www.hefusa.net
sales@hefusa.net

CERTESS® Carbon

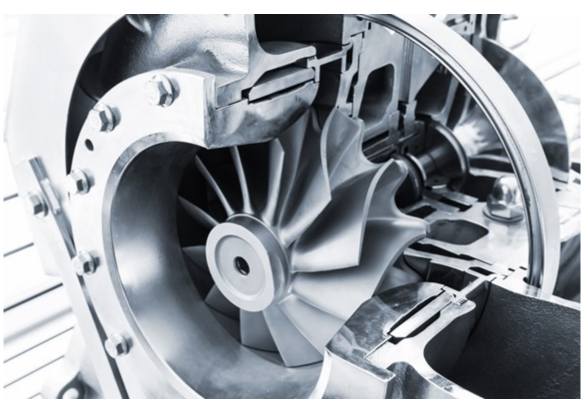
Diamond-like-Carbon (DLC) Tribological coatings

Extreme Hardness + Very low friction = Exceptional Wear Resistance










PVD Coatings Overview

Physical Vapor Deposition (PVD) coating involves the deposition of thin (2-10 microns; 0.0001"-0.0004") films on the surface of components. The PVD coating process, conducted under high vacuum conditions, can be divided into three stages:

- **Evaporation** - Removal of material from the target, source or cathode. Material is usually extracted from a high-purity solid source, such as Titanium, Chromium etc., by sputtering or by an arc-discharge.
- **Transportation** - Travel of evaporated material from the source to the surface of the component to be coated. The transportation step is through a plasma medium. Plasma is a collection of charged particles (ions), whose constituents can be influenced by magnetic fields and tend to travel in straight lines or "line of sight" from source to substrate. Different characteristics are imparted to the plasma depending upon the technique used to generate it.
- **Condensation** - Nucleation and growth of the coating on the component surface. A PVD coating is formed when plasma constituents and reactive gases, such as nitrogen, combine on the component surface to form thin and very hard coatings such as Titanium nitride (TiN) and Chromium nitride (CrN).

Besides its specific chemical constituents and the architecture of the sub-layers, the properties of a PVD coating depend upon: ion energy; the degree of ionization of the metal ions; and mobility of the atoms condensing on the component surface. If instead of a solid source, a hydrocarbon gas is utilized as the source material - a very hard, ultra low-friction Diamond-like-Carbon (DLC) coating can be deposited. This gas based process is referred to as **PACVD - Plasma Assisted Chemical Vapor Deposition.**

HEF PVD/PACVD coatings are deposited using two different technologies:

PEMS: *Plasma Enhanced Magnetron Sputtering*

HEF patented PEMS is a magnetron sputtering process enhanced by an auxiliary plasma source. This triode system allows independent control of material flux, ion energy and substrate bias. PEMS can provide a multitude of high performance coatings with application customized hardness, density and toughness.

CAM: *Coating Assisted by Microwaves*

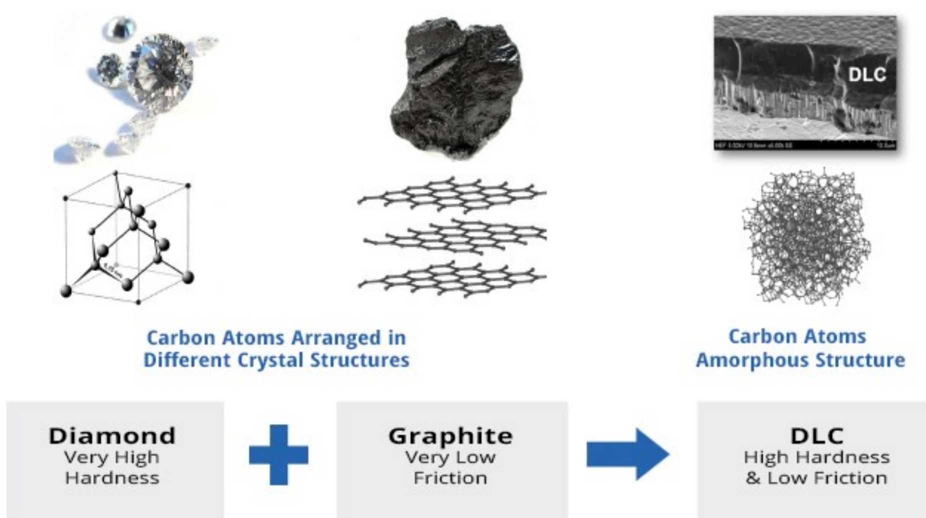
CAM permits the deposition of hard and ultra-low friction coatings at a very low temperature. Another major advantage is the ability to coat at low pressure, allowing more efficient use of the coating chamber and improved productivity.

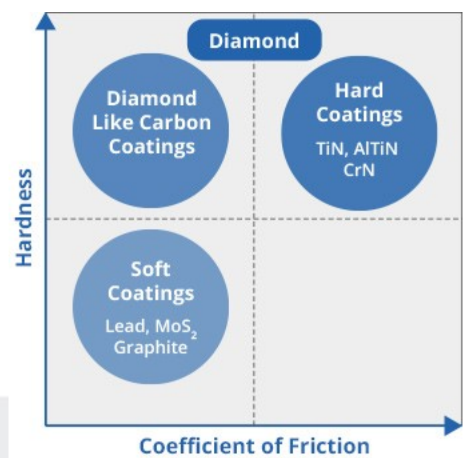
Attributes of PVD Coatings		
Hardest (1500 – 4500 HV) known synthetic materials	**Thin (2 to 5 microns**) coatings – minimal impact on size tolerance	**Low coating temperature (150 – 250° C)** – no distortion or core hardness loss
Low friction coefficients (0.1 – 0.5) – minimize friction losses	**Line of sight process** – difficult to coat cavities or IDs	**High Adhesion to a wide range of** steels, copper-alloys, plastics, glass……
Ability to deposit **alloyed and multilayered coatings**	**Possible to mask regions** on component where no coating is desired	**Zero environmental impact** – no effluents or toxic chemicals

DLC Coatings

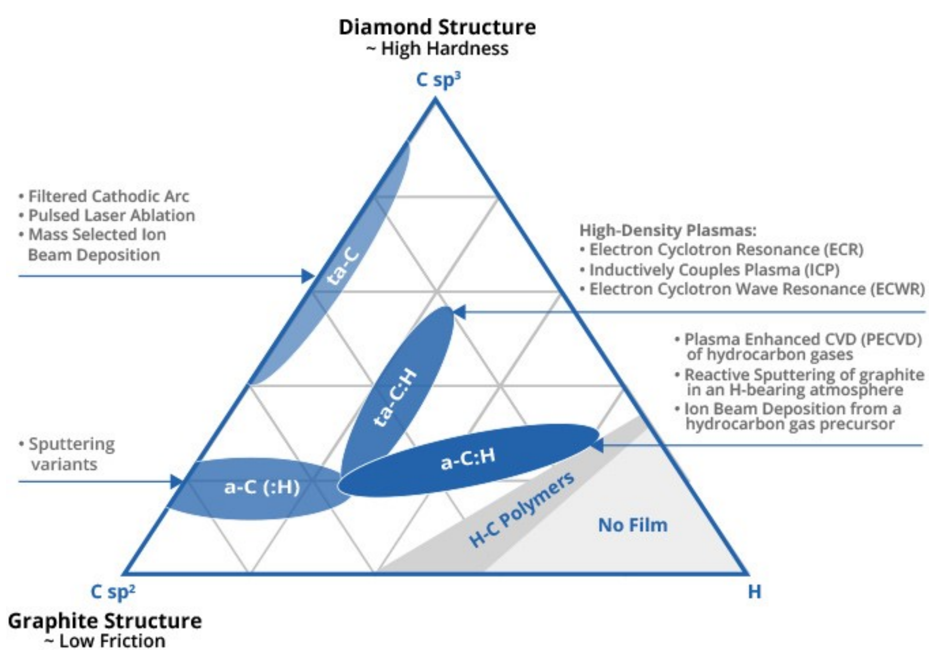
In recent years, a new generation of PVD + PACVD (plasma-assisted CVD) coatings has gained widespread commercial success. As is well known, in nature carbon can exist in two allotropic forms. Carbon, in a **Diamond** crystal structure, is one of the hardest know materials. Carbon, in a **Graphite** crystal structure, is very soft and lubricous. Carbon-based coatings, referred to as **Diamond-like-Carbon (DLC) coatings**, combine these two different properties of diamond and graphite - hence possess high hardness levels - in the range of conventional tribological PVD coatings (1500 - 3200 HV), coupled with a coefficient of friction which is 200-500% lower than that of conventional PVD coatings. These DLC coatings are generally amorphous (without a regular crystal structure) in nature.

What is a Diamond-Like-Carbon (DLC) Coating?



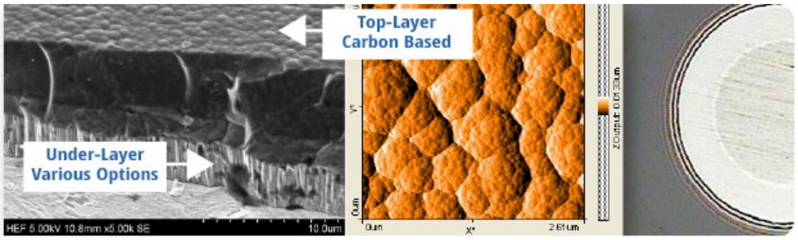


DLC coatings can be deposited using a diverse range of technologies and alloyed with elements such as hydrogen and metals such as chromium. These constituent elements and deposition technique can have a significant impact on the properties and structure of the DLC coating.



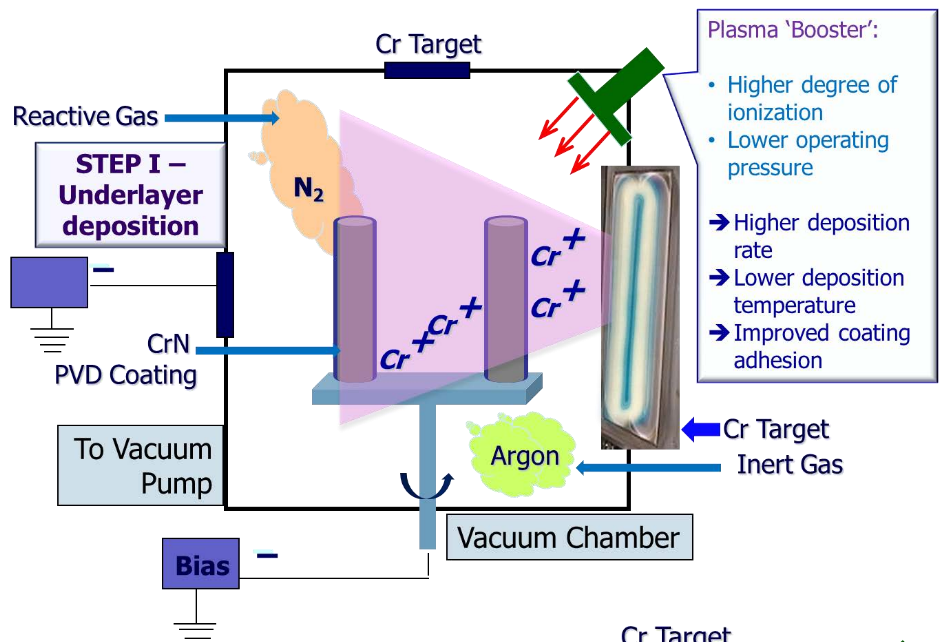
DLC COATING DEPOSITION: Simplified, Schematic view

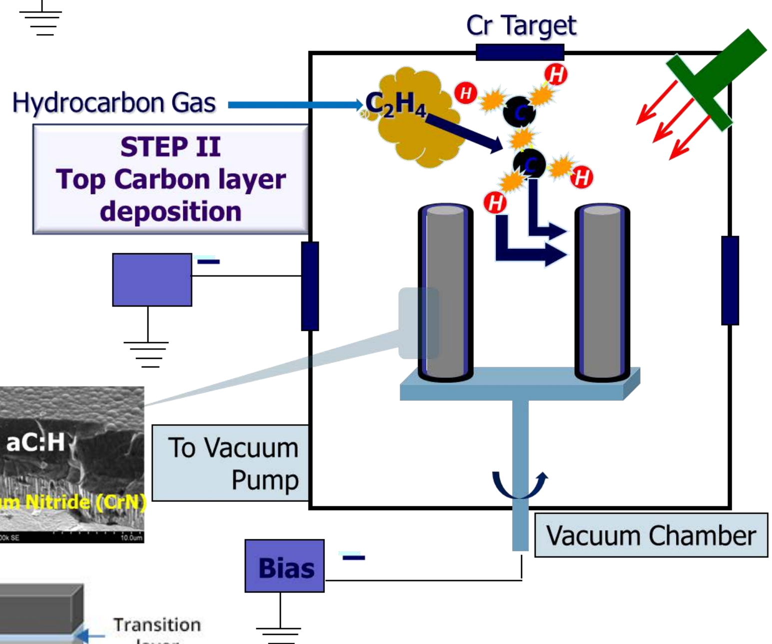
HYBRID PVD – PACVD deposition (CrN – aC:H)

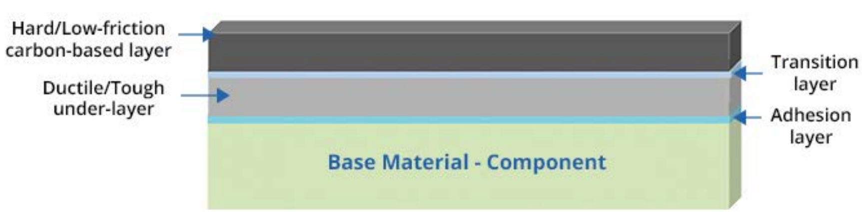


Topography of the top carbon layer depends on the morphology & and structure of the underlayer

In order to meet the diverse operating conditions encountered by engineered components used for automotive and other generic industrial applications, HEF has developed a family of diamond-like-carbon DLC coatings. These coatings usually include several layers of different materials such as Cr, CrN, W, WC-C, Si with a top layer of amorphous carbon, with hydrogen. The selection of the under-layer is based upon several factors such as: adhesion requirements, wear mode and contact mode, friction regimes encountered during operation, load carrying capacity, and other metallurgical considerations.



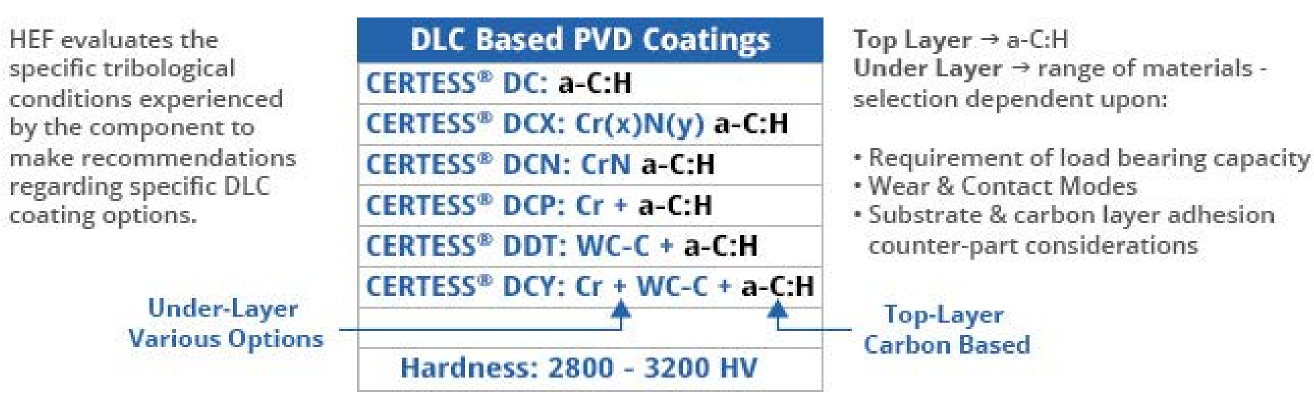




Diamond-Like-Carbon (DLC) Coating Properties

The properties of DLC coatings in terms of hardness; coefficient of friction; roughness; adhesion level; load carrying capacity; resistance to humidity influenced degradation; fatigue tolerance, etc. can be tailored over a wide range depending upon deposition parameters, deposition technology and the combination of materials constituting the coating. Some of the more common commercial variants of WCC and DLC coatings from HEF are as follows:

Properties	Coatings					
	CERTESS DT a-C:H:W	**CERTESS DTMO** a-C:H:W (modified)	**CERTESS DLC** a-C:H	**CERTESS DCX** CrN + a-C:H	**CERTESS DDT** WC + a-C:H:W + a-C:H	**CERTESS DCY** Cr + WC + a-C:H:W + a-C:H
Hardness (HV)	1200 - 1400	1700 - 1900	2000 - 2500	2500 - 3200	2500 - 3200	2500 - 3200
E (GPa)	125	140	200 - 210	200 - 210	200 - 210	200 - 210
Coeff. of Friction (dry)	0.20 - 0.25	0.20 - 0.25	0.11 - 0.15	0.11 - 0.15	0.11 - 0.15	0.11 - 0.15
Coeff. of Friction (5W30)	0.10 - 0.15	0.10 - 0.15	0.07 - 0.11	0.07 - 0.11	0.07 - 0.11	0.07 - 0.11
Scratch Lc (N)	60	60	20	25	25 - 30	30
Load Bearing Cap (arb. units)	1	1	3	8	9	9
Coating Thickness (microns)	1 - 3	1 - 3	1 - 3	2 - 4	2 - 4	2 - 4
Deposition Temp. °C	150 - 300	150 - 300	150 - 300	150 - 300	150 - 300	150 - 300
Max Usage Temp. °C	300	300	350	350	350	350



Other DLC coatings can be customized based upon the unique combination of wear mode, contact mode and the friction regime under which the component in operating.

DLC Coating Applications

Automotive Components

POWER-CELL

- Significant friction reduction
- Piston pin: Higher load sustainability without seizure

PISTON PIN PISTON RING

VALVE-TRAIN

ROCKER ARM PIN VALVE TAPPET ROCKER ARM

- Improved wear resistance
- Convert sliding contact to rolling contact: significant friction reduction

FUEL SYSTEM

- Improved sliding wear resistance
- Significant friction reduction

Motion & component holding and transfer mechanisms

♦ Rails & Guides ♦ Sprockets ♦ Links ♦ Spindles ♦ Collets ♦ Clamping Devices

- Reduced friction on sliding & rolling surfaces
- Enhanced wear resistance
- Dry, lube-free operations possible for applications such as medical, food processing and manufacturing of electronic devices
- High-speed spindles can operate with minimal wear - stable and precision operations

Industrial Gears

- Improved scuffing resistance
- Increase in rolling contact fatigue (pitting re-sistance)
- Ability to withstand high point contact loads

DLC Coating Applications

Compressor Components

- ♦ Vanes ♦ Swash plates ♦ Aerofoils ♦ Impellers ♦ Reciprocating pistons & plungers

- Lower friction coefficient and friction forces: important for oil-free operations and dry gas/refrigerant applications
- Improved wear resistance of tight tolerance components

Mechanical Seals

- Lower friction coefficient and friction forces minimizes seal damage
- Lower seal face temperature
- Superior wear resistance for leak free operation and improved lifetime

Hydraulic & Pneumatic equipment

- ♦ **Pump Components:** Components used in centrifugal; axial; vane; lobe; screw and spindle pumps. *Examples: Spindles, Vanes, Lobes, Gears, Screws, Plungers, Seals*

- ♦ **Valve Components:** Components used in Gate, Ball, Needle and Butterfly valves. *Examples: Seals, Seats, Stems, Balls, Glands, Actuator sub-components*

- Excellent sliding wear resistance: superior seal performance for leakage free operations
- Low DLC coating temperature and 2-4 micron thickness: ideally suited for high tolerance pump and valve components - typically used in high-pressure pumping applications
- Improved abrasion resistance when handling erosive liquids and slurries
- Reduced friction levels:
  - ◊ Lower energy consumption
  - ◊ Lower torque for valve actuation
  - ◊ Ability to operate effectively in low lubrication conditions

Plastic Injection Molding Dies

- Facilitates mold release
- Improved wear & corrosion resistance

Medical Instruments & Devices

- Prosthetic devices: orthopedic and spine implants; bone screws and plates
- Surgical instruments and tools
- Cardiovascular devices and implants: pacemakers; stents; guiding wires
- Dental implants

CERTESS® Carbon

Diamond-like-Carbon (DLC) Tribological coatings

HEF Group offers innovative solutions for wear, friction and corrosion reduction through a diverse selection of surface treatments and hard coatings. We partner with the industry's largest and most demanding manufacturers to develop application-specific surface engineering processes that substantially enhance performance and long-term durability. HEF is currently active in more than 20 countries throughout Europe, Asia, and the Americas and has 60 operating facilities

Our primary jobbing service offerings include the following:

- Application Engineered Liquid Nitriding / Salt Bath Nitriding: ARCOR®, MELONITE® / QPQ Treatments
- State-of-the-Art PVD Technology & PVD / DLC Coatings

TS USA

www.hefusa.net
sales@hefusa.net

HEF GROUPE