THIN COATING TECHNOLOGIES

Coating process

Origin of the process

The two technologies (PVD for Physical Vapor Deposition and PACVD for Plasma Assisted Chemical Vapor Deposition) currently used to coat medical components have been industrialized in the 1980s.

Thin films of metallic or ceramic structure can be deposited by using these technologies. Coating layers with high hardness, high oxidation resistance and low friction coefficient can be obtained.

The coating can also be used for color-coding.

Process

The P.V.D process

The two well known PVD process are the cathodic arc evaporation and the sputtering process. Cathodic arc evaporation allows the deposition of extremely hard coatings whereas the sputtering process is more inclined to provide smooth coatings with low friction properties.

The process description:

- The parts are fixed on a carrousel. The parts will rotate in a one, two or three fold rotation during the coating cycle in order to ensure homogeneous deposition.

- The chamber is pumped down to a high vacuum level of 10^{-4} to 10^{-5} mbar.
- The parts are heated using heating elements in the coating chamber.
- During an ion etching phase the parts are etched via sputtered by Argon ions. The goal is to enhance the adhesion of the metallic layer by removing any thin oxide layer on the surface of the parts and to create higher surface energy.
    - In the cathodic arc evaporation process, an electrical arc is formed on the surface of the target (Ti, Cr, AlTi…). The material is evaporated in the vacuum.
      The highly ionized metallic vapor leads to the growth of a coating on the biased parts (parts connected to a voltage of -100V).
      The addition of a reactive gas (nitrogen, oxygen, carbon containing gas…) allows the formation of Nitride (TiN), Oxide (TiO_2) or carbide (TiC) coatings in the case of a titanium target.
      The coatings obtained have excellent adhesion, high hardness and superior resistance to oxidation in the case of ceramic coatings.
    - In the sputtering process the targets are sputtered by ionized argon ions. Similar to the arc process, a reaction can be carried out with the addition of gas to create nitrides or carbo-nitrides.
      The energy level involved in the sputtering process is lower than in the arc process however the coatings are generally smoother.

P.A.C.V.D process

In this process the parts do not generally rotate during the process. The parts are placed on a cathode. The chamber is pumped down to 10^{-5} mBar.

After an ion etching, the reactive gas(es) are introduced into the chamber.

The parts are connected to a RF (radio frequency or mid frequency power supply). The high voltage ignites a plasma that creates ions and radicals in the chamber. The pars are then bombarded by the ions and radicals to form the coating layer on the surface.

Advantages and drawbacks

Advantages

These processes are environmentally friendly.

Primary coating properties :

- high hardness,
- low friction coefficient,
- superior resistance to oxidation and corrosion,
- thickness between 1 µm and 8 µm,
- de-coating is possible,
- many colors can be obtained,
- initial surface finish is maintained (polished, ground, sand blasted…),
- a broad range of coatings are certified biocompatible.

Drawbacks

Due to the low thickness of the coatings, the substrate has to support the mechanical load.

PVD deposition is a line of sight process. External surfaces are easy to coat but narrow holes are limited to a deposition depth approximately equal to the diameter.

The parts must be fixed in the chamber and some mounting surfaces will not be coated. The masking of parts requires specific mechanical tooling in most cases.

Application in the medical industry

The coating can be used on implants for :

- reducing wear and avoiding the creation of debris (metallic or polymeric),
- reducing the friction coefficient,
- increasing the corrosion resistance in when in contact with bodily fluids,
- enhanced bone growth (case of the PEEK),
- reducing the migration of metallic ions and allergy risks (Nickel).

On instruments :

- maintains the sharpness of the cutting instruments,
- the low friction coefficient reduces the temperature during drilling operations,
- reduces light reflection from instruments,
- allow color coding to quickly identify instruments,
- add protection to avoid galling or damaging the instrument.

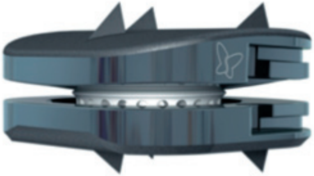
NAME	Material	Thickness range µm	Micro hardness HV 0.05	Friction vs. Steel	Service T° C	Depo T° C	Color	User benefit/features	Applications
Medthin ™ 01	TiN	1,5-5	2800	0.5	700	150-500	gold	sliding wear resistance, fretting	color coding, implantable components, instruments
Medthin ™ 16	TiAlN	2-4	3200	0.6	800	450	bronze	non specifically	color coding, implantable components, instruments
Medthin ™ 20	AlTiN	2-4	3500	0.55	700	450	blue-black	hardness, temperature stability	color coding, implantable components, instruments, anti reflection
Medthin ™ 30	CrN	2-40	2000-2600	0.55	700	150-400	silver	sliding, galling and wear resistance, oxidation	color coding, implantable components, instruments
Medthin ™ 43	a-C:H	2-5	2000-2800	< 0.1	300	160-200	black	slidind and adhesive wear resistance	low load implants, instruments, color coding
Medthin ™ 60	ZrN	2-4	2600	0.55	500	300	gold	hardness, resistance to pick up and corrosion	color coding, implantable components, anti alergy
Medthin ™ 62	Ti + MoS_2	1-2	1500	0.01	450	150C Ti 150C MoS_2	grey	wear resistance, resists galling and sticking	friction reduction between similar instrument materials
Medthin ™ 65	Ti	2-5	n/a	n/a	200	150	titanium	bone cell attachment	plastic components, osseo integration

Medthin™ are biocompatible PVD/PACVD coatings
Data shown is generic and subject to modification based on application. Subject to change without notice. Availability varies between coating centers.

Quality control

Quality controls include the indentation test to control the adhesion of the coating and a Calotest to measure the thickness of the coating.

Deposition temperatures are under 300°C in most cases.



Partner

Ionbond is a global leader in surface enhancement technologies with over 40 coating centers worldwide and has provided coating services to the medical device industry for more than 20 years. Ionbond has pioneered the commercial application of hard coatings.

The Ionbond Medthin™ line of Medical Grade Coatings meets the strict guidelines and performance requirements of the medical device industry. Quality and consistency are insured through compliance with established industry regulatory requirements that include certified biocompatibility according to ISO 10993-1 and compliance with the tenets of ISO 13485. Ionbond employs IQ, OQ, PQ process validated systems and Medthin™ coatings have US FDA Master Files for Medical Devices (MAF).

www.ionbond.com

ionbond