentation, A New Class of Ultra Barrier Materials. With 165 people in attendance, the interest in high-barrier flexible substrates and high-barrier encapsulation for flexible displays is confirmed. Metallized Polymer Films as Replacement for Aluminum Foil in Packaging Films was presented by Wolfgang Decker of Toray Plastics America. His presentation pointed out the advancement and advantages in using metallized polymer films as an alternative to aluminum foil. Angelo Yializis of Sigma Technologies presented UV versus Electron Beam Radiation Curing of Vacuum Deposited Polymer Leveling Coatings for Ultra-High-Barrier Applications. He discussed a cost-effective, promising technology for enhancing the gas and moisture barrier properties of polymer webs used in a variety of applications, from food to display packaging. Development of a Pilot Manufacturing Process for High-Volume Catalyzation of Fuel Cell Electrodes was presented by James Arps of the Southwest Research Institute. This presentation discussed a high-volume process for reducing the costs of membrane electrode assemblies for automotive fuel cell applications. As discussed in the committee meeting, the Web TAC would like to expand the theme of energy generation for the next technical conference.

The next presentation was Reactive Sputter Deposition in the Manufacturing of an Optical Biosensor by S. Schulz of SRU Biosystems. His presentation described the use of vacuum web processing in the manufacture of optical biosensors for label-free, high-throughput screening applications in the pharmaceutical industry. The last presentation of the session was an excellent one entitled, Ultra-High Barrier Coatings on Polymer Substrates for Flexible Optoelectronics: Water Vapor Transport and Measurement Systems and was presented by Ahmet G. Erlat of General Electric Global Research. Devices such as OLEDs require extreme water vapor transmission rates (WVTR). This presentation dealt with recent results to address both barrier and measurement issues.

The final session was on Processes, Process Control & Packaging and was moderated by

Roger Kelly of Amcor Flexibles Camvac. The invited presentation for the session was given by Bernard Henry from the University of Oxford, UK. The presentation, titled Gas Barrier Properties of Transparent Metal Oxide Coatings on PET Film, was the latest in a series from the same group, and it reviewed the science to bring us all up to date and then went on to try to change the thinking on which materials should be used in barrier coatings. Bernard ended his talk with a brief tribute to a colleague, Prof. Ron Howson, a long time supporter of SVC, who died earlier this year. Along with sharing his knowledge, Howson also shared his enthusiasm and sense of fun with his colleagues. This presentation was followed by Possible Future Trends for Aluminum Metallizing, given by Charles A. Bishop of C.A. Bishop Consulting Ltd. that gave an insight into some of the trends in metallizing and what might have to be done to make metallizing more profitable in the future.

The next presentation, Electron Beam Web Coating—Not only for Consumables? from Applied Films GmbH & Co was presented by Rainer Ludwig, who gave a positive view on the cost effectiveness of using electron beam deposition for multilayer optical coatings as well as the more usual high-volume coatings. This was followed by another presentation on electron beam deposition given by Ekkehart Reinhold of VON ARDENNE ANLAGENTECHNIK GMBH, High Speed EB-PVD Web Coating—A New Coater Concept for New Applications. This presentation included results from a prototype web coater that was designed with some of the newer multilayer optical coatings in mind and based on layers of titania and silica.

Rolf Rank of the Fraunhofer Institute for Electron Beam and Plasma Technology presented the talk, Adhesion Promotion Techniques for Coating of Polymer Film. This topic continues to be of great interest as the materials may change, but the need to control the adhesion never does. Increasing web speeds and changing plasma source design has increased the variations available, and this presentation addressed these issues.

This was followed by a presentation that dealt with another one of the problem areas of vacuum coating. Buckling or Wrinkling of Thin Webs off a Drum was presented by Mike McCann of McCann Science, and it detailed how wrinkling occurs and showed why downgauging can be a problem and why using clean web and cleaning the deposition drum can help prevent wrinkles.

The final presentation of the session was given by Al Douglas, Jr., of Flex Products and was entitled, The Application of Reliability Centered Maintenance (RCM) to High Volume Thin-Film Coaters. This presentation described what was a new (to most of the audience) method for reducing the amount of lost machine time due to machine or process failures in a way that was demonstrably cost effective.

Roger S.A. Kelly, Amcor Flexibles Camvac (roger.kelly@amcor-flexibles.com), and Peter J. Moulds, Ursa International Corporation (ursaintL@earthlink.net), are the 2004 TAC Co-Chairs. Charles Bishop, C.A. Bishop Consulting Ltd., (CABishopConsulting@cabuk1.co.uk) joins Peter Moulds as the new Web TAC Co-Chair for 2005.

Smart Materials Symposium

The Smart Materials Symposium took place on April 28–29 as part of the 47th Annual SVC Technical Conference. The Symposium included 18 presentations by authors from Australia, Bulgaria, France, Japan, Portugal, Sweden, Turkey, and the United States. The interest in the Symposium was encouraging, with the attendance usually between 50 and 100 people per talk.

The Smart Materials Symposium demonstrated, among other things, that the interest in switchable glazings—capable of varying the throughput of light and solar energy in windows—is growing. This was emphasized by Greg Sottile, Research Frontiers Inc., who presented recent results of a study of the knowledge of this emerging technology by American architects. New research results on electrochromic materials for switchable glazings (often referred to as "smart windows") were presented by Nilgun Ozer of San Francisco State University, Kostadinka Gesheva of the Bulgarian Academy of Sciences in Sofia, Vasco Texeira of the University of Lisbon in Portugal, and others.

Technology for switchable glazings, especially the ones based on electrochromic materials, is commonly regarded as ready for widespread market introduction and is currently worked on by a number of companies in the United States, Europe, and Japan, as surveyed by Carl Lampert, Star Science. Electrochromic automotive sunroofs will be introduced on some

Elsevier Helps Make the Smart Materials Symposium Possible

The Society of Vacuum Coaters wishes to acknowledge the support of Elsevier in organizing this successful Smart Materials Symposium.

Thanks also are extended to members of the Organizing Committee: Carl M. Lampert, Star Science; Ric Shimshock, MLD Technologies; Claes G. Granqvist, Uppsala University, Sweden; Ludvik Martinu, École Poytechnique, Canada; and Peter Martin, Battelle Pacific Northwest Laboratory.

Plans to repeat this successful experiment are already underway for the 48th SVC Annual Technical Conference in Denver.

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Photo by Jowdy Photography

Panel members for the Workshop on "Vacuum Coated Flexible Webs for Use in Displays" included Johannes Strümpfel, Hans-Georg Lotz, Charles Bishop, Hassan Memarian, Robert Rustin, Steve Sargeant, and Don McClure (see pages 7 and 8).

European cars already in the summer of 2004, as disclosed in an invited presentation by Jean-Christophe Giron of Saint Gobain Sekurit Deutschland in Germany. Other applications, especially related to polymer-based eyewear such as ski goggles and variable-transmittance visors for motorcycle helmets, were presented by Claes Granqvist of Uppsala University and Chromogenics, in Sweden. Many of the applications related to electrochromics employ thin films based on tungsten oxide. An economic analysis of thin film deposition by different technologies was given by Philip Henderson of Air Products and Chemicals. An alternative to electrochromic oxides in the future may be electrochromic polymers; research in this rapidly developing field was given by John Reynolds of the University of Florida in Gainesville.

Numerous other presentations were made, but only a few will be mentioned here. An invited presentation by Yoel Fink of the Massachusetts Institute of Technology pointed out the possibilities of integrating sophisticated concepts such as photonic band gap structures in optically functional textile yarns. Barrier films for food packaging is an important field, and the advantages of using a new high-density plasma source were delineated by John Madocks of Applied Process Technologies. Surface chemical properties are frequently of much interest for oxide coatings, and the role of hydroxyl groups was emphasized by Satoshi Takeda of the Asahi Glass Company in Yokohama, Japan. Vacuum windows, with superior thermal properties are critically dependent on the out-gassing performance of the used materials; new results were presented by Tetsuo Minaai of Nippon Sheet Glass in Kyoto, Japan. Further studies of such windows, related to the thermal and optical evolution, were given in a presentation by Nelson Ng of the University of Sydney in Australia.

The field of Smart Materials is strongly linked to vacuum coatings, as clearly demonstrated by this Symposium. The field is notable for being interdisciplinary and embracing several more-or-less interlinked areas of interest to science, technology, and business.

Claes G. Granqvist, Uppsala University (claes-goran.granqvist@angstrom.uu.se), is one of the organizers of the Smart Materials Symposium.

Education Program Has 27% Increase in Attendance at the Dallas TechCon!

After three years of declining attendance since 2001, this year's Education Program at the 2004 Technical Conference showed a healthy 27% increase in registration from last year.

Four new courses were offered:

- C-212 *Troubleshooting for Thin Film Deposition Processes*
- C-213 *Introduction to Smart Materials*
- V-304 *Cryogenic High Vacuum Pumps*
- V-305 *Challenges and Changes in Vacuum Equipment for Vacuum Coating Processing*

These courses drew a large number of participants.

The SVC Education Committee continues to reorganize its portfolio to tune its course offerings to the current needs of the vacuum coating industry. Look for more new courses at the 2005 Technical Conference in Denver, Colorado.

During the coming months before the next TechCon, take advantage of the SVC On-Site Education Program through which many of our SVC courses can be brought directly to your facility – thus saving travel expenses and time away from your company for your employees. Contact Vivienne Mattox, the SVC Executive Director at 505/856-7188 (viviennemattox@svc.org) for details concerning this program.

Ismat Shah, University of Delaware (ismat@udel.edu) is the Education Committee Chair, and Vasgen Shamamian, Dow Corning Corporation (v.shamamian@dowcorning.com), is the Education Committee Assistant Chair.

Photo by Jowdy Photography

Vacuum coating professionals took advantage of Dave Glocker's short course entitled, "Sputter Deposition in Manufacturing". It was just one of over 30 short courses offered during the TechCon.

Don McClure Awarded this year's Nathaniel Sugerman Award

Don McClure received this year's Nathaniel H. Sugerman Award during the Opening Ceremonies at the TechCon. Don has the spent the last 22 years in 3M's corporate research laboratory, where he has worked on a broad range of programs He recently joined a group developing flexible organic electronic materials and devices.

Don attended the SVC Conference for the first time in 1984. From 1990 through 1996 he presented his "Workshop on Vacuum Web Coating" and his first course, "Basics of Vacuum Web Coating," has been part of the educational program since 1994. He added his course on "Sputter Deposition onto Flexible Substrates" in 2003.

He was selected for the Board in 1991 and was elected Vice-President in 1994, President in 1996, and was Past President in 1998. He became the inaugural Secretary to the Board in 2000, and served for four years.

For more about Don's contributions to the SVC and the vacuum coating industry, go to http://www.svc.org/AW/AW_Nat.html.

Sample Guide from the Collection of Education Guides to Vacuum Coating Processing

by Donald M. Mattox
SVC Technical Director

Vacuum Technology:
In-Line Processing Systems

"In-line" processing systems use several processing chambers connected together to sequentially process the substrates. For example, the system can clean the substrate, modify the substrate surfaces, and deposit films or otherwise build structures or devices without exposing the substrate to the ambient environment between steps. An in-line system may involve several different types of processing, such as Physical Vapor Deposition (PVD) and Sub-Atmospheric Chemical Vapor Deposition (SA-CVD). The in-line systems are characterized by having the substrates moving from chamber to chamber in one direction so that a fixture can be under processing conditions in each module all the time. This can give very high product throughput of multi-process-built structures, particularly when the system is automated. Some in-line system designs have the capability of adding or changing process chambers with ease; others do not.

The processing chambers can be operating at different vacuums or they may use different processing gases. The processing chambers can be isolated from each other in several ways, as shown in Figure 1.

In the "Valve Isolation" system there is a valve between processing chambers. The fixture is moved from one chamber to another, valves close, and the process is physically isolated from the other processing chambers. After processing is completed, the chamber may be pumped out to remove the processing gases (if any), the valve is opened, and the fixture is moved. Figure 1a shows a linear in-line system where it is relatively easy to change or add more processing stages.

In the "Pump Isolation" system there is an intermediate chamber ("tunnel") between the processing chambers. This intermediate chamber has a low conductance for gas flow between chambers and the region is actively pumped to prevent gases and vapors from one chamber getting into the other chamber. An advantage to this system is that one end of a long substrate can still be in one chamber while at the other end it is entering the next chamber. This type of design is common in systems used to coat architectural glass (10' x 12' panes) with solar-control or low-E coatings. It is relatively easy to change or add more processing stages to this type of equipment.

In the "Vacuum Transfer" system the fixture is moved into and out of a transfer chamber that can be evacuated to a "rough" or even a "high" vacuum. The purpose of the transfer chamber is to prevent processing gases in one chamber from entering another by rapidly pumping the transfer chamber. In some cases the transfer chamber can be at a higher pressure than the processing chamber so that when the valve is opened, gas flow is into the processing chamber from the transfer chamber to further prevent "backflow" of the residual processing gases. In one application using SA-CVD, the pressure in the transfer chamber is 3 Torr when the valve is opened.

If the in-line system shown in Figure 1a used a separate chamber to separate and isolate two processing chambers, and not for processing, it would be called a vacuum transfer system. The system shown in Figure 1c uses a vacuum transfer chamber that is common to all the processing modules. This configuration is sometimes called a "Cluster In-Line" system. In one application of this system, the coating of auto headlight reflectors with aluminum, the cycle time for each processing chamber is 30 seconds. It is not possible to add more processing stages to this type of in-line system equipment.

In the "Controlled Atmosphere Transfer" system the transfer chamber is at atmospheric pressure, so hermetically sealed gloves can be used. In the transfer chamber, measurements and procedures, such as mask alignment or C-V measurements, can be performed between processing steps. The gas in the transfer chamber can be dry air if the product is moisture sensitive or an inert gas such as argon

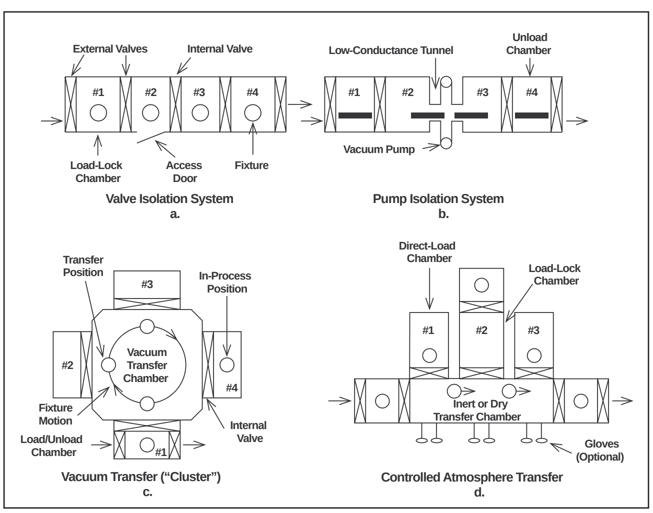

Figure 1: In-line processing systems. 1a: Valve isolation system, 1b: Pump isolation system, 1c: Vacuum transfer system, and 1d: Controlled atmosphere transfer system.

or nitrogen if chemical reaction is a problem. The individual processing chambers can be of a "direct-load" design where the processing chamber is opened to the transfer chamber during each cycle, or a "load-lock" design where there is a chamber between the transfer chamber and the processing chamber. In the transfer chamber the product may be packaged in an appropriate container before being exposed to the ambient.

Several types of valves can be used in the in-line system. If one side of the valve is at atmospheric pressure while the other is at a good vacuum ("external" valve), the sealing pressure is from the pressure differential and the valve can be a simple plate that seals against an elastomer seal. These can be used for the load-lock chamber and for access doors to individual chambers. Door movement should be such that the sealing surfaces are pressed "metal-to-metal" on sealing. Common polymer seals and their recommended maximum operating temperatures are: Buna-N (100°C), Viton (200°C), silicone (250°C), and spring-loaded Teflon™ (350°C).

The "internal" (isolation) valves have no large pressure differential during the process sequencing. They can be simple "flap-valves" that have little sealing pressure but just restrict the conductance of gas flow between chambers; or they can be valves that have a positive sealing pressure provided by mechanical means. The latter is desirable if the processing gases used in one process would be a contaminant if they get into another processing chamber or if high vacuums are required for processing.

In-line systems are meant to operate continuously, so heat build-up is a consideration. If high temperatures are desired in the processing chamber it may be best to design a vacuum oven using radiant heaters to heat the fixture and have water-cooled surfaces facing the chamber walls. Since there is no convective heating in the vacuum chamber, this will minimize heating of the chamber walls. It may be desirable to actively cool seal areas if heat build-up is a concern. This can be done using cooling coils on the exterior of the chamber. If the fixture has attained a high temperature during processing it may be necessary to have an exit chamber that is actively cooled by flowing gas to reduce the temperature to an acceptable level before the fixture leaves the in-line system.

Generally each chamber is provided with an access door(s). This allows easy cleaning, maintenance, and repair. Processing hardware, such as sputtering cathodes or ion guns, can be mounted on the access door.

Vacuum pumping of each chamber can be done with individual pumping "stacks," or the chambers may be joined to a common vacuum manifold. Often the chambers use a common roughing manifold and each chamber has an individual high-vacuum pump. This can result in limitations on the use of the system. For example: If two chambers at different pressures are opened to the roughing manifold at the same time, gases from the higher-pressure chamber will tend to enter the lower-pressure chamber. This may not be acceptable.

Transfer mechanisms are driven from outside the vacuum chamber by rotary-motion vacuum feedthroughs. The drive can be a positive mechanism, such as gear-and-sprocket, or it may be a friction drive, such as powered rollers. For tall fixtures, such as a vertical pallet fixture, it may desirable to stabilize the moving fixture by having a fixture guide at both top and bottom. Transfer mechanisms and drive trains are often the operational weak points of an in-line system.

Sometimes a back-and-forth motion is desirable in the processing chamber. For example, the fixture might need to have multiple passes in front of a planar sputtering cathode and a linear ion gun, both in the same chamber. This allows periodic "atomic peening" of the growing film structure by inert-gas ion bombardment to densify the film without requiring a bias on the substrate. Use of reactive ions allows reactive deposition by depositing a few monolayers of metal, followed by bombardment with a reactive species such as oxygen or nitrogen. A back-and-forth motion requires the necessary chamber length, drive mechanism,

continued on page 24

SVC Exhibit is Well Received by TechCon Attendees!

In spite of the slow economy and the struggles that other societies have with low exhibit traffic, the SVC Exhibit remains vibrant.

Photo by Jowdy Photography

With over 200 booths in Dallas, a broad range of exhibiting companies offered their products and services to the vacuum coating professional.

Here are some quotes from our exhibitors and conference attendees:

"The quality of exhibitors was good – met new ones I had never heard of."

"Well organized, compact, and well attended by attendees."

"Good networking opportunities."

"Many of our crucial customers/vendors were there."

"TechCon short courses draw a quality crowd."

"Broad range of exhibiting companies."

TechCon sponsors of the Internet Café, Beer Blast, and Coffee Breaks were highlighted with balloon bouquets at their booth and acknowledged in the Final Program, throughout the TechCon signage, and on the Web Site. The three Internet Café stations in the back of the Exhibit Hall were very popular and in constant use – but with no one having to wait for more than a few minutes.

The Program Committee scheduled the technical presentations to minimize conflict with the Exhibit Open Hours. As an example, all technical sessions ended at 3:30 p.m. on Tuesday so that everyone could visit the Exhibit and enjoy the Beer Blast. The afternoon break on Monday was almost an hour and two technical sessions instead of three sessions were scheduled for this time frame. The expansion of the TechCon to four days this year has enabled the Program Committee to really pay attention to scheduling issues that allow the conference attendees to spend more time in the Exhibit Hall.

Having the Poster session boards in the Exhibit Hall was also a well-conceived decision—conference attendees and exhibitors alike found the location to be convenient. SVC used new methods to promote the TechCon and Exhibit in 2004: a postcard mailing, E-mail blasts, and an On-line Visitor registration process which was popular.

The SVC Exhibitor Pass system enabled exhibit booth personnel to attend technical papers of choice. The SVC wishes to acknowledge the invaluable assistance offered by Harry Grover of MeiVac, Inc. to all of our exhibitors.

Photo by Jowdy Photography

The popular Internet Café was located in the Exhibit Hall.

Photo by Jowdy Photography

The Exhibit allows for one-to-one interaction between attendees and exhibitors.

We also welcome Lisa Robillard, with MKS Instruments, Inc. as our new Exhibit Committee Chair.

If you have questions or comments (positive and negative), please do not hesitate to send them to Vivienne Mattox, SVC Executive Director and Meeting Planner, at viviennemattox@svc.org.

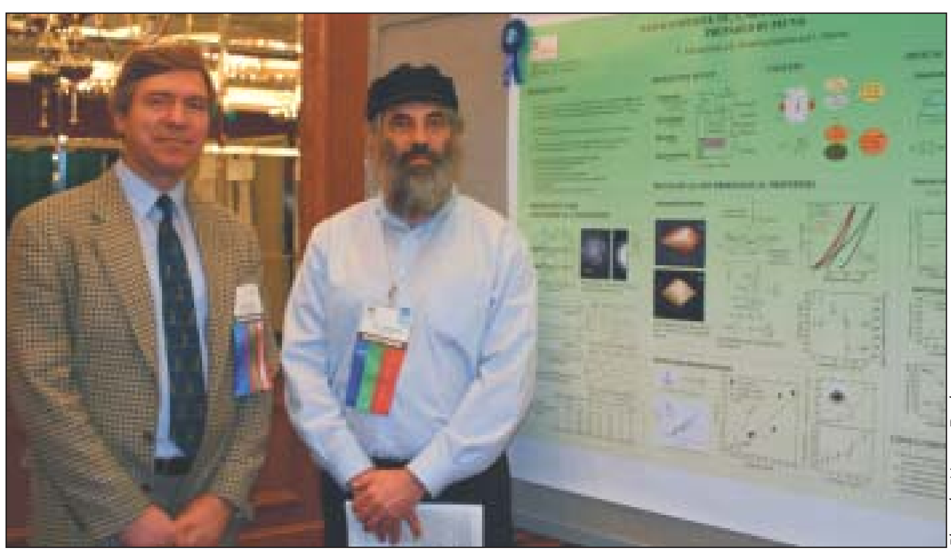

Photo by Linnea Dueker

Ric Shimshock (right), Program Chair, awards Ludvik Martinu of École Polytechnique the $200 prize for "Best Poster" presentation in the Exhibit Hall during the 2004 TechCon. The Poster Session was set up in the Exhibit Hall for extended viewing during the Exhibit.

Vacuum coating—An Enabling Technology

by Donald M. Mattox
Management Plus, Inc., Albuquerque, NM

Abstract

Vacuum (sub-atmospheric) coating processes have been the enabling technology in several fields for a number of reasons. The vacuum coating process has allowed a functional coating to be deposited when no other technique can do so and sometimes has allowed the production of a more functional coating than is available by other means. The use of a vacuum coating can provide a more marketable product that is produced at a low cost. In some cases the reproducibility of the process allows the production of very complex and demanding products such as multilayer diffraction gratings and bandpass filters. New markets have been generated due to the availability of vacuum coating processes. In many, if not most cases, a vacuum coating is a value-added process whose price and contributions to the economy and the environment is difficult to quantify. This presentation will address many of these subjects and compare some vacuum-coated products to non-vacuum-coated products and processes. In the past few years, plasma-based vacuum processes have become important production techniques and their use is expanding rapidly. Vacuum coating technologies will continue to develop and be an enabling technology for the foreseeable future.

Introduction

An "enabling technology" is one that allows something to be done on an industrial scale that could not be done otherwise. The first use of vacuum coating (sputter deposition) on an industrial scale was by T. Edison for making the sub-masters of his "Gold Moulded" cylinder records. However, the process was not an enabling technology because others were doing much the same thing by making their wax masters electrically conductive using carbon powder.

The second early process that might be considered enabling was the zinc coating of paper for paper capacitors by R. Bosch (Bosch Company) in 1935. The use of metallized paper (roll coating) instead of metal foil allowed the size of a capacitor to be reduced by about 50%. In 1940 Whiley (England) patented the use of aluminum for web coating. Lead foil was used for early packaging to some extent but tin foil was the first widely used flexible packaging foil. It was replaced by aluminum foil after 1910 when repeated rolling of aluminum was shown to provide a cheaper foil product. Aluminum foil was used to preserve "freshness" until well after WWII when it was replaced by metallized polymer film prepared by vacuum coating.

Web coating went on to be an enabling technology for such processes as coating polymer with vapor barriers for flexible

In February 2004, the SVC Board of Directors honored Don Mattox by creating **The Donald M. Mattox Tutorial Program,** in recognition of his many contributions to vacuum coating technology and the Society. Don was presented with a plaque at the Awards Ceremony in Dallas and was asked to prepare a presentation to kick-off the Tutorial Program bearing his name. His presentation entitled *"Vacuum Coating—An Enabling Technology,"* was the Inaugural Tutorial in The Donald M. Mattox Tutorial Program on April 26, 2004, at the TechCon. Don McClure of 3M Company, and Charles Bishop with C.A. Bishop Consulting Ltd., also presented Tutorials in this program.

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packaging. Multilayer coatings on webs began in the IC industry to metallize flexible substrates. A major advance in web coating was the use of sputter deposition for depositing compounds and multilayers. For packaging this is leading to "see-through" freshness packaging. Magnetron sputter deposition on flexible webs was first used by D. Charoudi in 1977.

The antireflection (AR) layer on old glass was recognized in the early 1800s. In the latter part of the 1800s all professional photographers knew that old lenses were better than new lenses because of the coating that formed on them with age. There were numerous attempts (and patents) on the chemical treatment of lenses to form an AR coating on the surface.

In 1935, A. Smakula (Zeiss Company) discovered the use of vacuum coating to form

Figure 1: RF sputter deposition of Cr and Cu on a Kapton® web, (Morrill, Egan, Paszek, and Aronson) JVST 9(1)350 (1972)

single-layer AR coatings on lenses but the patent was considered to be a Military Secret until 1940 [1]. In 1936 John Strong discovered the use of vacuum coating for forming an AR coating on lenses and published it in the open literature. Again this might be considered an enabling technology even though chemical treatments can be used to formed AR coatings on surfaces. It is interesting to note that the Germans did not use AR coatings on camera lenses until after WWII. Single-layer AR coatings continued in use well after WWII [2].

The first explanation of the effect of a single-layer coating on antireflection was by Airy in 1832 [3]. He used classical ray and wave techniques to show the effect. In 1939 using chemical techniques (Langmuir-Blodgett films) to form layers of very precise thickness and varying indices of refraction Blodgett showed the AR effect and equations for the relationship between thickness and index of refraction in AR coatings [4].

Multilayer AR coatings are another matter. Cartwright and Turner deposited 2-layer coatings in 1939. There is one report that the Schott Co. (Germany) formed multilayer AR coatings (3-layer) on lenses during WWII by spray pyrolysis. Otherwise mutilayer AR and filter coatings were not used until the late 1940s.

It has been asserted that Monarch Cutler, an undergraduate student at MIT, was the first to calculate the effect of multi-coatings on the AR properties of a surface [5]. Mr. Cutler's senior thesis at MIT was entitled *"Reflection of Light From Multilayer Films"* (May 1939). It is interesting to note that in the acknowledgment of his thesis Mr. Cutler acknowledged Dr. Cartwright and Dr. Turner "for information concerning their work in the production of color films." He also acknowledged Richard P. Feynman, also an undergraduate student at MIT, for his help in deriving the equations for the reflection and transmission of multilayer films. Dr. Feynman later received a Nobel Prize in Physics (1965) for his work in quantum electro-dynamics (QED) and was considered one of the finest physics lecturers of all time [6].

Feynman's senior thesis at MIT was *"Forces and Stresses in Molecules."* In my research I have not found any other reference to a relationship between Dr. Feynman and Mr. Cutler's 1939 work. By 1946 several authors were involved in calculating the optical properties of multi-layer films [7].

The vacuum deposition of aluminum reflecting coatings on glass by vacuum deposition can certainly be considered an enabling technology for the subject of astronomy. John Strong published the first work on aluminizing large mirrors in 1936 [8]. For about 100 years before that time chemical deposition was used. The "modern" techniques of deposition by chemical reduction began with Liebig in 1835 [9]. There are two widely used methods of chemical silvering. The "Brasher method" was used to deposit thick coatings on front-surface mirrors that could be subsequently polished for telescope mirrors and the "Rochelle Salts method", that has a slower deposition rate, and was used to deposit thin silver films such as were used in partially silvered mirrors.

In 1920 at a discussion on "The Making of Reflecting Surfaces" R. Kanthack, in his Introduction, stated "Six weeks of bibliography hunting have given me the impression that at the present time—85 years after Liebig's classical discovery!—we have not evolved any method of chemical deposition on glass so scientific and practically perfect that it could be adopted officially" [10].

Polishing, which leaves minute scratches, reduces the resolution of the reflected light as was shown in tests by Strong on the Hooker 100 inch telescope on Mount Wilson in the mid-1930s. The Hooker telescope had used polished chemical-silver coatings and had barely been able to see the companion star (magnitude of 8) of the extremely bright star Sirius (magnitude of minus 1.5). Strong's vacuum evaporated aluminum coating enabled the "Companion of

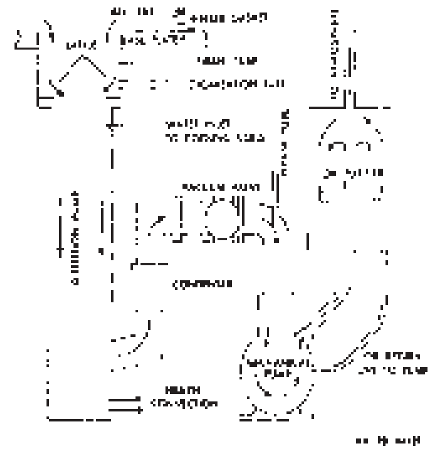

Figure 2: American vacuum system for coating optics during WWII. Note the lack of a high vacuum valve.

Sirius" to be resolved easily by the Hooker telescope. During WW II Heraeus (Germany) used the sublimation of a protective layer of SiO on the surface of aluminized mirrors. In 1946 Turner addressed the effect of a single layer dielectric on mirror surfaces ("protected" surfaces) [11]. Today multilayer reflecting coatings are used in all kinds of reflecting applications. These include heat mirrors, cold mirrors, low-E window coatings, silver coatings on astronomical telescopes and many others.

Corrosion protection is one of the most demanding applications for coatings of any type. Electroplating on electrically conducting substrates was developed soon after the development of the Volta Cell in 1800 and has been used to deposit corrosion protective coatings for many years. A problem with the electrodeposition of many materials from aqueous solutions is the co-deposition of hydrogen. This hydrogen can cause embrittlement of high strength steels (>200,000 psi), particularly when they are under stress. The electroplating industry uses heating to try to outgas the incorporated hydrogen but this can be difficult to quantify. Vacuum deposited cadmium (VacCad) was formally accepted as a replacement for electrodeposited cadmium by the military in 1958 (Mil Spec. 8837) as a sacrificial corrosion protective coating.

A major advance in corrosion resistant coatings was the development of the "Ivadizing" process at McDonnell-Douglas in the late 1960s. The ivadizing process allowed adherent evaporated aluminum to be coated on steel and titanium fasteners in a "barrel coater." These coated fasteners prevent galvanic corrosion when they are used in contact with aluminum such as on airplane "skin." The process was later just called "ion vapor deposition" and is now known in the aerospace and military related industries as IVD coating. The aluminum deposited by IVD is often shot peened or burnished in order to seal pinholes that are a problem with using vacuum coatings for corrosion protection.

Vacuum coating for tribology, using low-shear-strength metals, was studied and developed by NASA for use in vacuum in the late 1960s. Their advantage is that they do not "creep" as oils and greases do. An example of their current use is in the coating of bearings used on the rotating anode in x-ray tubes,

Vacuum deposition of electrical resistors didn't come into real use until the age of the "integrated circuit" (IC) technology. The IC industry began in the late 1950s. In IC technology tantalum was a material of great interest for making stable thin film conductors with low temperature coefficient of resistivity (after annealing), thin film resistors made of reactively sputter deposited TaN that could easily be "trimmed" to the correct resistance values by anodizing, and thin film capacitors that could be made by anodizing (oxidizing) the film surface to form a dielectric (Ta_2O_3). For the IC industry very high volumes of coated substrates were needed.

The IC industry brought about the introduction of high-volume coating systems such as the air-to-air in-line coater [12], the load-lock in-line coater, and the random-access process chambers with a central vacuum chamber [13] that may be considered the forerunner of the modern cluster tool that is widely used for processing wafers.

Sputter cleaning is an in situ cleaning process that is often integral to obtaining good adhesion of the deposited coating. Sputter cleaning was first used in ultrahigh vacuum technology in the field of Surface Science to obtain atomically clean surfaces. Sputter cleaning as a separate step in vacuum coating is often not as successful as it could be because of recontamination of the surface between processing steps. An enabling technique was introduced in the early 1960s whereby the sputter cleaning was continued while the first of the coating material was applied by evaporation. As long as the deposition rate exceeded the sputtering rate a film was formed, essentially on an atomically clean surface.

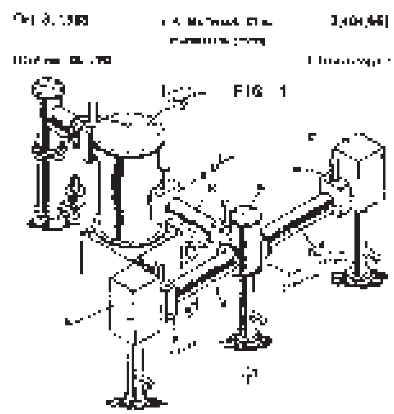

Figure 3: Patent for a vacuum system with a central vacuum chamber and separate processing chamber. This may be considered the forerunner of the cluster tool [13].

Summary

There are a number of developments in vacuum coating technology that might be cited as "enabling technologies" but the following would certainly be included in any list.

1. Evaporation of aluminum from tungsten filaments.
2. Deposition of single-layer and multilayer optical coatings.
3. Development of electron beam (e-beam) evaporation techniques.
4. Use of concurrent bombardment during deposition to modify the properties of the deposited material.
5. Integration of the sputter cleaning process with the deposition process to give a "clean" interface.
6. Development of reactive sputter deposition.
7. Development of the in-line deposition system ("tool").
8. Development of magnetron sputter deposition technology.
9. Development of plasma enhanced chemical vapor deposition (PECVD) technology.
10. Development of arc vapor deposition.

Acknowledgements

The author thanks Ric Shimshock for pointing out the very interesting relationship of Richard P. Feynman to Monarch Cutler and providing the title page of the Cutler thesis. Thanks are also extended to George Dobrowolski for calling

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attention to the Russian work (Appendix I) that describes 2-layer AR coatings and providing the translations given in Appendix 1.

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Appendix I

May 3, 2004

To: Don Mattox (by E-mail)

From: George Dobrowolski

Below is the Russian original and the English translation of the contents of the title page of the book which I am also appending in the form of a file for your interest:

Academician I.V. Grebenshchikob, A.G. Vlasov, B.S. Neporent, N.V. Suikobskaya

The Antireflection Coating of Optics/Reduction of the Reflection of Light by the Surfaces of Glass (Prosvetlenie Optiki/ Umienshenie otrazheniya sveta poverchnost'yu stekla), edited by I.V.Grebenshchikov, published by Gocudarstvennoe Izdatelstbo Technicko-Teoreticheskoi Literaturyi (State Publishers of Technical-Theoretical Literature) Moskva 1946 Leningrad

The book consists of 212 pages and is organized in 9 chapters with headings:

1. Physical basis for the antireflection effect
2. Mathematical theory of the antireflection effect of thin films
3. Physical properties of antireflection coatings and their control
4. Antireflection coating of silicate glasses using an etching method
5. Antireflection of glasses by deposition of silicon-organic solutions
6. Deposition of antireflection coatings through the deposition of fluoride vapors in a vacuum
7. Antireflection though the deposition onto the surface of a glass of monomolecular layers of organic materials
8. The manufacture of glasses with an enhanced reflection coefficient through the deposition of titanium dioxide layers
9. Antireflection coating through the deposition of two-layer coatings.

It contains 99 illustrations (some of equipment), tens of tables, and over a hundred references. Very impressive for a book which must have been written during the Second World War, if it was approved for publication in March of 1946 and came out later in the same year.

Sample Education Guide — Vacuum Technology: In-Line Processing Systems

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and position sensors.

Position sensors allow a "fail-safe" operation of the transfer mechanism. The fixture must be in the correct position for the process to begin or for a valve to close. Position sensors may operate by optical, mechanical, electrical, or magnetic sensing.

Sensors in the system enable software to be programmed to allow automation of the motion and the processing. In high-throughput systems, movement of fixtures from one processing chamber to another or into or out of a transfer chamber are often coordinated to maximize efficiency. This can lead to an inflexibility in system use. This can be important if the system is also going to be used for development or process characterization. If this is a consideration, the software should be such that it can be reprogrammed easily. It may even be desirable to run the system in a manual mode, yet leave the "fail-safe" sensors operative.

In some modules, the substrates may be electrically isolated ("floated") so a bias voltage can be applied to the fixture/substrates or so a uniform self-bias can be created on the surface of a dielectric material. (Note: Often a dielectric surface that is being subjected to a flux of charged particles and is being held in a grounded metal fixture will have a different surface potential near the edges from that at the center due to surface-charge leakage. This effect can be minimized by electrically isolating the fixture from ground.) Electrical isolation can be provided to the whole fixture and transfer assembly or just to the part of the fixture that holds the substrates. If the whole fixture and transfer assembly are biased, the total area can be very much greater than just the substrate area. This wastes power and may cause operational problems. Electrical contact to just an area on the fixture that is electrically isolated from the rest of the fixture and the transfer mechanism can be done using brush-contacts or mechanically loaded make-break contacts that release before the fixture is moved.

Sometimes redundant processing volumes, such as long processing chambers or dual cooling chambers, may be needed to allow for more processing time than is required by other processes. The cycle-time-limiting processes need to be carefully considered in the design of the in-line processing system.

Effective Closed-Loop Control for Reactive Sputtering Using Two Reactive Gases

by Dan Carter, Bill Sproul, and David Christie
Advanced Energy Industries, Inc., Fort Collins, CO

Presented on April 29, 2004, at the 47th SVC TechCon in the Process Control and Instrumentation Session.

Abstract

Reactive sputtering is becoming a more widely accepted practice for the deposition of many useful compound thin films. The use of closed-loop control for the deposition of such films is also increasing in popularity. The closed-loop process for forming binary compounds, typically oxides or nitrides, is conveniently accomplished using one of several feedback mechanisms coupled to a high-speed reactive gas control valve. Optical emission, target voltage and mass spectroscopy have all been successfully used to provide feedback for such processes when using a single reactive gas. The presence of two reactive gases in a reactive sputtering process adds significant complexity and presents the issue of competing reactions. Since both reactive gases can affect the state of the target surface and the plasma conditions, both also affect common feedback control signals such as the cathode voltage and optical emission. Modeling has shown that the way to control a two-gas reactive sputtering process is to produce individual control signals for each gas. In this study, partial pressure signals for each reactive gas were used to control the deposition of SiO_xN_y and TiO_xN_y compounds. The results of this study are presented here and shown to support the modeled behavior. The two-gas, closed-loop approach is then demonstrated to provide a stable, high rate solution for the deposition of these highly complex thin film materials.

Introduction

Oxide and nitride thin films are becoming increasingly popular for their electrical, optical, wear resistant, and other functional properties. Driven by improvements in deposition techniques, these thin film materials are becoming commonplace in many vacuum coating applications. Reactive sputtering continues to emerge as one of the most economical methods for depositing these materials. With properly configured power delivery and process control measures, high rate, arc free deposition of many oxides and nitrides is now possible. As reactive sputtering methods have matured, interest in extending the technique beyond simple binary compounds has been growing. As material complexity increases however, so do the challenges of process control as we examine and discuss in this study.

Although the concept of reactive sputtering is quite simple, the art of employing it effectively to produce high quality insulating films at maximum rates can be a real challenge. The nature of forming insulating layers in a direct-current sputter deposition is inherently disruptive to the process. In recent years the issue of arcing in reactive sputtering has been effectively managed using one of several power delivery techniques [1-4]. The most common of these are pulsed-dc in a single magnetron system and low frequency ac power in a dual magnetron system. In both cases a voltage reversal at the cathode is used to effectively eliminate charge build up on the target surface and thus avoid the breakdown event. Many modern power supplies also possess arc detection and arc handling circuitry designed to quickly extinguish an arc should one occur.

Target transition control is another major challenge in these processes. As the reacted, insulating deposit is formed on the work piece, it also forms on the target surface causing a change in its sputtering character. Increasing reactive gas flow to the sputtering process increases conversion of the deposit to the desired compound but also increases the coverage percentage of the compound on the surface of the target. At a critical point, an avalanche transition often occurs where full coverage of the target is experienced. This change in target condition, commonly called poisoning, has several detrimental effects on the process. Dramatic voltage swings, a decrease in deposition rate and an uncontrolled increase in processing pressure are all common results of target poisoning [5-7]. Further complicating the matter is the hysteresis character commonly brought on by this behavior. Figure 1 shows a typical transition curve for reactively sputtered titanium nitride showing how the poisoning process is not directly reversible by simply decreasing reactive gas flow.

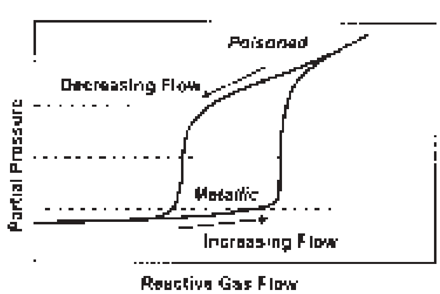

Figure 1: Partial pressure hysteresis behavior typical for titanium nitride reactive sputtering.

Reactive sputtering can be performed from a fully poisoned target but this approach results in low deposition rate and lack of composition control. Operation of these processes in the transition region offers a significant rate advantage [7-9] along with the ability to control the composition of the produced film [9]. This would be most advantageous in a two reactive gas process as the potential exists for a broad range of film properties by adjusting, for instance, the ratio of oxygen and nitrogen incorporated in an oxynitride film. Compositional control in oxynitride depositions has been demonstrated using CVD, PECVD and ion assisted evaporation [10-12] but these techniques tend toward higher complexity and cost and often require more heat tolerant substrates than most typical sputtering applications.

Over the past two decades closed-loop control systems have been developed for reactive sputtering processes [5,6]. These techniques, when properly implemented, allow for stable control within the so-called transition region of the target. Process feedback is in the form of optical emission, mass spectrometry or target voltage [5,6,9] and control is derived by regulation of a single reactive gas through one or more high speed flow devices.

Adding a second reactive gas significantly complicates the process control challenge [13]. With two reactive gases present, the independent reactions compete with one another. Depending on the reactivity between the metal and each gas, one reaction may dominate causing the process to become trapped in an undesirable state preventing incorporation of the less dominant reactive gas. This behavior was predicted in the Carlsson model and has subsequently been demonstrated experimentally [14,15]. To prevent this, independent control of both reactions is necessary.

Control in one gas reactive depositions is often achieved by managing the surface condition of the target. Target voltage is convenient when transition causes an impedance change and optical emission of the sputtered species is effective when transition affects sputter yield. These methods, however, offer no means for discriminating the effects of multiple reactive gases. To accomplish such discrimination the partial pressure of each reactive gas must be measured. As compound formation consumes a reactive gas, the partial pressure is affected. During target transition, the consumption of reactive gas decreases due to reduced unreacted target surface and decreased metal flux to other surfaces. This behavior gives rise to partial pressure monitoring as a direct feedback for compound formation in such a process. Most importantly, partial pressure control offers the critical advantage of being species dependent, thus allowing for independent monitoring and control of multiple reactive species.

Depositions for this study were performed

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in an open volume, batch style, cylindrical chamber measuring approximately 50 cm in diameter and 55 cm deep. An Angstrom Sciences 150 mm source was used with either a silicon or titanium metallic target. The chamber was pumped to a base pressure of less than 1.33 x 10^{-4} Pa (1.0 x 10^{-6} Torr) prior to each test and operated with 0.4 Pa (3.0 x 10^{-3} Torr) argon. An Advanced Energy Pinnacle®Plus pulsed-dc power supply was operated at 1000 watts pulsed at 100 kHz and 60 or 80% duty factor for all depositions (depending on arc activity). An Advanced Energy IRESS reactive sputtering controller [16] equipped with an Inficon Transpector 2 mass spectrometer was used to actively regulate reactive gas partial pressures by providing control signals to Advanced Energy Aera® 980 series high-speed mass flow controllers. Glass slides and polished silicon slices were used as substrates and loaded onto a shuttered, rotating sample holder. A schematic of the test setup is shown in Figure 2.

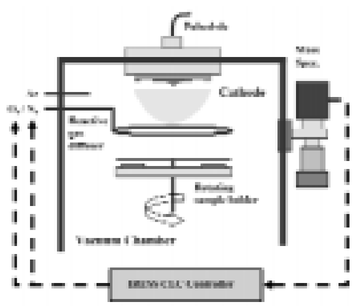

Figure 2: Vacuum and control apparatus used for two gas reactive sputtering process.

Using partial pressure reactive gas control we first investigated single gas behaviors, depositing oxides and nitrides. We evaluated target transition effects with each reactive gas and then showed how adding a second gas using flow control only can lead to unwanted transitions and target trapping. The effect of adding partial pressure control for the second reactive gas was then investigated demonstrating a means for stable control throughout a broad processing space allowing access to a wide operating range and expansive compositional matrix.

Results

Two Gas Reactive Sputtering for Silicon Oxynitride

Oxide and nitride transition curves were generated in order to verify operation and baseline the process in preparation for multi-gas processes. Figure 3 shows reactive gas partial pressure versus reactive gas flow for silicon oxide and silicon nitride formation. Partial pressure values are reported on a 0-10 volt scale representing current collected on the Faraday cup in the mass spectrometer. These values are proportional to the actual pressure of each constituent being measured. Pumping curves for both reactive gases are also shown for reference. Noteworthy differences are the relatively higher pumping efficiency for nitrogen and increased consumption of oxygen to the reaction, especially at the lower partial pressures. This gives rise to a maximum flow value of oxygen at the onset of target transition of approximately 15 sccm. A maximum flow and indication of transition are not observed for the nitrogen reaction.

With partial pressure control in place, all points on each curve in Figure 3 were available for stable operation. In addition, stable control was achieved by either starting in the metal mode or by beginning the process in the poisoned or dielectric mode.

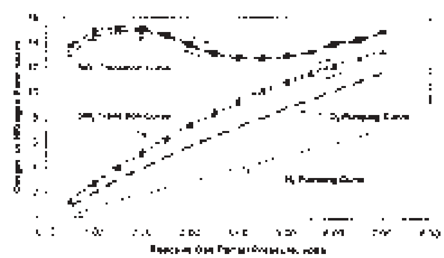

Figure 3: Partial pressure transition curves for SiO_x and SiN_y. Pumping curves for each gas for comparison.

As nitrogen is added to the silicon oxide process the effect is to suppress the amplitude of the transition curve, or decrease the amount of oxygen consumed in the process. Figure 4 shows this effect in a family of curves generated with increasing fixed nitrogen flow. In these curves, only oxygen is under partial pressure control. The importance of this distinction is discussed below.

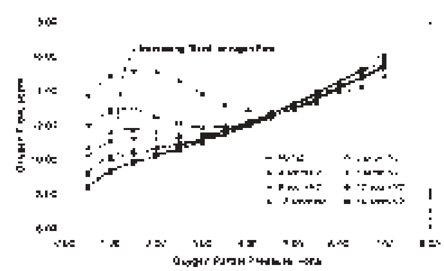

Figure 4: Fixed nitrogen flows and their effect on oxygen partial pressure transition curves for SiO_xN_y.

Above approximately 12 sccm nitrogen, the transition curves in Figure 4 become nearly linear, suggesting that little if any oxygen is being incorporated in the reacted film. Despite the significant change with increased nitrogen flow, stable process control throughout the transition appears to be achieved in each case as the smooth character in the transition is maintained.

The corollary to Figure 4 is to operate the deposition in nitrogen partial pressure control. Here oxygen is added at fixed flow values.

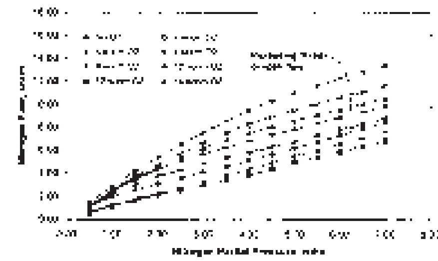

Figure 5: Fixed oxygen flows and their effect on nitrogen partial pressure transition curves for SiO_xN_y.

Figure 5 gives these results.

Again, the curvature is suppressed as the second gas is added indicating reduced nitrogen consumption at higher oxygen flows. Throughout the range tested, the process appears to remain stable. This observation, however, is misleading. What is not shown in Figure 5 is the oxygen partial pressure. For this test only nitrogen was under partial pressure control. In this case oxygen was in fixed flow control leading to the behavior shown in Figure 6.

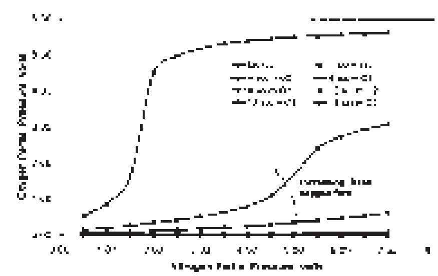

Figure 6: Oxygen partial pressure at fixed flows with nitrogen under partial pressure control.

Figure 6 illustrates the onset of target trapping as described by Carlsson et.al. [13]. At low oxygen flows, consumption by the reaction keeps oxygen partial pressures low throughout the tested nitrogen partial pressure range. As the oxygen flow is increased, the process begins to poison, resulting in an uncontrolled increase in oxygen partial pressure. This behavior indicates the presence of oxygen in excess of what the deposition process can consume.

The trapping effect is more clearly illustrated in Figure 7 where partial pressures of both nitrogen and oxygen were plotted along with target voltage. As before, nitrogen partial pressure is actively controlled and is incrementally increased over time to a predefined maximum. At this point the nitrogen partial pressure is decreased back to zero. As before, oxygen is introduced at a fixed flow and its partial pressure is monitored but not directly controlled. The oxygen flow is 14 sccm here, chosen based on results from Figure 6.

As nitrogen partial pressure increases we initially observe a gradual increase in oxygen partial pressure. At just over three minutes into

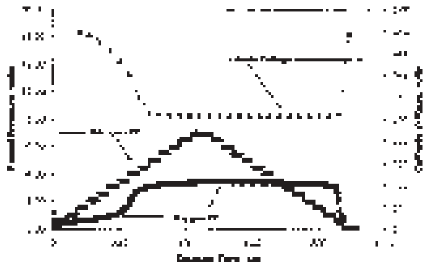

Figure 7: Cathode voltage and reactive gas partial pressures during SiO_xN_y deposition resulting in target trapping. Nitrogen is under partial pressure control and oxygen fixed at 14 sccm.

the run, a poisoning event is experienced causing a rapid increase in oxygen partial pressure and a rapid decrease in sputtering voltage. Once poisoned, the oxygen partial pressure remains relatively unchanged at a point of saturation and the target remains in a trapped state until both gases are removed from the process.

We found that trapping can be prevented by applying partial pressure control to both reactive gases. Figure 8 gives results from the same process sequence carried out in Figure 7, but

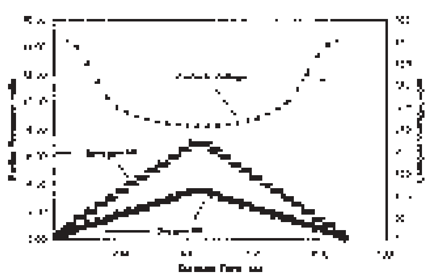

Figure 8: Cathode voltage and reactive gas partial pressures during deposition of SiO_xN_y using partial pressure control of both gases. No target trapping is observed.

this time operated with partial pressure control for oxygen as well. In this case oxygen partial pressure was set to 50% the nitrogen partial pressure.

Similarly smooth transitions, not shown here, were obtained across a broad range of oxygen to nitrogen partial pressure ratios (O_2:N_2) from 0.05:1 to 4:1, operated with either nitrogen or oxygen as the primary gas. None of these runs, operated with both gases in partial pressure control, showed any evidence of uncontrolled target poisoning or trapping.

With stable control established, we tested the ability to deposit intermediate oxynitride compositions. Figure 9 gives rate and refractive index measurements for films deposited with varying reactive gas partial pressure ratios. At either extreme in the chart we see results representative of the binary process. SiO_x films yielded RI ~ 1.45 at 1510 Å/min while SiN_y gave RI ~ 2.10 at 940 Å/min. Intermediate compositions provided values between the two extremes. These results demonstrate the ability to use such control to access intermediate compositions possessing properties between those of the pure oxide or nitride film.

Figure 9: Rate and refractive index for SiO_xN_y deposited by reactive gas partial pressure control.

Two Gas Reactive Sputtering for Titanium Oxynitride

The titanium oxynitride process shows many similarities to the silicon process. The most notable difference is a rise in cathode voltage upon target transition opposed to the fall seen for silicon. Aside from this difference, most other behaviors are quite similar. Titanium oxide and nitride transition curves are shown in Figure 10. As was the case for silicon, the oxide process consumes more reactive gas and shows a more distinct target transition.

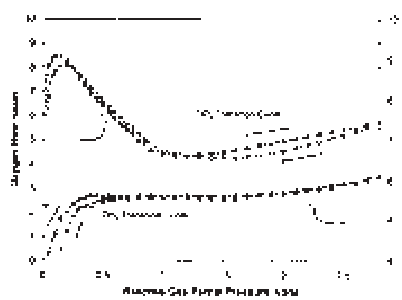

Figure 10: Partial pressure transition curves for TiO_x and TiN_y.

Target trapping was also observed for titanium oxynitride depositions. Again, as we saw for silicon, when one of the gases is regulated by flow only, the possibility for trapping exists. Figure 11 shows a case where we controlled the nitrogen partial pressure and operated oxygen at a fixed flow of 7 sccm. For this test nitrogen partial pressure was increased incrementally and then decreased. A poisoning event is clearly shown at approximately 400 seconds into the run. From this point the target is trapped as indicated by both oxygen partial pressure and target voltage. Only when the reactive gases are removed does the target

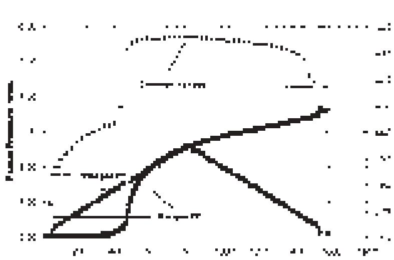

Figure 11: Cathode voltage and reactive gas partial pressures during TiO_xN_y deposition resulting in target trapping. Nitrogen is partial pressure controlled and oxygen is fixed at 7 sccm.

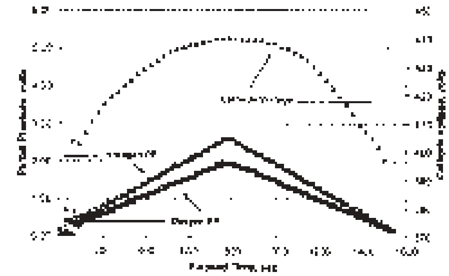

Figure 12: Cathode voltage and reactive gas partial pressures during deposition of TiO_xN_y using partial pressure control of both gases. No target trapping is observed

transition out of the poisoned state.

Partial pressure control of both reactive gases was again shown to prevent this behavior. We tested a wide range of partial pressure combinations and found stable, controlled operation in all cases. Figure 12 is one example of such control. Here both oxygen and nitrogen are subjected to partial pressure control. The result was a smooth transition throughout the entire range tested for both reactive gases as well as for target voltage.

Discussion

The presence of multiple reactive gases in an oxynitride reactive sputtering process adds variables that can exceed the control capability of the typical single gas technique. The multi-gas process is complicated as the two reactive gases compete for available metal. The two simultaneous reactions taking place do not act independent of one another and, in fact, one reaction may dominate allowing the process to become poisoned and then trapped in an undesirable state preventing stable operation of the process.

To effectively prevent target trapping, a process control technique capable of differentiating the effects of individual reactive gases is needed. We have demonstrated the occurrence of target trapping in both silicon oxynitride and titanium oxynitride reactive depositions. We also show the behavior to be effectively prevented by employing partial pressure control for both the oxygen and nitrogen reactive gases during deposition. By using such control, a broad range of operating conditions is available providing stable process performance throughout.

Generating a composite summary of the operating range tested, we can produce a process response surface for stable operation of such depositions. One such response surface is shown in Figure 13 for the silicon oxynitride deposition studied.

Using this surface one can visualize a vast range of operating conditions available to perform the two gas reactive deposition. We studied film properties from only a small portion of this surface. Points tested are indicated on the chart and film data were presented earlier, in Figure 9.

Corporate Sponsor Profile

W.C. Heraeus

The Thin Film Materials Division of W. C. Heraeus is one of the world's largest—and most experienced—developers and manufacturers of high-purity sputtering targets and evaporation materials. Our core markets are: large area coatings, magnetic data storage, and electronics. Additionally, our extensive product line covers many other important thin film applications, including flat panel displays, optical disc storage media, photovoltaic, and optics.

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Effective Closed-Loop Control

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Conclusion

Measuring the partial pressure of reactive gases provides a critical means for control of individual gases in a two reactive gas deposition. Without the ability to differentiate the effects of each reactive gas such processes are subject to a phenomenon called target trapping. Target trapping can be effectively prevented by controlling the partial pressure of the individual reactive gases in a multi-gas reactive sputtering process. With such control in place, reactive sputtering can be successfully used to produce oxynitride thin films with varying compositions and properties.

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Corporate Sponsor News

Over 80 people attended the **Applied Films' 3rd Web Symposium** on March 24–26, 2004, in Alzenau, Germany. Participants traveled from all over the world to attend this event to celebrate the 500th machine built by Applied Films, the former Leybold Systems web coating group, and to be introduced to the latest developments in technology for vacuum web coating equipment. Customer and market presentations covered a wide range of products ranging from electronics, food packaging, security devices to optical layers required for window film and other high tech applications including flexible displays. Applied Films is the only company that offers a full range of web coating equipment, and their ownership of more than 165 patents proves their core technology and experience is truly developed in-house. The symposium also included several demonstrations at the production facility of new product capabilities and new technologies. "It was evident from the number and quality of participants at this symposium that our customers consider AF to be on the cutting edge of technology and appreciated the ability to have a hands on experience with several of the new products and applications which have been presented and are now ready to offer," said Joachim Nell, Executive Vice President, Worldwide Sales and Marketing from AF Alzenau. For more information on the Applied Films Symposium or AF products, please contact gloebig@eu.appliedfilms.com.

MKS Instruments, Inc. announced that it will provide all residual gas analyzers (RGAs) and vacuum gauging for the particularly demanding environment of the Diamond Synchrotron Light Source facility being constructed at Chilton, Oxfordshire, U.K. The order will exceed US$ 1 million. MKS will furnish multiple radiation-resistant vacuum gauging and control systems that measure pressures from atmosphere down to 10-11 mbar and monitor the vacuum environment for residual gases.

Advanced Energy Industries, Inc. announced that it recently named Buck Kim general manager of Greater China Customer Operations. Formerly with Varian and PRI Automation, Kim is chartered with building on AE's existing customer base in Greater China's semiconductor and thin-film transistor (TFT) markets, and will oversee all sales, service and marketing for the company's power, flow, source and thermal product lines in China, Hong Kong and Taiwan.

CeramTec North America (CTNA) announced that it has invested more than a half million dollars in the expansion of the Company's grinding capabilities. More specifically the new specialized double disc grinding equipment gives CTNA the capability to grind thin ceramic substrates to excellent flatness, parallelism, and finish specifications. CTNA also announced that as of April 2004 it has appointed Greg Gill as the Engineering Manager for Ceramaseal® products. Gill will manage the engineering department at CTNA's New Lebanon, NY facility. Gill was previously the Engineering Manager at Insulator Seal, Inc. (ISI) and had held various sales and engineering related positions within the industry for more than 18 years.

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Society and Industry News

The Society of Vacuum Coaters wishes to acknowledge **Elsevier** for their support in co-sponsoring the very successful **Smart Materials Symposium** held at the 2004 SVC Annual Technical Conference (see page 15). It is planned to repeat this format and the extension of the TechCon to four days in 2005 in Denver.

The SVC has created a new section of the Web Site called **"In Memoriam"** to honor the passing of those who have been part of the SVC community and who have served the Society. SVC Mentors, short course instructors, TAC Chairs, Board members, and those who have been interviewed for oral histories will be remembered. It is with regret that we announce the passing of **Ted Van Vorous** in February 2004.

Please visit our tribute to Ted at http://www.svc.org/AboutSVC/AS_Memoriam.html

The Society regretfully announces the passing of **Professor Ron Howson** of Loughborough University, UK. Ron helped initiate the IPAT series of international conferences and was involved in the *Coatings on Glass* series of conferences. He was a regular contributor to many of the international vacuum coating conferences across the world and part of his legacy is the continued contribution to the field made by so many of his past research students. In 1982 he and his research group won the BP National Energy Research Prize, followed the next year by the BP International Prize for Energy Research.

SVC Thanks TechCon Event Sponsors

The SVC would like to acknowledge the companies sponsoring many events during the TechCon.

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The SVC Awards Committee announced the **Mentor Award recipients** for 2004 at the SVC Annual Business meeting held on April 25 in Dallas: **Harold Gadon,** Providence Metallizing Company, Inc. (retired); **Russell J. Hill,** VON ARDENNE Coating Technology; and **Richard Swisher,** Sheldahl, Inc.

The new **SVC Nominations Committee Chair, John Felts,** welcomes suggestions from members for nominees for the position of Director. John can be reached at felts.dnai@rcn.com. The Board will have several vacancies for Director to fill for the 2005-2008 period. SVC Board policy is that the Nominations Committee and Board of Directors have members who represent the broad interests of the different technologies associated with the society.

SVC is pleased to announce several new **SVC Committee Chairs: Lisa Robillard,** MKS Instruments, Inc. has accepted an appointment as the SVC Exhibit Committee Chair. She can be reached at lisa_robillard@mksinst.com. **Ismat Shah,** University of Delaware, has accepted an appointment as the SVC Education Committee Chair. **Vasgen Shamamian,** Dow Corning Corporation, has accepted an appointment as the SVC Assistant Education Committee Chair. Ismat and Vasgen can be reached at ismat@udel.edu and v.shamamian@dowcorning.com respectively. Lisa, Ismat and Vasgen all welcome your views on how to move SVC forward in these areas.

SVC welcomes **Charles Bishop,** C.A. Bishop Consulting Ltd., (CABishopConsulting@cabuk1.co.uk) as the new Vacuum Web Coating TAC Co-Chair, and **Roel Tietema,** Hauzer Techno Coating BV, (rtietema@hauzer.nl) as the new Tribological and Decorative Coating TAC Chair.

The Society of Vacuum Coaters is co-sponsoring the **5th International Conference on Coatings on Glass (ICCG)** to be held July 4–8, 2004 in Saarbruecken, Germany. For details visit www.iccg.de.

AVS 51st International Symposium & Exhibition will be held at the Anaheim Convention Center, Anaheim, CA on November 14–19, 2004. Session topics include the following: Advanced Surface Engineering; Applied Surface Science; Biomaterial Interfaces; Electronic Materials and Devices; High-K Dielectrics; Magnetic Interfaces and Nanostructures; MEMS and NEMS; Manufacturing Science and Technology; Nanometer Scale Science and Technology; Organic Films and Devices; Plasma Science and Technology; Semiconductors; Technology for Sustainability; Thin Films; Vacuum Technology. For details visit the new AVS Web site at www.avs.org

SVC is a Cooperating Society for the **Optical Interference Coatings Ninth Topical Meeting and Tabletop Exhibit,** June 27-July 2, 2004, Loews Ventana Canyon Resort & Spa, Tucson, Arizona. For more details visit http://www.osa.org/meetings/topicals/oic/

The Association of Industrial Metallizers, Coaters and Laminators honored **Celplast Metallized Products Ltd.,** Toronto, Ontario, with its Metallized Product of the Year Award in March during its Winter Management Meeting. Celplast metallizes Cellofoil™ low-density polyethylene for bread bags used by Canada Bread Co. Ltd., Etobicoke, Ontario, for its Dempster's® brand white bread.

The SVC sponsored three promising students through its **Student Sponsorship Program** at this year's TechCon. **Zuzana Kucerova,** a student at Masaryk University in the Czech Republic, presented a paper in the Optical Coating Session entitled, "Multilayer Protective Coatings for Polycarbonates Prepared by Plasma Enhanced CVD". **Jean-Michel Lamarre,** a student at École Polytechnique in Montréal, Canada, presented his paper in the Optical Coating Session entitled, "Optical Response from Single- and Multi-layer Metal/Dielectric Nanocomposite Thin Film Systems". **Ales Kolouch,** a student at the Technical University of Liberec in the Czech Republic, presented his paper entitled, "Comparison of Titanium Oxide Coatings Deposited by PVD and PECVD" in the Tribological and Decorative Coating Session.

The SVC Student Sponsorship Program is devoted to being a link between students and industry professionals. For more information about student sponsorship, visit http://www.svc.org/EP/EP_StudentProg.html.

For the first time, all Poster presentations at the SVC TechCon were eligible for a **$200 Best Poster Award** (see page 20), which resulted in a technically and visually exciting session. The Poster presentations were displayed side-by-side in a highly visible area in the busy Exhibit Hall and remained there until the end of the Exhibit on Tuesday afternoon. By extending the viewing time and placing the Posters in the Exhibit Hall, more attendees were able to see the posters and take part in the question and answer phase without missing any of the Exhibit.

The SVC plans to continue the "Best Poster" Award for the 2005 TechCon in Denver, CO, and reminds authors that the deadline for submitting abstracts is October 1, 2004.

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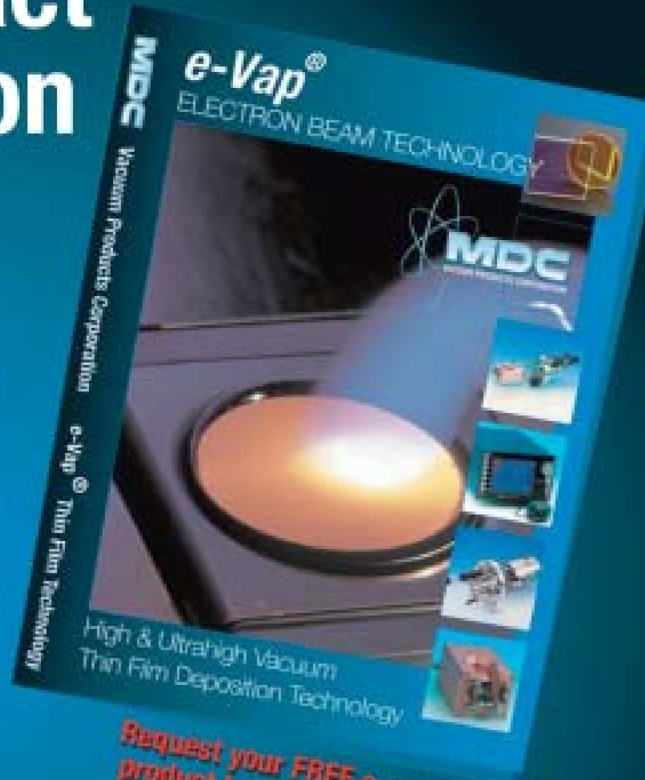

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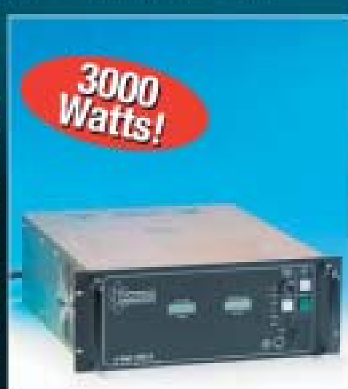

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