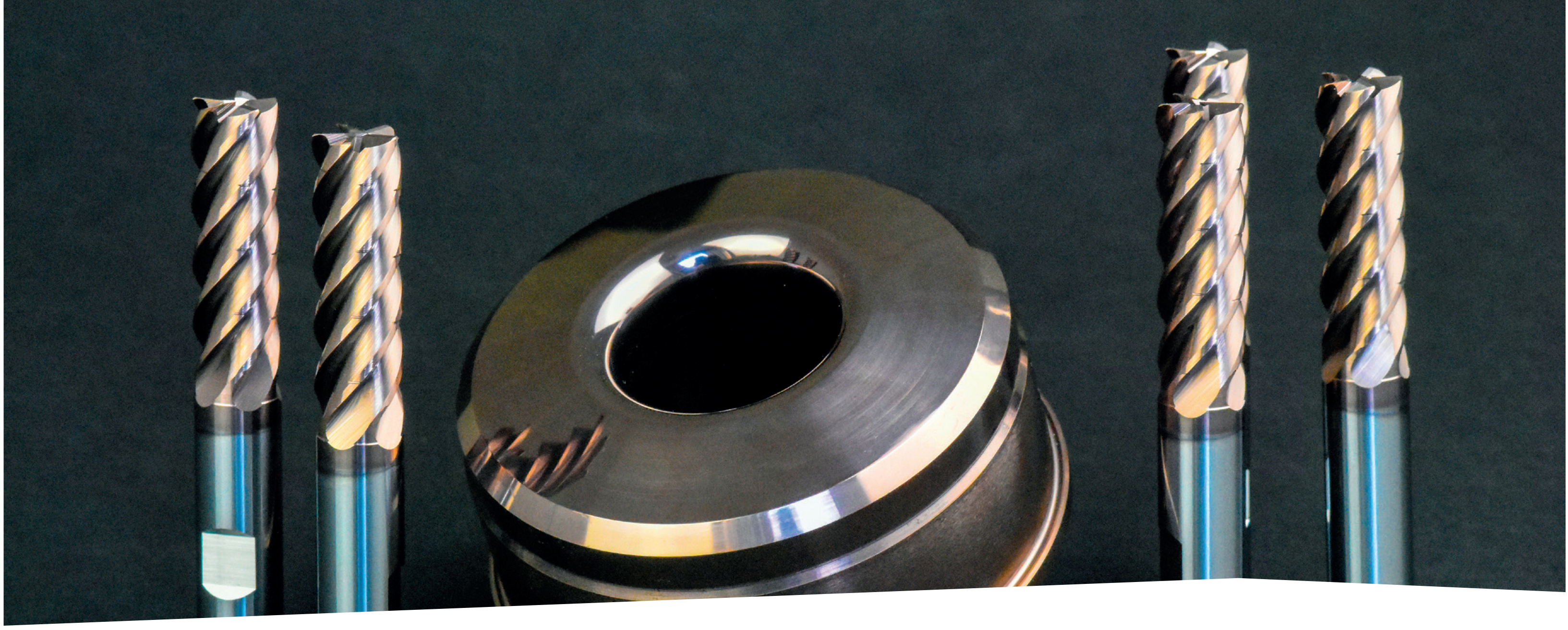
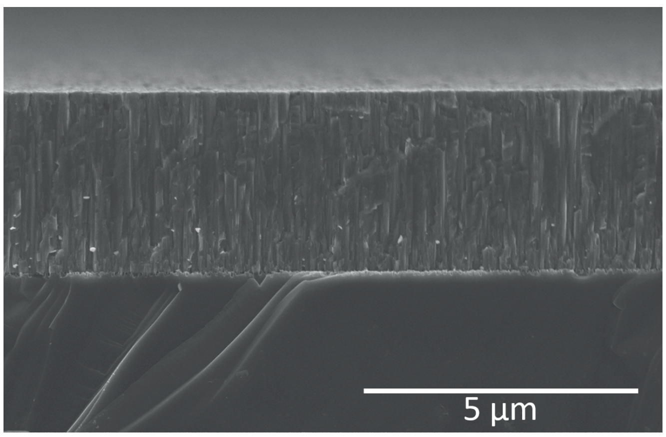


Versal-HP

For difficult-to-machine materials

The Danish Technological Institute has developed a new wear-resistant coating named Versal-HP. The production of Versal-HP, which is a TiAlSiN coating, is based on the latest HiPIMS technology (see the reverse page). Using HiPIMS technology, a very high degree of plasma ionization is achieved in the coating process, resulting in a smoother, denser and harder coating as compared to conventional DCMS.

Compared to traditional TiAlN-based coatings, the addition of silicon (Si) contributes to making the coating both harder and more temperature-resistant.



Cross-sectional electron microscopy image of the Versal-HP coating. The coating consists of titanium (Ti), aluminium (Al), silicon (Si) and nitrogen (N).

The Versal-HP coating is especially suitable for cutting in cast iron, steel, stainless steel, titanium and nickel-based alloys, including various Inconel alloys. In addition, the Versal-HP coating can be used for cutting materials which are particularly difficult to machine, including hardened steel types and other hard materials.

In cutting tests, an increased service life of up to 60% has been achieved when cutting in Inconel, and up to 100% when cutting in cast iron and stainless steel compared to TiAlN-coated tools. In addition, Versal-HP has shown an excellent performance with up to 40% higher cutting speed than traditional PVD-coated tools when cutting in stainless steel.

Excellent for stainless steel

The Versal-HP coating prevents sticking of e.g. stainless steel and titanium to the tool surfaces. When a material like stainless steel or titanium sticks to the tool surface, it becomes difficult or impossible to obtain a satisfactory surface finish when machining items. The anti-sticking properties of the Versal-HP coating make it excellent for use in forming of stainless steel and other materials that tend to adhere or "surface weld" to the forming tool. The Versal-HP coating is therefore especially useful for forming and punching items to which there are high demands on the quality of the finished product.

The TiAlN family	**TiAlN-LT^2**	**TiAlN-nano**	**Versal-HP**
Composition	Ti, Al, N	Ti, Al, N	Ti, Al, Si, N
Micro hardness [HV]	~2600	~3000	~3300
Process temperature [°C]	<150	450	450
Highest application temperature [°C]	<800	<850	<1100
PVD technology	Pulsed DCMS	DCMS	HiPIMS (HP)
Thickness [µm]	1-3	3-5	2-4

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QUALITY SYSTEM CERTIFICATION DNV ISO 9001

DANISH TECHNOLOGICAL INSTITUTE

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.

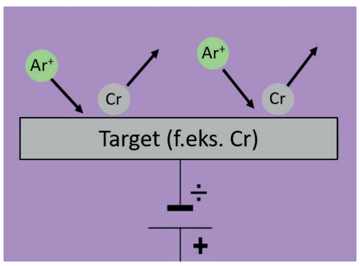

Fig. 1: Principle sketch of the conventional Direct Current Magnetron Sputtering (DCMS) process, which is based on a constant DC voltage between the raw material (target) and the plasma in the vacuum chamber enclosing the parts to be coated.

High Power Impulse Magnetron Sputtering (HiPIMS)
With a traditional PVD coating (DCMS), the target power is often significantly below 25 W/cm^2. 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.

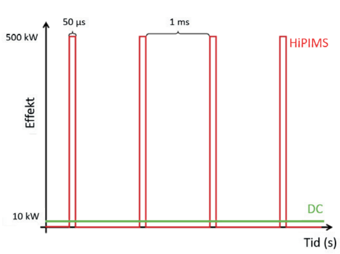

Fig. 2: The difference between the two processes; the conventional Direct Current Magnetron Sputtering (DCMS) and the new High Power Impulse Magnetron Sputtering (HiPIMS). In the example, there is about the same mean energy in the HiPIMS and DCMS process.

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.

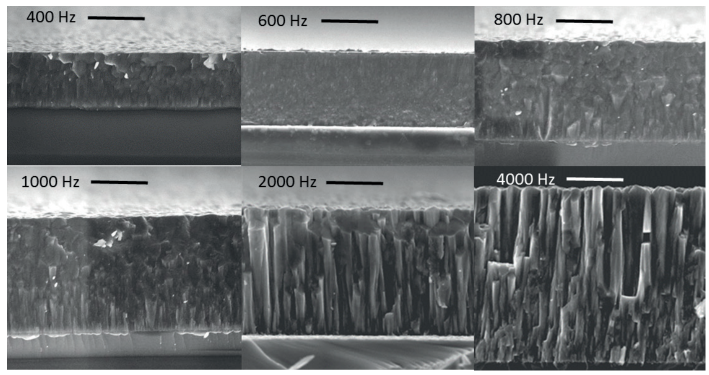

Fig. 3: Example of cross sections of coatings. The structure changes as the frequency of the HiPIMS pulses increases. The lower right image approaches conventional DCMS.

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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