 ISSN 0737-5921, ISBN 978-1-878068-45-3

High Durability Dental Drills Due to Wear-Resistant DLC Protective Coatings

Angela Bertuna[1], L. Mendizabal[2], O. Hernandez[2], E. G-Berasategui[2]
[1]Protec Surface Technologies, Bedizzole, Italy
[2]Tekniker, Eibar, Spain

The aim of this study was to increase the dental drill lifetime and performance by using wear-resistant diamond like carbon (DLC) coatings to enhance success rate of an implant surgery.

For DLC protective coating development, the PF650 system manufactured by PROTEC was employed. The PF650 is equipped with 4 magnetrons (800x100 mm) powered by High Power Impulse Magnetron sputtering (HIPIMS) sources from VIESCA, and pulsed dc plasma enhanced chemical vapor deposition (PECVD) technology. Different DLC coatings were initially deposited on flat samples at different C_2H_2 pressures and characterized by scanning electron microscopy, Raman spectroscopy, nanoindentation and adhesion tests. Cr adhesion layer using HIPIMS technology was optimized for adhesion improvement. The best-performing DLC coating was deposited on dental drills and analyzed by confocal microscope to ensure coating adhesion on cutting edges.

DOI: https://doi.org/10.14332/svc25.proc.0024

Protec
SURFACE TECHNOLOGIES

Tekniker
MEMBER OF BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

HIGH DURABILITY DENTAL DRILLS DUE TO WEAR-RESISTANT DLC PROTECTIVE COATINGS

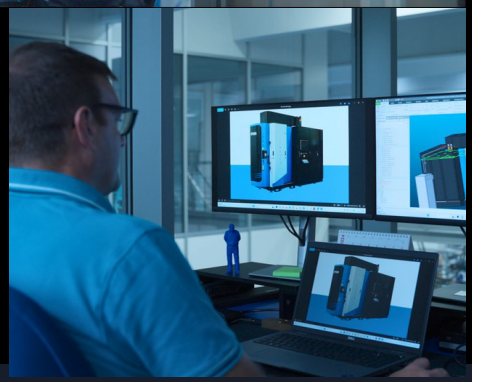
68th Annual SVC Technical Conference • May 19 - 22, 2025

SUMMARY

- About Protec ST
- About Tekniker
- Collaboration
- Heart of the Matter
- Requirements
- DLC coatings
- Equipment and Technology
- Our Proposal
- Lab Tests
- Conclusions

ABOUT PROTEC ST

Founded in **1996**, **Protec Surface Technologies** has established itself as a **leader** in the field of **high-vacuum deposition systems,** specializing in both Physical Vapour Deposition (**PVD**) and Plasma Enhanced Chemical Vapour Deposition (**PECVD**).



SUSTAINABILITY: WE LOOK TO THE FUTURE WITH RESPONSIBILITY

INNOVATION AND GROWTH: WE EVOLVE TO CREATE VALUE

EXCELLENCE: UNCOMPROMISING QUALITY

TEAMWORK AND CUSTOMER ORIENTATION: COLLABORATION FOR SUCCESS

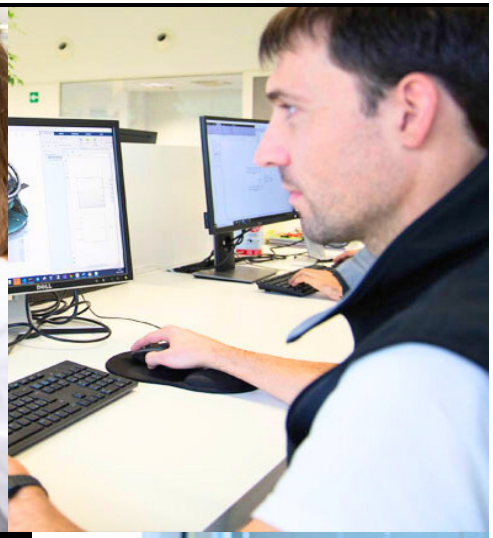
Tekniker
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

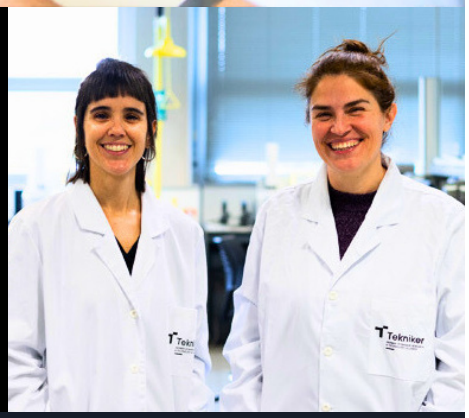
ABOUT TEKNIKER

Tekniker is a technology center specialized in:

- Advanced Manufacturing
- Surface Engineering
- Product Engineering
- ICTs for manufacturing

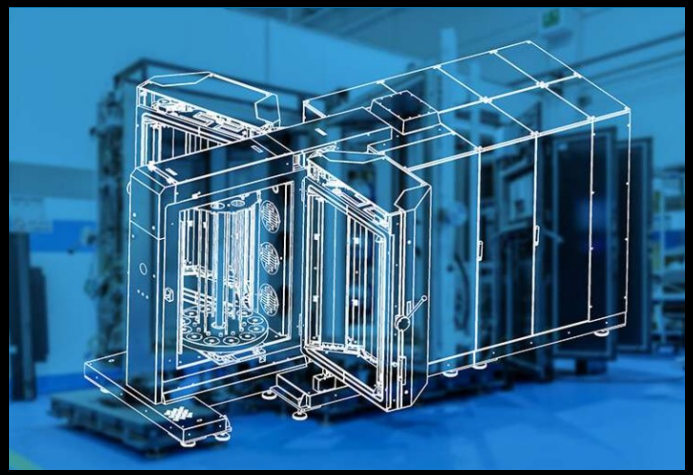
The mission is focused on bringing about growth and wellbeing for society at large through R&D&I actions and by furthering the competitiveness of our industrial fabric in a sustainable manner.





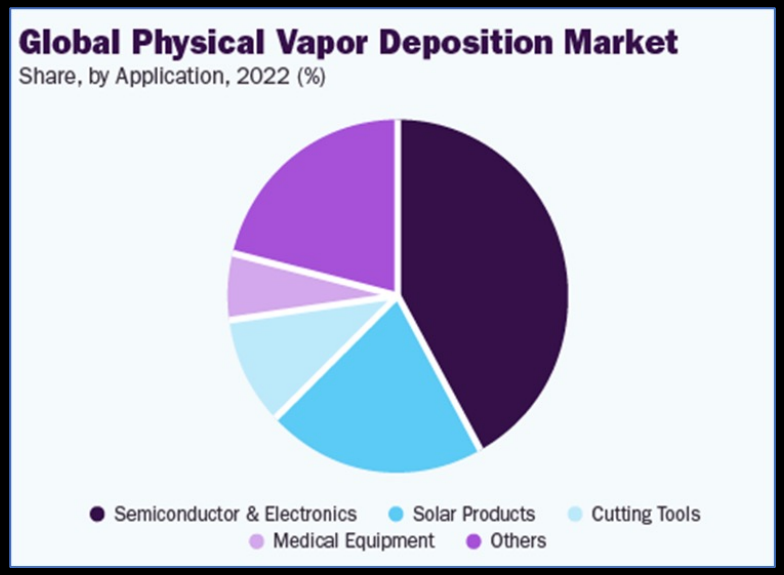
COLLABORATION

Protec: Realized the equipment



Tekniker: Studied the coating

HEART OF THE MATTER



..To have an idea..

- Global PVD market size estimated currently to be approx. USD 18 - 20 Billion
- Global PVD market size estimated in the closer future to be approx. USD 25 - 26 Billion
- Medical market share: approx. 10-15%

HEART OF THE MATTER

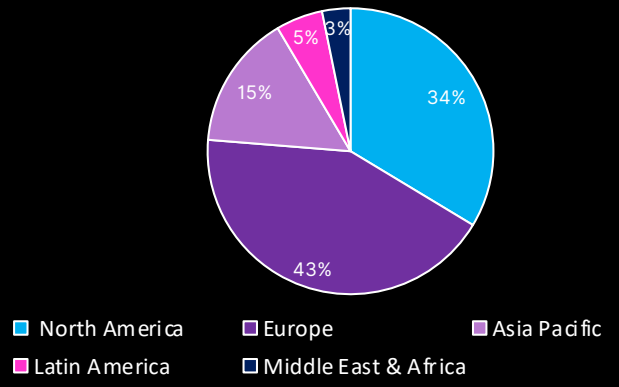
Dental Implant

- Excellent way of replacing teeth
- A titanium screw
- A porcelain crown

Coated advantages

- Smooth surface
- Improve wear resistance
- Low friction
- Reduction of torque at the application of the screws
- Biocorrosion resistance

*Abutments Region Market share



- Data for 2018 to 2022
- The global dental implants market size was valued at $4.15 billion in 2022 & is projected to grow from $4.42 billion in 2023 to $6.95 billion by 2030

REQUIREMETS

AESTHETIC

- Better categorization
- Fast identification

LOW COEFFICIENT OF FRICTION

- No lubrication
- Reduction of the heat production

CORROSION RESISTANCE

- Protection against cleaning liquids
- Sterilization cycles
- Be autoclavable
- Resistance in critical environments (e.g. the mouth)

ANTI-GLARE

- Prevention of light reflection in surgery rooms

SCRATCH RESISTANCE

- Protection of surface aesthetic features

WEAR RESISTANCE

- Maintaining sharp cutting edges
- Healing speed of wounds

ANTI-BACTERIAL

- Prevention/reduction of infection risk
- Probability of a revision surgery thereof

BIOCOMPATIBLE

- The basic requirements for coatings

Tekniker
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

DLC COATINGS

DURABILITY & LONGEVITY

Higher abrasion means longer service life

Reduction in instrument replacement

PRECISION & EFFICIENCY

Less wear means precision over time

More accurate interventions and less risks of error

PATIENT SAFETY

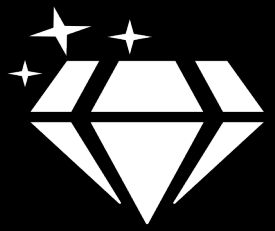
Less wear means reduction of damages during use

Increased patient safety and reduced complications

QUALITY OF TREATMENT

Higher abrasion means consistent treatment quality

Improving patient experience and clinical outcomes



DLC COATINGS

Diamond Like Carbon
Thin, highly durable carbon-based coating

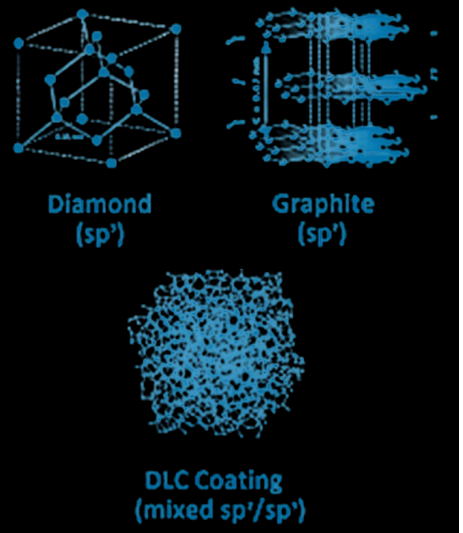
WHAT IS DLC?

Diamond

- The hardest known material
- The material for machining many aluminum alloys & plastics
- Excellent for surfaces used in human surgery

Graphite

- Very low coefficient of friction (no grease/oiling necessary)
-

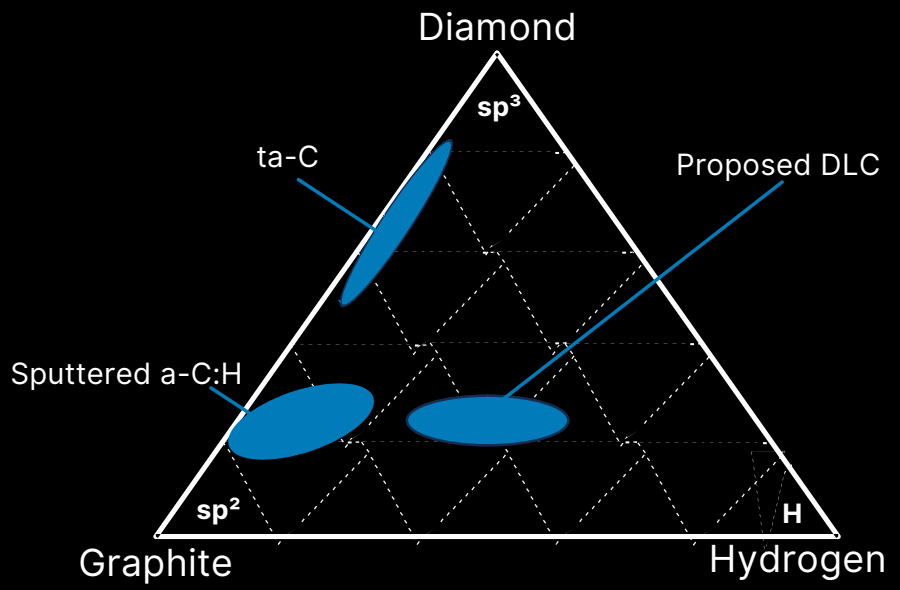


WHAT TYPES OF DLC ARE THERE?

- Hydrogen-free DLC (a-C):
  - Denser and harder than hydrogenated DLC
- Tetrahedral amorphous carbon (ta-C):
  - High sp^3 bond content
  - Harder
  - High wear resistance
- Hydrogenated DLC (a-C:H):
  - H atoms in the structure
  - reduced internal stress

↓

PROPOSED DLC



Tekniker
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

EQUIPMENT & TECHNOLOGY

POWERFLEX 650

- Technical coatings
- 3 possible technologies: Cathodic arc, Magnetron Sputtering and Hybrid (Arc+Sputtering)
- Process optimization
- Customized solutions
- Good process repeatability
- Fast processes
- Useful volume ⌀ 780mmx650mm
- Internal chamber dimensions: 1000mmx1200mm

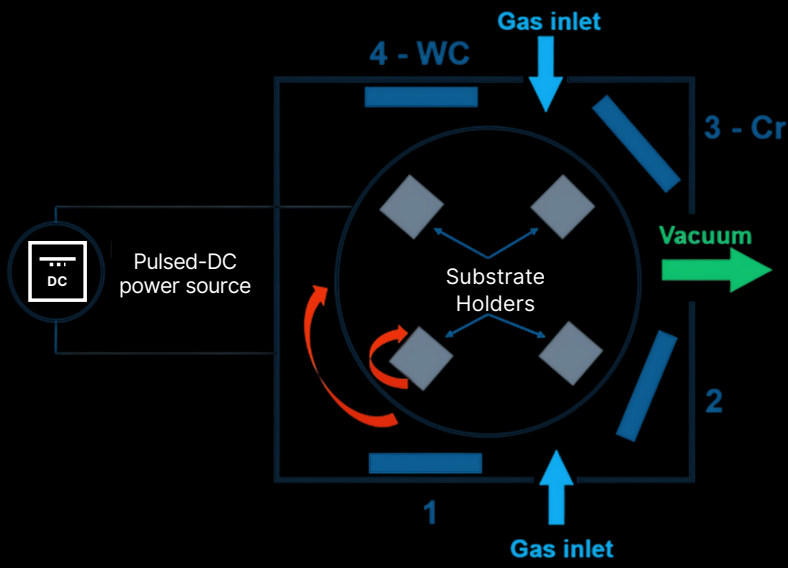
Technical coating are the key to **enhancing** the **performance** and **durability** of **tools**, **molds**, and **industrial components**

EQUIPMENT & TECHNOLOGY

PVD + PECVD:

- PVD Magnetron DC
- PVD Magnetron DC pulsed
- PECVD

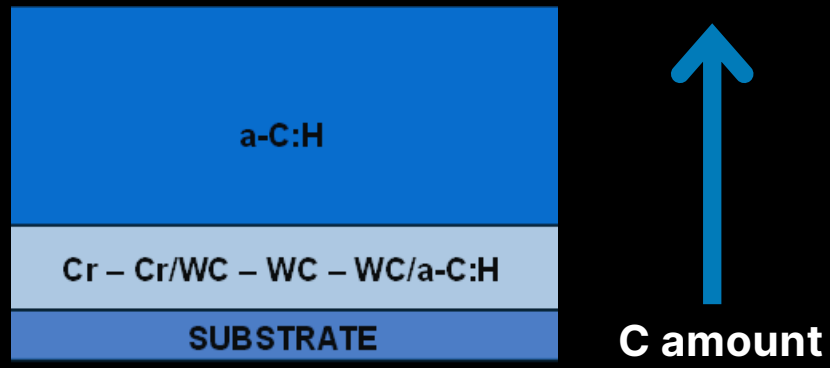
The whole process is performed in the same machine



OUR PROPOSAL

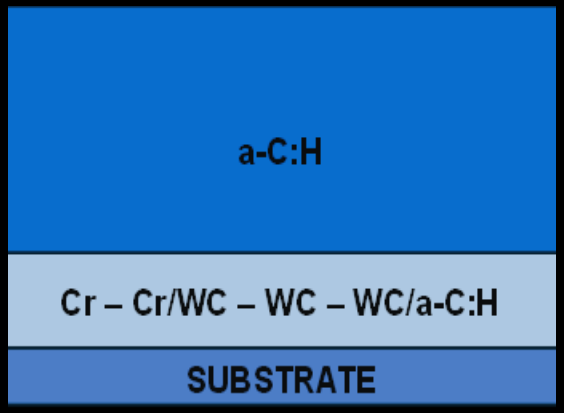
Film architecture:

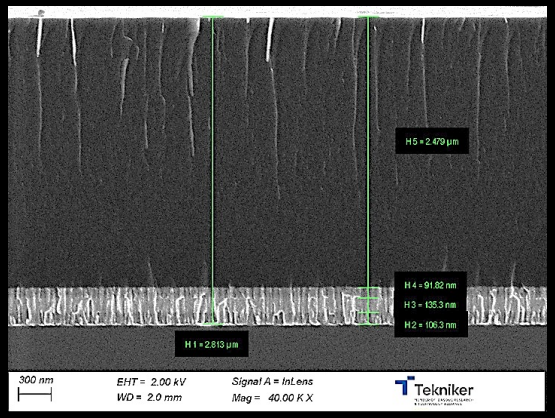
- Cr adhesion layer by DC
- WC buffer layer by pulsed DC
- a-C:H by PECVD



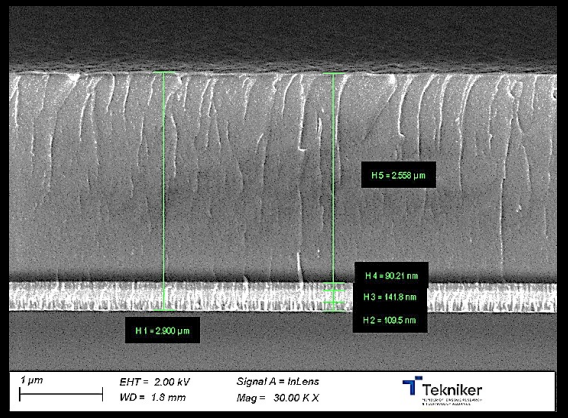
OUR PROPOSAL

Different samples obtained changing the pressure



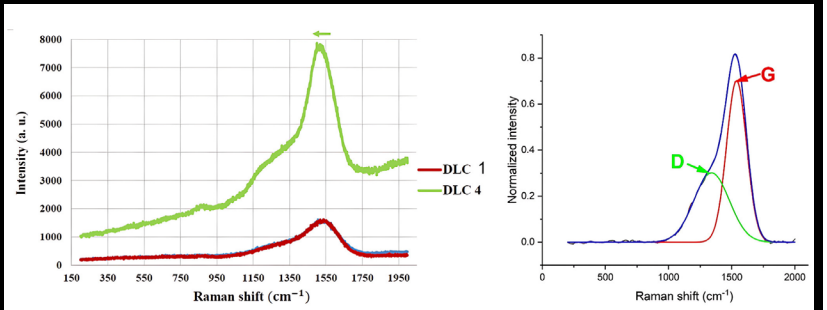


a-C:H @ 1Pa

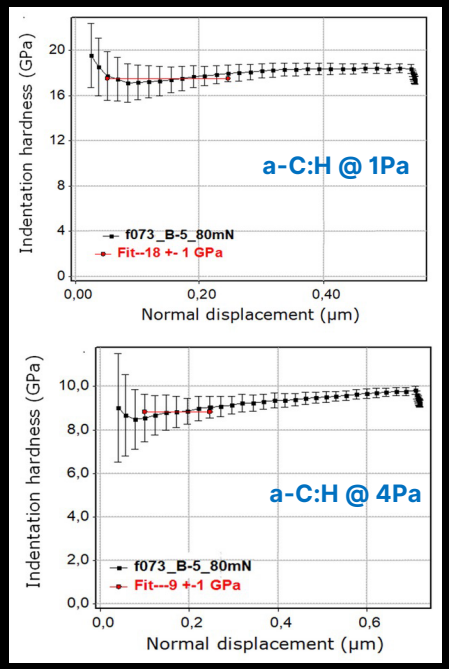


a-C:H @ 4Pa

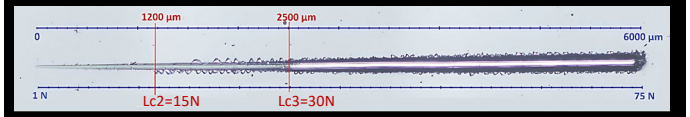
LAB - TESTS



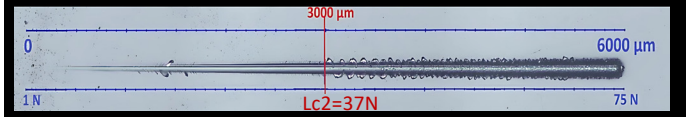
Reference	I(G)	I(D) / I(G)	Pos(G) [cm⁻¹]	H content [at%]
DLC 1 Pa	0,7	0,43	1536	21,5
DLC 4 Pa	0,66	0,32	1527	30,2



a-C:H @ 1Pa



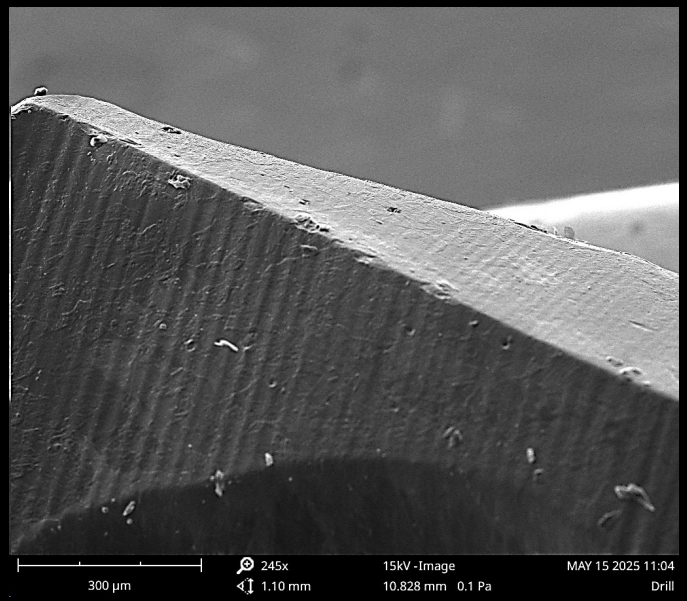
a-C:H @ 4Pa



Tekniker
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

ONGOING LAB TESTS

Wear resistance tests



CONCLUSIONS

- Importance of PVD in medical market
- Technical requirements
- Dental field
- Importance of DLC in this field
- Developed coatings
- Tested properties
- Ongoing tests

LET’S KEEP IN TOUCH!

angela.bertuna@protectim.com

Via Benaco, 88 - 25081 Bedizzole (BS) Italia
T. +39 030 6871703 | F. +39 030 6873773
info@protectim.com | www.protectim.com

Protec Surface Technologies S.r.l.

www.protectim.com

https://www.linkedin.com/company/protec-surface-technologies-s-r-l

www.youtube.com/@PandPHolding

info@protectim.com

+39 030 6871703