TAKE CARE,
HAVE A COATING!

CUTTING TOOLS
COATINGS
BRIEF ON THE TECHNOLOGY OF PVD DEPOSITION

Surface treatments can be divided into two broad categories:

- **Filler surface treatments,**
- **Surface modification treatments.**

The “filler surface treatments” are also referred to as “coatings” and among the best known are the galvanic coatings, CVD and PVD.

Among the “surface modification treatments”, to name only the most well-known, we find the nitriding, the carburizing and the oxidation.

In order to improve the characteristics of cutting tools, among the various technologies mentioned certainly stands the PVD that, thanks to its peculiar requirements, allows the deposition of compounds with different intrinsic properties.

**PVD** stands for Physical Vapor Deposition.

The mechanisms of deposition can be schematized in three steps:

- **generation**
- **transport**
- **deposition**

In the case of PVD, the generation takes place by physical evaporating metals which compose the coating layer. The transport from the sources to the parts to be treated takes place through the plasma (ionized gas at low pressure). The deposition is instead facilitated by the presence of an electric field.

The PVD techniques are varied, but may briefly be divided into techniques in solid source (cathodic deposition, such as sputtering or arc) and techniques in molten source (such as evaporation due to joule effect or by the electron gun).

The increasing search for new compounds to be deposited, has increasingly directed the development towards the cathode sources, in order to be able to deposit alloys of different elements (for example, nitrides of Titanium and Aluminum, nitrides of Titanium and Silicon, etc.). This development has made it possible to improve the characteristics of this technology, while diminishing its weaknesses.

Today, for example, with the **cathodic arc** it is possible to achieve high levels of ionization of the plasma through the use of new generation sources which in addition to improving the intrinsic quality of the deposited layers, allow in parallel to reduce to a minimum the phenomenon of “droplets” which has always been considered the only small demerit of this technology. The “droplets” effect refers to the presence in the deposited layer of tiny droplets of material that, after being evaporated, has aggregated not in an atomic form.

The modern technology available today in **STS**, makes it possible to obtain layers of coatings almost “droplet-free.”
The coatings for cutting tools designed by STS are the result of years of experience in collaboration with important and well-known tool manufacturers as well as by deriving valuable feedback from end-users.

In STS the research and development never stop and every year the company is able to offer innovative and functional coatings to the numerous and more strict requirements of machining.

Each of the three Service Centers STS have a prestigious department of PVD coatings where it is possible to take advantage of the most advanced technologies to develop and deliver high-quality coatings.

Skilled operators and specialized technical personnel form the winning team of STS, a team that operates with total care and attention to ensure the highest result.
The technology of cathode arc PVD deposition has since long been considered mature and able to give stable and constant results.

The studies that have been focusing for years in order to bring further improvements to this technique have provided the coatings market increasingly effective up to express performances that have revolutionized the methodologies of machining.

The latest result of these efforts is referred to by the acronym of the HDP (High Density Plasma) that thanks to the new generation of cathode sources, allows to obtain a plasma density that is much higher compared to a traditional arc system.

The possibility of combining the effects of the system HDP to a polarization pulsed rather than static, favors the realization of layers of complex structure that maximizes the characteristics required by each specific processing providing striking results.

Thanks to HDP technology are made highly compact layers capable of reaching higher levels of hardness while managing to retain a formidable degree of toughness.

These conditions allow on one hand to deposit very thin layers with extreme precision and almost totally devoid of droplets (macro-particles voted to congenital arc technology), and on the other hand to increase the thickness of the coating without incurring in the phenomenon of self-detachment due to strong internal stress.

One of the primary goals of research in this field has always been the fact that aimed to achieve the deposition of very thick layers that were not previously considered interesting because of their high fragility, but now thanks to HDP technology, they represent a certainty and a great opportunity.
SURFACES OPTIMIZATIONS

PRE-TREATMENT COATING

Today’s needs in terms of machining by chip removal are becoming more demanding as a result of the use of advanced cutting parameters. Hence the need to achieve high performance tools capable of withstanding heavy removal, or high feed. For this purpose, the tool must be built with the best raw material and in strict compliance with the maximum precision and tighter tolerances. But all this may not be enough if we do not take into account a proper surface finishing of the tool combined with the best PVD coating.

The processes of preparation and coating must be considered as a single cycle of surface refinement. First, it is necessary to intervene on the cutting edge of the tool through an action that is intended to eliminate residual smoothing irregularities (Fig. 1-2), or any micro-cracks that represent a serious threat to trigger premature failure of the edge while using the tool.

A preparation aimed at eliminating these defects that at the same time does not affect the tool’s cutting power leads to a situation described in Figure 3.

OPTIMIZATION OF THE CUTTING EDGE

The optimization of the cutting edge of the tool ensures that after the treatment its cutting capacity won’t be altered. To obtain a well-defined cutting edge and of constant radius also allows greater freedom to choose the thickness of coating to be applied. In the case of tools not pretreated, the thickness should be limited effectively to not accentuate the phenomena of micro-chipping which could occur in the particular conditions of use. Because of this it was not possible to express all the potential of the new coatings with high aluminum content that combine high hardness to a resistance to hot oxidation (directly related to the thickness).

The intervention of optimization of the cutting edge allows on the contrary the deposition of significant thicknesses, thus managing to exploit the full potential of the coating.

POST-COATING TREATMENT

Arch traditional surface treatments suffer, in a more or less accentuated manner, the presence on the surface of macro-particles of deposit (droplets) (Fig. 4).

In the case of processing not particularly extreme, these micro defects do not alter the behavior of the coating.

Instead, when it is necessary to exploit the full potential of the whole tool-coating, also the improvement made by a post-polishing treatment is essential.

The POST-COATING TREATMENT should be conducted in an extremely controlled manner so to ensure that the macro-particles are removed, without damaging the coating or the cutting edge of the tool (Fig. 5).

Fig. 4 : UNTREATED - Magnification of the surface of a coated tool showing the presence of macro-particles.

Fig. 5 : TREATED - From the coated surface of the tool have been removed macro-particles significantly improving the sliding ability.
HDP technology generates the specific solution for small tools, called HDP Micro. This development takes into account carbide cutters and carbide drills (HM) ranging in size from a diameter of 0.5 mm and 6 mm and also HM reamers. The study of a coating suitable for this kind of tools originates from the necessity of having to comply with a refilling which must necessarily be contained within the thickness of 1-1.5 microns. The experience gained in this field in fact denounce how is counterproductive to exceed this limit due to the excessive rounding of the cutting edge that may ensue and that would not allow the tool a proper cutting. Consequently the objective was to achieve a layer that expresses within little thickness the best features of hardness, wear resistance and heat resistance, ensuring extra-ordinary stability of the cutting edge. All this is possible thanks to the HDP technology that allows to realize coatings with an exceptionally compact structure highly linked to the substrate.

HDP Micro has revealed an extraordinary potential in boring (HM tools) where the concepts for small tools are also important.

BORING TEST
Tools used: Reamers in HM Ø 7.935 (Ø / ±0.002 mm)
Reamers have been used to ream the hole of a sintered steel connecting rod with the following chemical composition:
C = 0.3-0.6%, Cu = 2.5-3.5%, Mn <0.08%, S = 0.3-0.5%, others <0.5%, Fe = remaining
The reamer is used on a transfer MIKRON with the following parameters:
Spindle motor speed = 1500 rev / min.
corresponding to a cutting speed of 37 m / min.
Feed = 0.23 mm / rev
Machine productivity = 550 pieces / hour

MILLING TEST
Tool: Cutter Ø 6 Z / 2 R.3
Milling a surface inclined at 15 ° , milling with parallel passages alternate with alternating climb milling and up milling.
Processed material: W300 1.2343 X38CrMoV51 hardened 55-56 HRC
Work parameters used: Vt = 320 m / min. => S 17000 rev / min.
F = 1700 mm / min. => Fz = 0.05 mm / rev x tooth
Removal:
ap = axial removal = 0.05 mm
ae = radial removal = 0.05 mm (displacement at each step)
Tool overhang from the spindle: 39.3 mm
Contact time (step 1): 1 hour, 0 min., 34 sec.
Contact time (step 1): 99.529 mt.

The process of surface preparation helps to get the best result too, but in the case of small tools it must be re-adapted to be able to eliminate any kind of imperfection of the cutting edge without creating an excessive rounding.
The HDP technology among other innovations has enabled the development of RED, a very versatile coating that is so widely used in many applications. HDP RED was in fact designed to give a universal answer to the more traditional processes giving the tools a constant efficiency and performance at the highest levels. The particular characteristics of this layer are:

**Extraordinary tenacity** = represents the strength of RED and determines its versatility and ability to express itself at its best in different applications (milling - drilling - tapping). **Adhesion to the substrate** = HDP technology achieves the highest levels of adherence of coatings to the surface making even more cohesive the combination tool + coating.

**Microhardness** = the highly compact layer of HDP RED is able to express in its 3 microns thickness high hardness values that represent a solid barrier against wear ensuring extra-ordinary performance.

**Low friction coefficient** = another important feature and aesthetically very evident because of the remarkable brilliance of the layer. Also the low friction coefficient of RED is made possible thanks to the HDP technology that enables the deposition of coatings almost totally devoid of “droplets” (macro residual particles from the surface) that for traditional coatings condition the surface roughness if not carefully removed.

In lubrorefrigerated milling with HSS or HM tools - in cutting or rolling Tapping - in drilling with HSS tips - HDP RED is undoubtedly the ideal solution.
The processing of materials that are more and more "hard to cut" requires new steps forward in the development and implementation of PVD coatings.

Essential phase of this development is the analysis and understanding of their mechanisms of the cutting so as to be able to limit the potential destructive actions for the tool.

The milling processes of steels with high hardness, in fact generate both mechanical and thermal stress which must be countered by the intrinsic properties of the coating. STS, which has long been focused in the study of the phenomena involved in cutting with chip removal and introducing the advanced HDP deposition system, was able to capture the full potential of PVD technology to create HDP EVO, the best you can offer to the aid of a tool intended to the toughest challenges.

HDP EVO combines the basic elements that give it excellent mechanical strength and high stability on the cutting edge.

The intrinsic properties of the layer are in fact enhanced by the peculiar characteristics of the HDP deposition system, which is thus able to optimize the maximum values of hardness, toughness and heat resistance, providing better adhesion of the coating to the tool tip.

These conditions make the tool suitable to withstand the most extreme stresses caused by the energy that is released during the toughest machining allowing to effectively counteract the shear forces.

During the various tests that have favored its development, HDP EVO showed a particular aptitude for the machining of stainless steels.
DEEP HOLE DRILLING

With the HDP STAR4 process STS aims to a remarkably effective product for deep drilling.

From tests carried out it has been noticed in fact that the drilling with carbide tools needs of nanolayers with weaving differentiated, alternated inside the main layer and manufactured in such a way as to allow maximum absorption of compression residual stresses.

The opportunities offered by new HDP technologies to have different elements in the phase of deposition within the same fill, has led to the definition of a coating with specifications unique in its kind and consisting of 4 dissimilar elements.

Thanks to the processes’ parameters determined and refined during various laboratory experiments, it has come to a multilayer structure that combines excellent wear resistance to hot to a very high toughness, the latter feature that allows the deposition of the coating also in high thicknesses.

The particular layer of HDP STAR4 is able to express the best of its potential when the surfaces where it lies down are carefully prepared.

The invaluable contribution of final polishing instead makes a running tool and gives the surfaces involved in the process an extraordinarily smooth effect facilitating the sliding and the chip evacuation (see SURFACES OPTIMIZATIONS on page 4).

### Basic Composition
- Aluminium Titanium Silicon Compound

### Coating structure
- High Density Plasma Multilayer

### Microhardness (HV 0.05)
- 3.800

### Coefficient of friction against 100 Cr 6
- 0.25

### µm thickness (microns)
- 1 - 4

### Deposition Temperature (°C)
- 500

### Max Temperature of use (max °C)
- > 900

### Colour
- Light Purple
Combining elements such as Aluminum, Chromium and Nitrogen is obtained a compound which reveals excellent values of hardness and wear resistance even when exposed to high temperatures.

By means of the *PVD* technology it is possible to bind these elements in thin layers to obtain the structure of AlCrN (Aluminum Chrome Nitride) that for its intrinsic characteristics finds wide application in the field of tooling for chip removal machining.

STS, as a result of further development, has been able to refine the configuration of AlCrN.

In fact, thanks to a new and sophisticated deposition process it has been possible to develop this layer renamed *CRONAL* and now able to express its full potential.

*CRONAL* proves to be a very flexible coating because it is applicable so much to HSS tools for traditional uses, as to HM tools for more demanding applications.

This universality of the *CRONAL* coating is due to its excellent structural toughness and the ability to adhere to the substrate with very strong ties that make it a formidable wear barrier.

The peculiar characteristics of the elements that compose *CRONAL* also confer an extraordinary thermal stability which raises considerably the point of oxidation of the layer allowing its use even at very high temperatures (1000 ° C).

This means that, although not disdaining the use of lubricant, *CRONAL* expresses itself at its best in dry machining.

<table>
<thead>
<tr>
<th>Basic Composition</th>
<th>Coating structure</th>
<th>Microhardness (HV 0.05)</th>
<th>Coefficient of friction against 100 Cr 6</th>
<th>μm thickness (microns)</th>
<th>Deposition Temperature (°C)</th>
<th>Max Temperature of use (max ° C)</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium Chrome Nitride</td>
<td>Monolayer</td>
<td>3.200</td>
<td>0.6</td>
<td>1 - 4</td>
<td>480</td>
<td>&gt; 900</td>
<td>Grey-Light Blue</td>
</tr>
</tbody>
</table>
**WONDER** originates from the research that made it possible to take the first steps towards the introduction of the element Aluminum in compounds deposited by PVD technology.

**STS** was able to develop a layer that had to meet the growing need to confer, for solid carbide tools, such performances to tackle the critical issues arising from those processes that became more and more challenging.

Over the years **WONDER** has undergone various developments that have improved its structure and increased its performance so much that it is still one of the coatings production in STS among the most demanded by the market.

**WONDER** is distinguished by a different alloying of high levels of aluminum which gives high hardness and excellent mechanical strength, making it a very good coating in a variety of applications, mainly applied to HM Tools.

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<table>
<thead>
<tr>
<th>Basic Composition</th>
<th>Coating structure</th>
<th>Microhardness (HV 0.05)</th>
<th>Coefficient of friction against 100 Cr 6</th>
<th>μm thickness (microns)</th>
<th>Deposition Temperature (°C)</th>
<th>Max Temperature of use (max ° C)</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>Monolayer</td>
<td>3.400</td>
<td>0.6</td>
<td>1 - 2</td>
<td>480</td>
<td>800</td>
<td>Dark blue</td>
</tr>
<tr>
<td>Titanium Nitride</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TiCN

The TiCN coating (Titanium Carbonitride) comes from an evolutionary study of the precursor TiN (Titanium Nitride), inheriting the already appreciated qualities and also some of its features. Indeed, thanks to the introduction of the C (Carbon) within the layer, it was possible to obtain a structure that provides a hardness greater than about 50% compared to that of TiN.

In consequence to this, the TiCN coating ensures a higher wear resistance while retaining excellent toughness which makes it ideal when applied to tools for interrupted cutting. A further improvement of the TiCN was achieved by developing a “multilayer” (multi-layer) structure composed of several hundreds of layers that give better control of structural stress within the coating.

STS recommends the use of TiCN combined with HSS tools for milling and tapping with the use of lubrocoolant and in the specific machining of austenitic stainless steel.

TiCN PLUS

It is the result of the superposition of the TiCN coating (MoS₂). This combination proved to be often very valid in tapping operations, due to the phenomenon of lubrication made from MOVIC® that, in addition to facilitating the cutting, allows a good chip evacuation avoiding microsolderings which cause the break of the tools.

MECHANICAL BEHAVIOR OF MOVIC®

<table>
<thead>
<tr>
<th>Coating</th>
<th>Basic composition</th>
<th>Coating structure</th>
<th>Microhardness (HV 0.05)</th>
<th>Friction coefficient against 100 Cr 6</th>
<th>µm thickness (microns)</th>
<th>Deposition temperature (°C)</th>
<th>Max Temperature of use (max °C)</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>TiCN</td>
<td>Titanium Carbonitride</td>
<td>Multilayer</td>
<td>3.500</td>
<td>(max °C)</td>
<td>Colour</td>
<td>350 - 480</td>
<td>350</td>
<td>Grey Blue</td>
</tr>
<tr>
<td>TiCN Plus</td>
<td>Titanium Carbonitride + Molybdenum Disulphide</td>
<td>Multilayer</td>
<td>3.500</td>
<td>&lt; 0,1</td>
<td>1 - 3</td>
<td>350 - 480</td>
<td>350</td>
<td>Dark Grey</td>
</tr>
</tbody>
</table>

Graphite Structure

Bodies still in contact

Bodies in motion

MOVIC® Structure

S

Mo

C
Always very fascinating for its bright gold color, TiN (Titanium Nitride) was the first PVD coating to be used successfully in industry, applied to cutting tools for chip removal machining.

The enthusiasm for the TiN reached the highest levels when the market realized that, thanks to the PVD technology, it was possible its deposition also on tools in HSS (high speed steel) as applicable at temperatures below 500 °C.

Although over the years, research has enabled the development of more complex coatings, TiN is a product of great actuality and it is still appreciate in many applications.

Having refined the deposition techniques, STS is able to propose a TiN coating for cutting tools capable of expressing all those peculiar characteristics that make it interesting and very effective in the most traditional processes for the removal of chips.

<table>
<thead>
<tr>
<th>Basic Composition</th>
<th>Coating structure</th>
<th>Microhardness (HV 0.05)</th>
<th>Coefficient of friction against 100 Cr 6</th>
<th>µm thickness (microns)</th>
<th>Deposition Temperature (°C)</th>
<th>Max Temperature of use (max ° C)</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titanium Nitride</td>
<td>Monolayer</td>
<td>2.200</td>
<td>0.6</td>
<td>1 - 4</td>
<td>140 - 480</td>
<td>500</td>
<td>Yellow Gold</td>
</tr>
</tbody>
</table>
PVD MAGNETRON SPUTTERING TECHNOLOGY

MOVIC® is a self-lubricating and anti-adhesive coating based on MoS2 (Molybdenum Disulphide), and is produced with PVD Magnetron Sputtering technology.

Developed in aerospace from the need to find an alternative to traditional lubricants (e.g., oil, grease) when their use is not permitted, revealed excellent tribological properties that have made it, as a result, very interesting for a variety of application fields.

TECHNICAL FEATURES/SPECIFICATIONS

- Monophase amorphous self-lubricating coating based on MoS2.
- "Soft" coating with a very low coefficient of friction (friction coefficient in dry air <0.05).
- Mono-layer coating that can be combined with any hard coating.
- Functional coating thickness <0.5 microns.
- Deposition temperature <150 °C.
- Traces of soft wear, lubricants ("Fail-safe" behavior, that is no abrasive particles are created by the wear of the coating).
- Great running-in on rough surfaces (the coating becomes smoother during the running-in).
- Positive transfer of the lubricant film on the body in contact.
- MOVIC® can be easily re-coated. If necessary the removal is easily achievable.

WHY MOVIC® BEHAVES LIKE THAT.

To understand the mechanism of sliding, you have to think about the crystal structure of molybdenum disulphide, which is the basis of MOVIC®.

As it can be seen in the illustrations below, the structure of the MoS2 is similar to that of graphite, with sliding planes that are oriented in the direction of the stress, thus creating a lubricating effect.

<table>
<thead>
<tr>
<th>Basic Composition</th>
<th>Coating structure</th>
<th>Microhardness (HV 0.05)</th>
<th>Coefficient of friction against 100 Cr 6</th>
<th>µm thickness (microns)</th>
<th>Deposition Temperature (°C)</th>
<th>Max Temperature of use (max °C)</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>MoS2</td>
<td>Magnetron Sputtering</td>
<td>-</td>
<td>0.1</td>
<td>1</td>
<td>&lt;100</td>
<td>700</td>
<td>Grey</td>
</tr>
</tbody>
</table>

MECHANICAL BEHAVIOR OF MOVIC®

Graphite Structure

MOVIC® Structure
# COATINGS APPLICATION

**Processing with the use of lubricant**
The boxes contain information relating to coatings that STS recommends for different applications. Each box can hold 1/2 options. Some options suggest the combined use of 2 coatings eg.: Wonder + PLC (WN + PL). There where indicated (HON) and (TOP) it is suggested to adopt the treatment of “surface optimization.”

<table>
<thead>
<tr>
<th>Materials to be processed</th>
<th>Milling</th>
<th>Drilling</th>
<th>Boring</th>
<th>Tapping Cut</th>
<th>Tapping Roll</th>
<th>Cutters for threads</th>
<th>Microtools</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel</td>
<td>Carbide</td>
<td>Steel</td>
<td>Carbide</td>
<td>Steel</td>
<td>Steel</td>
<td>Carbide</td>
</tr>
<tr>
<td></td>
<td><strong>RD / TN</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>RD / TN</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>RD</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td>Non-alloy steel:</td>
<td><strong>RD / CL</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>RD / CL</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>RD</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td></td>
<td><strong>WN / CL</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>RD</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td></td>
<td><strong>WN / CL</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>RD</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td>Alloy steel:</td>
<td><strong>WN / CL</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>RD</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td></td>
<td><strong>WN / CL</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>RD</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td>Steels &lt; 50 HRC</td>
<td><strong>WN / CL</strong></td>
<td><strong>EV / CL (HON)</strong></td>
<td><strong>WN+PL / CL</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>RD</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td>Steels &gt; 50 HRC</td>
<td><strong>WA</strong></td>
<td><strong>EV</strong></td>
<td><strong>WA</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>RD</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td>Stainless Steels</td>
<td><strong>WN</strong></td>
<td><strong>EV</strong></td>
<td><strong>WN</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>RD</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td>Cast iron</td>
<td><strong>WN / CL</strong></td>
<td><strong>EV / CL (HON)</strong></td>
<td><strong>WN + PL / CL</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>RD</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td>Aluminum Alloys</td>
<td><strong>WN (TOP)</strong></td>
<td><strong>MC</strong></td>
<td><strong>WN + PL</strong></td>
<td><strong>S4 (TOP)</strong></td>
<td><strong>TN</strong></td>
<td><strong>MC (TOP)</strong></td>
<td><strong>TP</strong></td>
</tr>
<tr>
<td>(Si &lt; 6 %)</td>
<td><strong>WN (TOP)</strong></td>
<td><strong>MC / EV (TOP)</strong></td>
<td><strong>WN + PL</strong></td>
<td><strong>S4 (TOP)</strong></td>
<td><strong>TN</strong></td>
<td><strong>MC (TOP)</strong></td>
<td><strong>TP</strong></td>
</tr>
<tr>
<td>Aluminum Alloys</td>
<td><strong>WN (TOP) / TA</strong></td>
<td><strong>EV (TOP) / TA</strong></td>
<td><strong>WN + PL / TA</strong></td>
<td><strong>S4 (TOP) / TA</strong></td>
<td><strong>WN(TOP) / TA</strong></td>
<td><strong>MC (TOP) / TA</strong></td>
<td><strong>RD / TA</strong></td>
</tr>
<tr>
<td>(Si &gt; 6 %)</td>
<td><strong>WN (TOP) / TA</strong></td>
<td><strong>EV (TOP) / TA</strong></td>
<td><strong>WN + PL / TA</strong></td>
<td><strong>S4 (TOP) / TA</strong></td>
<td><strong>WN(TOP) / TA</strong></td>
<td><strong>MC (TOP) / TA</strong></td>
<td><strong>RD / TA</strong></td>
</tr>
<tr>
<td>Titanium Alloys</td>
<td><strong>WN / CL</strong></td>
<td><strong>EV</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>WN (TOP)</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td>Inconel and Nickel</td>
<td><strong>WN / CL</strong></td>
<td><strong>EV</strong></td>
<td><strong>WN / CL</strong></td>
<td><strong>S4 (HON+TOP)</strong></td>
<td><strong>WN (TOP)</strong></td>
<td><strong>MC</strong></td>
<td><strong>RD</strong></td>
</tr>
<tr>
<td>Alloys</td>
<td><strong>WN (TOP) / TA</strong></td>
<td><strong>WN (TOP) / TA</strong></td>
<td><strong>WN + PL / TA</strong></td>
<td><strong>S4 (TOP) / TA</strong></td>
<td><strong>WN(TOP) / TA</strong></td>
<td><strong>MC (TOP) / TA</strong></td>
<td><strong>TP</strong></td>
</tr>
<tr>
<td>Brass / Bronze / Nickel</td>
<td><strong>WN (TOP) / TA</strong></td>
<td><strong>WN (TOP) / TA</strong></td>
<td><strong>WN + PL / TA</strong></td>
<td><strong>S4 (TOP) / TA</strong></td>
<td><strong>WN(TOP) / TA</strong></td>
<td><strong>MC (TOP) / TA</strong></td>
<td><strong>TP</strong></td>
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<tr>
<td>Copper</td>
<td><strong>WN (TOP) / TA</strong></td>
<td><strong>WN (TOP) / TA</strong></td>
<td><strong>WN + PL / TA</strong></td>
<td><strong>S4 (TOP) / TA</strong></td>
<td><strong>WN(TOP) / TA</strong></td>
<td><strong>MC (TOP) / TA</strong></td>
<td><strong>TP</strong></td>
</tr>
<tr>
<td>Graphite</td>
<td><strong>TA / DI</strong></td>
<td><strong>TA / DI</strong></td>
<td><strong>TA / DI</strong></td>
<td><strong>MC / TA</strong></td>
<td><strong>TA / DI</strong></td>
<td><strong>TA / DI</strong></td>
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<tr>
<td>Composite Materials</td>
<td><strong>TA / DI</strong></td>
<td><strong>TA / DI</strong></td>
<td><strong>TA / DI</strong></td>
<td><strong>MC / TA</strong></td>
<td><strong>TA / DI</strong></td>
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<td></td>
</tr>
<tr>
<td>COATING</td>
<td>Basic Composition</td>
<td>Coating structure</td>
<td>Microhardness (HV 0.05)</td>
<td>Coefficient of friction against 100 Cr 6</td>
<td>µm thickness (microns)</td>
<td>Deposition Temperature (°C)</td>
<td>Max Temperature of use (max ° C)</td>
</tr>
<tr>
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</tr>
<tr>
<td>PLC</td>
<td>Carbon</td>
<td>Monolayer</td>
<td>1.500</td>
<td>0,1</td>
<td>1</td>
<td>140 - 480</td>
<td>300</td>
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<tr>
<td>ta-C</td>
<td>Carbon</td>
<td>Monolayer</td>
<td>5.300</td>
<td>0,1</td>
<td>1 - 2</td>
<td>&lt;100</td>
<td>600</td>
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<tr>
<td>DIAMANTE</td>
<td>Polycrystalline</td>
<td>Monolayer</td>
<td>10.000</td>
<td>0,6</td>
<td>4 - 10</td>
<td>900</td>
<td>300</td>
</tr>
<tr>
<td>CrN</td>
<td>Chromium Nitride</td>
<td>Monolayer</td>
<td>1.800</td>
<td>0,5</td>
<td>1 - 10</td>
<td>140 - 480</td>
<td>750</td>
</tr>
<tr>
<td>ZrN</td>
<td>Zirconium Nitride</td>
<td>Monolayer</td>
<td>1.600</td>
<td>0,4</td>
<td>1 - 4</td>
<td>140 - 480</td>
<td>700</td>
</tr>
<tr>
<td>Advance</td>
<td>Titanium Aluminium Nitride + Amorphous Carbon</td>
<td>Multilayer</td>
<td>3.000</td>
<td>0,6</td>
<td>1 - 3</td>
<td>480</td>
<td>700</td>
</tr>
</tbody>
</table>
The ever-increasing demand for higher performance is leading to a continuous development of improved solutions for the tools, resulting in enrichment of the intrinsic value of each item.

In order to preserve this value in time gain most importance the techniques which maximize the performance of the tool in all circumstances. Among these, the de-coating plays a crucial role.

The constant evolution of coatings requires a concomitant evolution of the techniques of de-coating, which is the process that has to remove the hard layer deposited but at the same time must not minimally affect the basic characteristics of the tool (eg. must not generate the “cobalt leaching” phenomenon in hard metal tools).

While the techniques used for the high speed steel were always minimally invasive against the base material, in the case of hard metal tools the presence of cobalt as a binder has made it more difficult this operation. In addition, the research of performance on such tools has prompted the use of alloying elements more and more dissimilar.

This requires that the operation of de-coating is carried out wisely and accurately through the use of techniques and chemicals always aimed to achieve the maximum operational advantage but with a watchful eye to security and ecology.

The first de-coating techniques historically focused on tools HSS, where the overlapping of successive layers (re-coating) on the sides of the cutting edges brought to accumulate errors on geometric essentials, such as pressure angles and rake angles.

Proved to be the ideal solution to systematically remove, before any re-sharpening, the pre-existing coating, so also to facilitate the grinding operation of the cutting edges’ chest.
PVD APPLICATIONS FOR MECHANICAL FIXING TIPS

The ongoing research aims at achieving a specific coating for mechanical fixing tips, has encouraged the development of a new layer with a high content of Aluminum though much higher in thickness than the standard.

This coating deposited with PVD technology, and that takes the name of CUTMILL, thanks to a sophisticated structure composed by nano-stratifications of different elements, reaches the extraordinary thickness of 5 to 7 microns.

It is also thanks to this exceptional condition that CUTMILL allows us to reach much higher levels of performance to current standards.

Another feature that makes CUTMILL the ideal coating, is the ability to withstand high temperatures (up to 900°C) due to the reduced thermal conductivity which allows to transfer to the chip a good part of the heat generated by cutting.

The high hardness of CUTMILL (> 4000 HV) provides excellent wear protection and makes possible a better exploitation of the insert and its prolonged use over time.

The fields of application where CUTMILL is most appreciated today range from the processing of reclaimed materials (54/56 HRC), milling, turning and parting of Cast Iron at high or low density and of Aluminum with a high percentage of Silicon.

In more traditional machining CUTMILL allows to increase the parameters of the feeding and removal to reduce the time of the production process and consequently the production costs.

CUTMILL also stands as a viable alternative to CVD coatings.

<table>
<thead>
<tr>
<th>Basic Composition</th>
<th>Coating structure</th>
<th>Microhardness (HV 0.05)</th>
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<th>µm thickness (microns)</th>
<th>Deposition Temperature (°C)</th>
<th>Max Temperature of use (max °C)</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Titanium aluminium Nitride</td>
<td>Monolayer</td>
<td>3.200</td>
<td>0.6</td>
<td>1 - 4</td>
<td>480</td>
<td>&gt; 900</td>
<td>Black</td>
</tr>
</tbody>
</table>


## PVD APPLICATIONS FOR MECHANICAL FIXING TIPS

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Titanium Nitride</td>
<td>Monolayer</td>
<td>2.200</td>
<td>0.6</td>
<td>1 - 4</td>
<td>140 - 480</td>
<td>500</td>
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<tr>
<td>Titanium Carbonitride</td>
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<td>350</td>
<td>Grey Blue</td>
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<td>800</td>
<td>Dark Blue</td>
</tr>
<tr>
<td>Titanium Compound</td>
<td>Multilayer High Density Plasma</td>
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<td>1 - 3</td>
<td>480</td>
<td>350</td>
<td>Red</td>
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