DLC coating

The acronym DLC means *Diamond - Like Carbon*.
This is a special coating, very variable in its characteristics suitable for different applications.
The film that covers a substrate can have thicknesses of a few nanometers up to a little more of the micrometer.
The DLC coating combines high hardness, low coefficient of friction and this makes it very useful for increasing the efficiency of parts of machines, tools and microgears.
Thanks also to the remarkable resistance to chemical attack and biocompatibility is used in jewelry and medical engineering.
The first information of applications dating back to 1970 , that is, when A. Aisemberg and R. Chabot published reports of their research on the possibility to deposit thin carbon films on substrates of different nature (crystalline silicon, glass, stainless steel).
in this context is that, given some properties strikingly similar to those of diamond, was assigned this name.

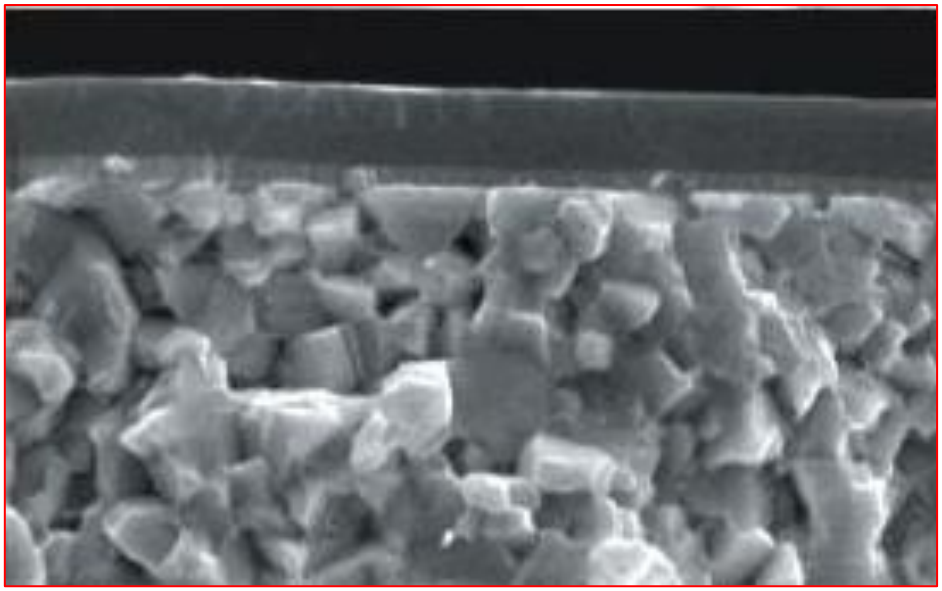

Figure N°1- DLC coating on sintered carbide (Korloy – Corea)

The most important physical properties of the DLC coating is certainly the film hardness.
Since the film has a thickness of a few tens of nanometers or at most one or two micrometers, we must speak of nano-hardness, because the methods Vickers and Rockwell are not very suitable for this purpose.
The nano-hardness is measured in GPa (Giga Pascal).
The following table shows the nano-hardness of some materials and some titanium-based coatings.

Material	Nano-Hardness GPa
Stainless steel	3
DLC in different combinations	9 - 30
Natural diamond	60 - 80
DLC pure	60 - 130
TiN (titanium nitride)	24
TiCN (titanium carbonitride)	31
TiAlN (Titanium aluminum nitride)	35 - 40
TiAlCN (Titanium aluminum carbonitride)	28

Also the coefficient of friction is very low, ranging between 0.1 and 0.2, ie much lower than all of the coatings used in tools sector.
As mentioned above, there are many possible applications of the DLC thanks to its hardness, transparency and resistance to chemical attack.
It is used in the electronics industry, the heads of the Hard Disk in jewelry and industrial tooling. As the product is biocompatible can be used for implants inside the human body.
There are also variants which provide a deposit of a layer composed of Si-DLC DLC between the substrate and the pure DLC.
This allows to increase the thickness of the film to over one micrometer and to improve the performances. (See figure N°1).
The application techniques are those used for other titanium-based coatings, varying obviously gases inside the chamber because is no longer necessary the nitrogen.
In nature there are two different geometric shapes of crystallization of the diamond (ie carbon).
The first and most common, known in jewelry has carbon atoms arranged in a cubic three-dimensional structure.
The most rare instead has the hexagonal shape, similar to cells in a beehive.
The chemical composition of the layer of DLC is crystallized carbon in its different structures and therefore is amorphous.
For example in figure N°2, which reproduces an image taken by the electron microscope, we can see the individual grains, roughly the size of a virus, which have cubic or hexagonal structure.
The grains arranged so randomly and alternate have a structure so compact that the surface appears like a mirror.

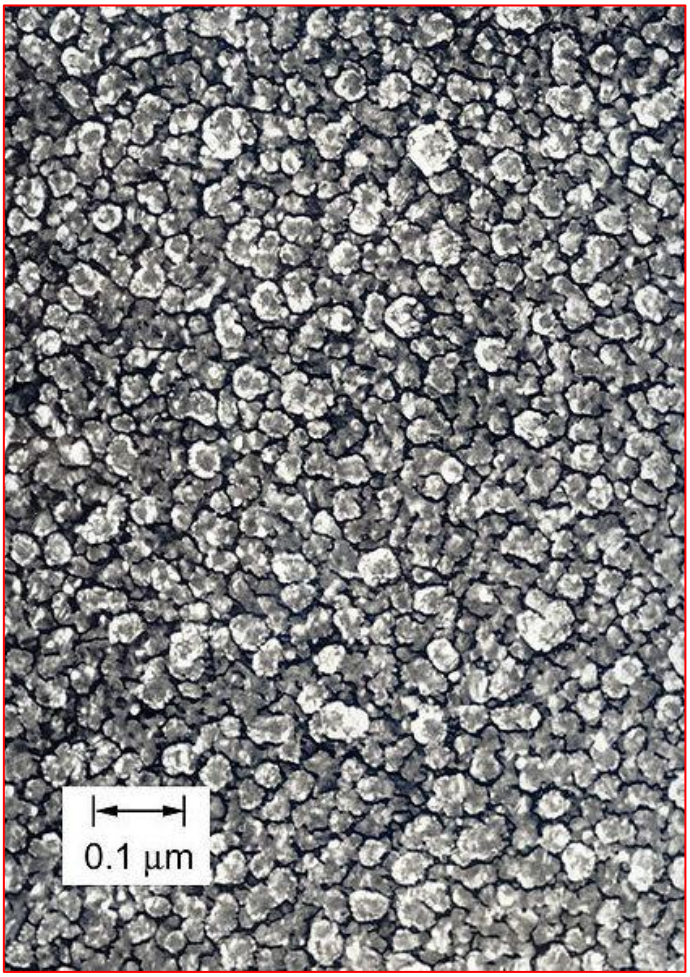

Figure N°2- *Crystals of C present in a layer of DLC*

In the super-hard DLC coatings (80 GPa) there is an increase of internal stresses in the layer thickness up to 200 nm.
In order to reduce these tensions the monolayer is replaced with alternating layers of hard DLC (70 GPa) and soft DLC (35 GPa).

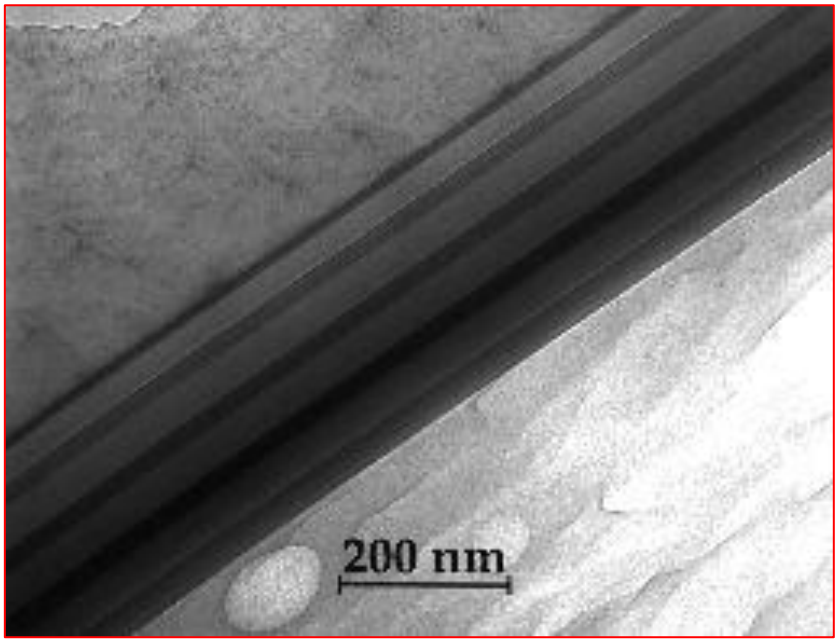

Figure N°3 – M*ultilayer DLC*

In the field of tooling, cutting tools coated with DLC have successfully used in processing of non-ferrous materials such as aluminum, graphite, plastic, wood.
During machining with chip removal do not have phenomenon of sticking of the chip on the cutting face .
Thanks to the extremely low friction coefficient and the characteristic self-lubricating, the surfaces are finished in a better way because we can increase the cutting speed without compromising the performance of the tools.

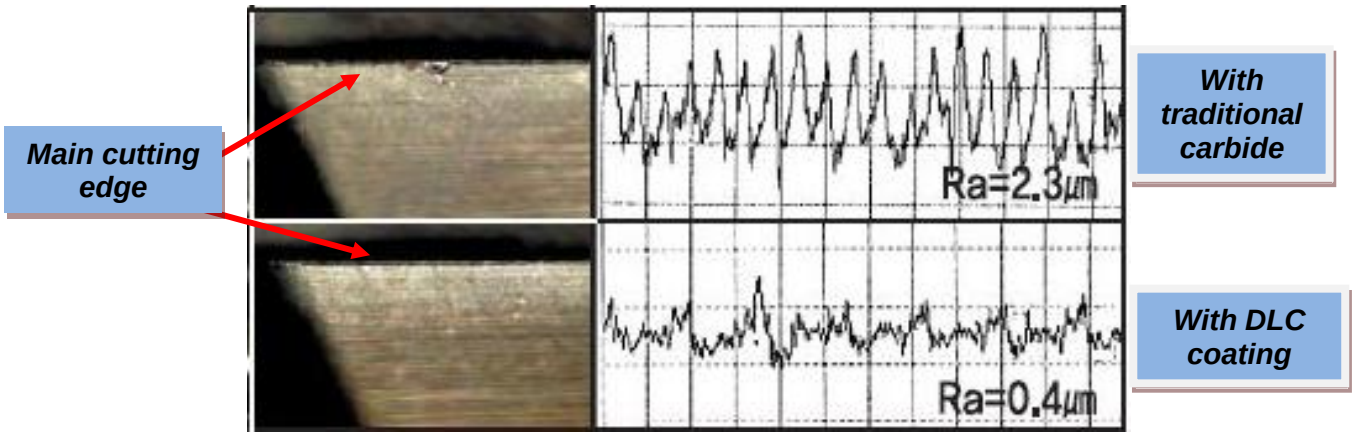

Figure N°4- *Example of reduction of surface roughness using DLC coatings*