TiBto-HP

Something special for aluminum and titanium

The Tribology Centre has developed a new PVD coating consisting of the ceramic material titanium diboride (TiB_2). The coating is named TiBto-HP, where HP refers to the coating being based on the latest HiPIMS technology (see the reverse page). Using the HiPIMS technology, a very high degree of plasma ionization is achieved during the coating process, resulting in a smoother, denser, harder and more defect-free coating compared to a traditional PVD coating. The TiBto-HP coating has a hardness of approx. 3800 HV and is the hardest coating we have developed so far.

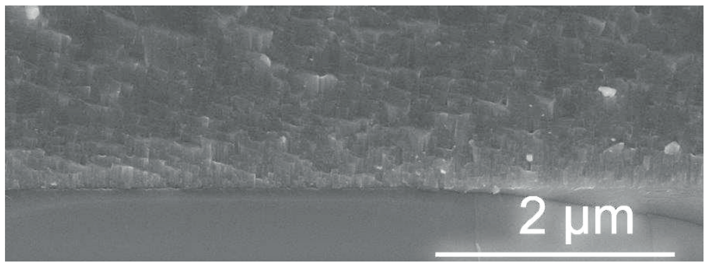
The HiPIMS technology makes it possible to achieve this impressive hardness while simultaneously keeping the internal stress of the coating at a low level.

Tools coated with TiBto-HP

The TiBto-HP coating has an extremely high wear resistance due to the combination of its high hardness, its ability to withstand oxidation at relatively high temperatures (up to 1000 °C) and its chemical stability. However, the most notable feature of TiBto-HP is that the coating has a very low affinity to sticking metals. This feature makes TiBto-HP particularly suitable for machining non-ferrous materials.

By using TiBto-HP, a better chip control can be achieved e.g. when milling in aluminum and titanium. At the same time it is possible to avoid edge-up as a result of adhesion of e.g. aluminum on the tool surfaces.

The TiBto-HP coating is also suitable for knives as well as punching and bending tools for aluminum and similar adhesive materials.



Cross-sectional electron microscopy image of the fine-grained TiBto-HP coating. The very dense and fine-grained structure is due to the use of the HiPIMS technique.

Tools made of all types of hard metal as well as all types of tool steel with a hardness above 60 HRC and a tempering temperature of more than approx. 500 °C are suitable as basic materials for a TiBto-HP coating.

Properties of TiBto-HP coating	
Hardness [HV]	~3800
Process temp. [°C]	450
Application temp. [°C]	<1000
Suitable for treatment of	Non-ferrous metals, e.g. aluminium alloys, (especially cast aluminium), titanium alloys, copper alloys, and magnesium alloys. In addition to this, TiBto-HP can be used on tools, machining extremely abrasive materials, e.g. fibre composites

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HiPIMS - the latest technology for industrial PVD coatings

Traditional PVD coating

PVD coatings can be made using several different methods. So far, the Tribology Centre has primarily used the so-called Magnetron Sputtering technique (MS) based on direct current (DC), the DCMS method. In a DCMS coating process, an electrical potential difference is created in the vacuum chamber between plasma and the raw material (e.g. chromium or titanium), from which the coating is formed. As the raw material (target) is subjected to a negative electrical voltage, positive ions from the plasma (e.g. Ar^+) will accelerate towards the target. This releases atoms from the target material as vapour. The evaporated material is then condensed on the surfaces to be coated and a PVD coating is formed. If the plasma also contains a reactive gas, e.g. nitrogen (N_2), it will react with the evaporated material, and a coating of e.g. chromium nitride (CrN) or titanium nitride (TiN) is formed.

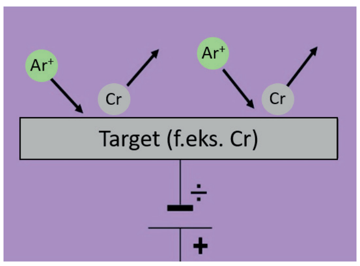

Fig. 1: Principle sketch of the conventional Direct Current Magnetron Sputtering (DCMS) process, which is based on a constant DC voltage between the raw material (target) and the plasma in the vacuum chamber enclosing the parts to be coated.

High Power Impulse Magnetron Sputtering (HiPIMS)

With a traditional PVD coating (DCMS), the target power is often significantly below 25 W/cm². However, in the new HiPIMS processes, much higher power is used in very short pulses (see Fig. 2). The mean power is about the same in the DCMS and HiPIMS processes, but the short, intense pulses in the HiPIMS processes provide a markedly different composition of the plasma. By the DCMS technique, mainly neutral atoms are detached from the raw material, whereas the HiPIMS technology forms far more electrically charged ions.

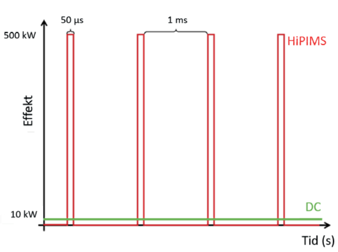

Fig. 2: The difference between the two processes; the conventional Direct Current Magnetron Sputtering (DCMS) and the new High Power Impulse Magnetron Sputtering (HiPIMS). In the example, there is about the same mean energy in the HiPIMS and DCMS process.

The higher degree of ionization in the HiPIMS processes makes it possible to create surface coatings with unique mechanical properties and completely different structures than is the case for conventional DCMS processes.

By changing the pulse lengths and/or the pauses between the pulses (frequency) and thus the energy per pulse, coatings can be developed with new and improved properties such as increased density, increased hardness and reduced internal stresses. Figure 3 shows an example of how the coating structure can be varied by changing the HiPIMS pulses.

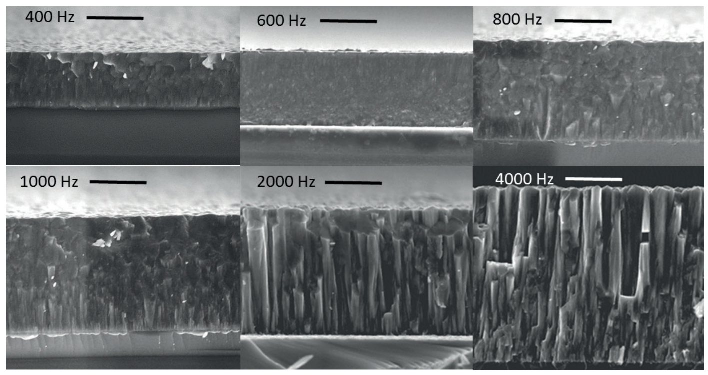

Fig. 3: Example of cross sections of coatings. The structure changes as the frequency of the HiPIMS pulses increases. The lower right image approaches conventional DCMS.

The Tribology Centre's new line of HiPIMS coatings has been optimized to provide coatings that are harder, denser and smoother. This has so far resulted in the coatings CrN-HP, Versal-HP and TiBto-HP.

The table below summarizes the differences between DCMS and HiPIMS.

Property	**DCMS**	**HiPIMS**
Percentage of electrically charged metal particles in the deposition process	Very low e.g. ~3% for chromium	Very high e.g. >70% for chromium
Density of the coating	Dense	Very dense
No. of defects in the coating	Few	Very few
Hardness	Hard	Harder
Even coverage of edges	Good	Better

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