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GEMECON

Customer magazine
for coating technology

# FACTS

## HYPERLOX®PLUS: Developed for cutting inserts
## Now even thicker

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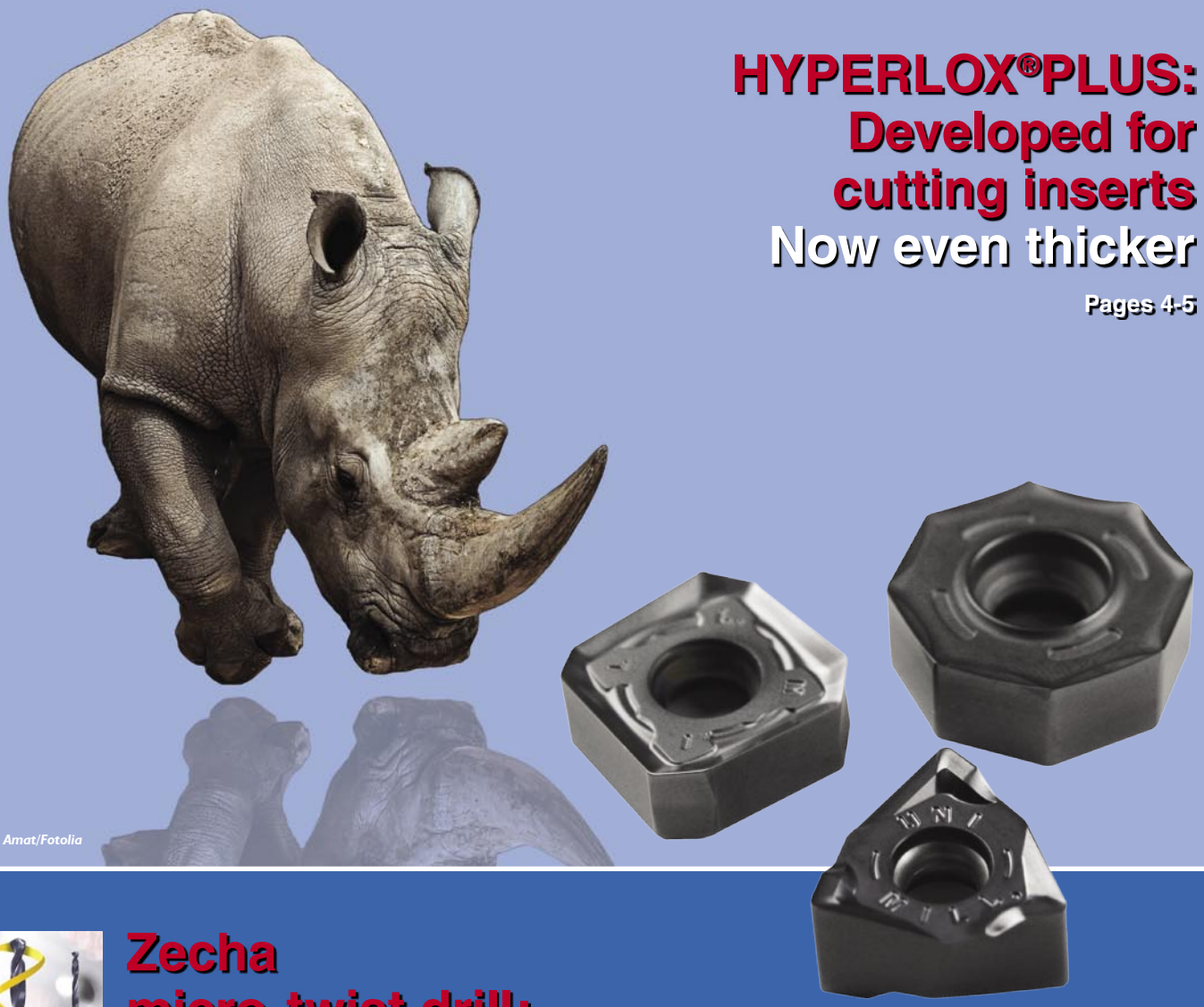

Photo: Aaron Amat/Fotolia

Photo: Zecha GmbH

## Zecha micro-twist drill: A "Winner" in chip removal

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Photo: ARNO GmbH

## Innovative HPN1-based coating for ARNO: Combating thermal cracks

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# New impetus with high pulses

**Dear FACTS reader, ...**

***Dr. Toni Leyendecker***
*CEO CemeCon AG*

... as we came to market with the first industry-ready HiPIMS product HPN1 in 2010, the technology was only known to a small group of scientists and specialists. Today, two years later, the high-pulse method has made its name and gained reputation within the tool manufacturers' industry. In remarkable practical examples our customers have already achieved great success with HPN1. You will find further information on pages 6 to 10.

Whether your tools need thick or thin coatings to get the right performance kick, CemeCon offers a variety of coating materials in different thicknesses. With that you always achieve the optimum mixture of perfect geometry, ideal carbide and individually tailored coating, just what you expect from a precision tool. HYPERLOX®PLUS, for example, was specifically developed for cutting inserts and offers significant advantages in high-performance machining. Read more about it on pages 4 and 5.

**Prepare to be inspired!**
**Yours sincerely,**

Dr. Toni Leyendecker

## Imprint


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## In this issue



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***ARNO gets improved performance due to HPN1.***

## Production and use of CVD diamond coatings

# Hard, smooth and resistant

**Diamond is a fascinating material – especially on tools. In response to frequent requests from our readers, we are again presenting a concise article on chemical vapor deposition (CVD) of diamond, including production methods and application areas. Detailed information can be found in our FACTS 34, which is no longer available in print form but can be downloaded on the Internet.**

CemeCon started producing deposited diamond coatings using the CVD method in the late 1980s, making us a pioneer in this area. Diamond produced by the CVD method has good physical and chemical properties close to those of natural diamond. Its high hardness and its low tendency to adhere to the workpiece material, along with its high chemical inertness and thermal conductivity, have made CVD diamond an important aid in many industries, for example as an anti-wear coating. Among other things, diamond-coated tools are used to machine highly abrasive or difficult materials such as graphite, aluminum-silicon alloys, printed circuit boards and carbon-fiber reinforced plastics (CFRP).

## CVD diamond production

Numerous CVD methods are used for depositing polycrystalline diamond films under relatively low pressure and temperature conditions. The films are classified as microcrystalline or nanocrystalline (smooth) coatings, depending on the size of the crystallites. Multilayer coatings with improved mechanical properties can be produced by alternate deposition of microcrystalline and nanocrystalline layers.

The commonly used methods for the production of diamond coatings are plasma based methods, microwave CVD and hot-filament CVD. Only the latter yields good results for coating three-dimensional substrates, such as tools and components. This is why CemeCon chose the hot filament method when it started developing these coatings. Intensive research ultimately led to patented smooth nanocrystalline films, which played a major role in accelerating the acceptance of diamond coatings. Today CemeCon operates the world's largest diamond coating center in Würselen (Germany).

The energy in the hot filament method comes from incandescent wires, which can be arranged either vertically or horizontally in the process chamber according to the application. The filaments are made from tungsten or tantalum and are electrically heated to temperatures above 2,000°C. They heat and chemically activate a mixture of process gases, such as hydrogen and methane, which is fed into the coating chamber at low pressure. In this way diamond is deposited under defined process conditions on the substrate, which is heated to approximately 800°C.

## The hot wire is the key: hot-filament CVD

The methane supplies the carbon needed for diamond growth, while the atomic hydrogen required by the process is generated by splitting hydrogen molecules on the hot filaments. The atomic hydrogen removes most of the graphitic and amorphous carbon away from the substrate surface. What remains is pure diamond. Tools are usually coated with 4 to 15 $\mu$m thick diamond coatings. These crystalline diamond coatings should not be mixed up with DLC or ta-C coatings, which are entirely amorphous. ■

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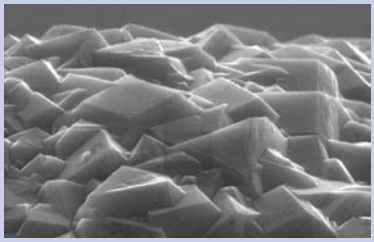
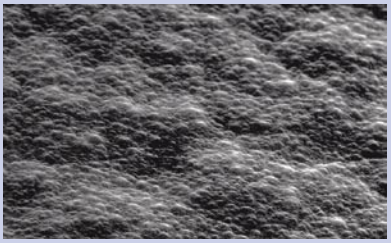
## Diamond coatings "through the magnifying glass"





*From left to right: microcrystalline diamond and nanocrystalline (smooth) diamond.*

***Diamond coatings can be used to enhance even the smallest cutting tool geometries and increase their wear resistance.***

## HYPERLOX®PLUS: Developed for cutting inserts

# Now even thicker

**Cutting inserts are efficient and economical, and they offer ideal characteristics needed for efficient production. Performance can be improved even further with the appropriate coating and coating thickness which are available with the supernitride HYPERLOX®PLUS.**

Sputter-coatings applied using PVD (physical vapor deposition) have considerable advantages: They are particularly smooth, hard and tough, which makes them an ideal choice either for the machining of demanding materials or reliable processing of large batches. "Those are the properties that make these coatings the best there is in industrial production," according to Inka Harrand, Product Manager for Cutting Inserts. It is not only the advances in the technology itself, but also the variations in layer thickness that increase the success quota of the tools that are treated.

### Thick "shell" with a protected "core"

The idea of depositing thicker layers is not new. It has been used successfully at CemeCon for many years. Inka Harrand on this: "CVD (Chemical Vapor Deposition)-layers are always applied more thickly. With the PVD-method, there is no standard yet. But successful trials with coatings, which are deposited with good adhesion via sputtering even up to 12 µm, demonstrate that it can improve tool performance".

But what is so special about layers that are up to 12 µm thick? PVD layers are normally applied up to around 3 µm. "But thicknesses of 6 to 8 µm protect the substrate considerably better against the effects of the machining process, as our test series has shown," Inka Harrand explains. "Also, in some applications, the user benefits from the double layer thickness with a nearly 100 percent increase in the service life!"

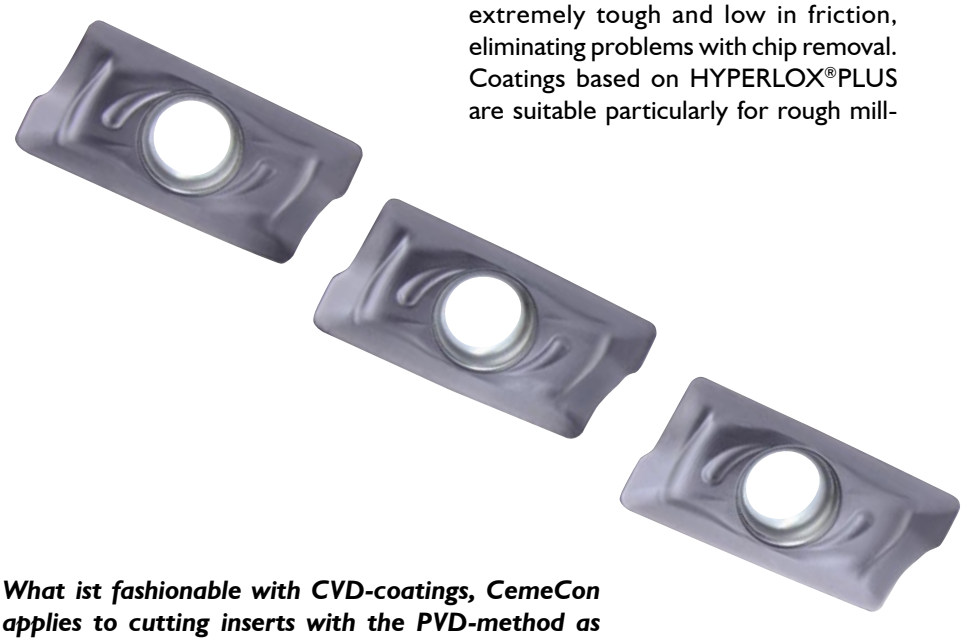
### It depends on the cutting edge

The efficiency of a tool also depends on its pretreatment. "Proven methods provide optimal preparation for the tools and ensure the best layer adhesion. Preparation of the cutting edges plays a special role: It is an essential feature of the success of the overall tool design," Inka Harrand knows. For example, if layer thicknesses of 6 to 8 µm are applied, the cutting edge should be rounded to at least 20 µm.

### HYPERLOX®PLUS – supernitride for hard cases

The especially smooth high-performance coating HYPERLOX®PLUS is tailored to the highest requirements in machining operations. The supernitride of the newest generation was developed specifically for cutting inserts and its high aluminum content makes it very efficient. It can be applied at cooling or in dry cutting.

A composite-structure with high aluminum content, which ensures extreme hardness and resistance to oxidation, are among the features that enable HYPERLOX®PLUS to provide superior protection against wear for milling applications. The layer material is also extremely tough and low in friction, eliminating problems with chip removal. Coatings based on HYPERLOX®PLUS are suitable particularly for rough mill-



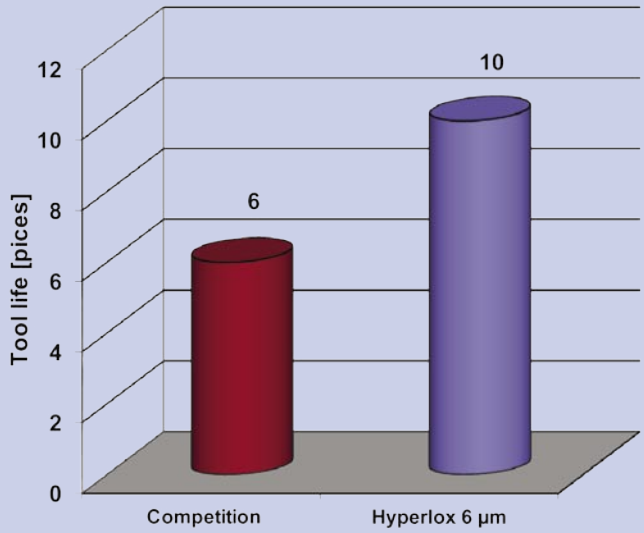
***What ist fashionable with CVD-coatings, CemeCon applies to cutting inserts with the PVD-method as well: coating thicknesses of 6 µm and even thicker.***

ing applications in all the usual steels and cast irons as well as for alloyed and stainless steels.

A long and above all repeatable service life is therefore ensured, for example, in materials such as 20MnV6 (1.5217), a steel whose uses include guide columns. In this material, a milling cutter with inserts produced six parts with the competitor's coating during slot milling into the solid material ($v_c$ = 200 m/min, $f_z$ = 0.23 mm) using air cooling. Inka Harrand: "We were then excited to see how our HYPERLOX®PLUS would do under the same operating conditions with a layer thickness of 6 µm. It was already clear from the first test results that we could expect better than average results. The increase from six processed parts to ten with HYPERLOX®PLUS is a result that certainly qualifies the supernitride for high performance machining!" ■

***Thick layers better protect the substrate against effects from the machining process. High wear volume ensures best cutting results.***

## HYPERLOX®PLUS in detail




### Milling of 20MnV6

Starting point
- Material: 20Mnv6 (1.5217)
- Component: Guide column
- Tool:
  Milling cutter with inserts
- Processing: Slot milling into solid material
- Parameters:
  $v_c$ = 200 m/min
  $f_z$ = 0.23 mm
- Cooling: Air

CemeCon coating solution
- Competition: 6 parts
- HYPERLOX®PLUS 6 µm: 10 parts
- Service life increased by 60%

### HYPERLOX®PLUS layer material

**Properties**

Layer material class: supernitride
Composition: AlTiN
Layer thickness: 6 µm (edge rounding 20 µm)
Microhardness: 3,700 $HV_{0.05}$
max. operating temperature: 1,100°C
Color: Black-anthracite

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## Innovative HPN1-based coating for ARNO:

# Combating thermal cracks

**Thermal cracks on the cutting edges of tools are a nightmare for steel machining. They are caused by the variable thermal loads imposed on coatings and carbide substrates during interrupted cutting operations. The use of coolant also reinforces the effect. It leads to inferior workpiece surfaces, and in the worst case to sudden total failure of the tool. ARNO GmbH in Ostfildern, Germany, is now using HPN1 to banish thermal cracks and reap the benefits.**

Even the smallest fractures on cutting edges are a source of weakness, with the risk that the tool may have to be taken out of service earlier than expected. "In many cases it's already too late, and the workpiece surface has already been damaged. With regard to cost-effective and reliable machining, thermal cracks and their consequences are a real nuisance," emphasizes Werner Meditz, Technical Director at ARNO.

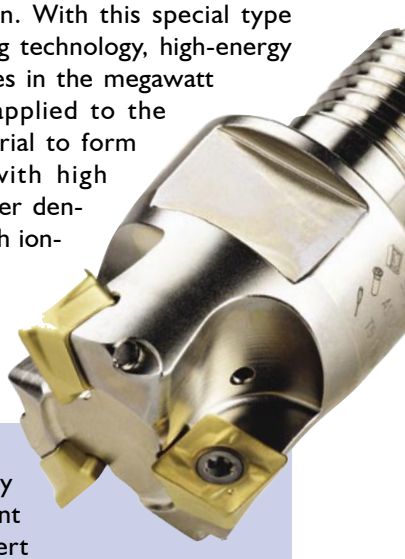
What should you do? Shift the machining parameters towards the safe side and give up valuable potential time savings? Or change the tools much earlier than usual, resulting in higher tool usage and higher costs? Meditz's answer: "Obviously, none of these alternatives was acceptable for our Duo-Mill product. We needed an optimized coating that could stand up to wet milling with interrupted cutting as long as possible and deliver excellent machining quality."

### The search begins

Confronted with this extremely difficult task, ARNO turned to several coating companies which offered various solutions. The requirements were far from easy, since the focus with high-feed cutting (HFC) is on very high feed rates and correspondingly large material removal rates. Due to the interrupted cutting, this is accompanied by extreme stresses. Cutting edges heat up very quickly during tool engagement and then cool down quickly after the tool exits the workpiece. The cooling lubricants used in the process further intensify this "fracture resistance test".

"We wanted the coating to enhance our Duo-Mill indexable inserts in two ways: first it needed to be able to largely 'mask out' the considerable temperature differences during the cutting process, and second, we wanted to generally boost performance," according to Meditz. A total of eight different coating solutions were available for comparison, including CemeCon's HPN1 coating material.

"HPN1 is the first coating material so far that we are going to use high-power impulse magnetron sputtering (HiPIMS). This technique, which has been patented and refined by CemeCon, delivers a crucial improvement in hardness and toughness," according to Marc Semder, Sales Europe at CemeCon. With this special type of sputtering technology, high-energy power pulses in the megawatt range are applied to the target material to form a plasma with high charge carrier density. The high ion-



Duo-Mill is a milling concept developed by ARNO that allows two geometrically different indexable inserts to be clamped in a single insert position. This enables different milling operations with just one tool by using two different cutting edge angles. Square shoulder milling and HFC milling can be performed with a single tool, which reduces tool costs while providing major flexibility for numerous machining tasks. Coatings for various grades of steel as well as stainless, castings and aluminum machining are available. Duo-Mill milling tools are available from stock in threaded, end mill and shell versions with diameters from 25 to 160 mm.

*Duo-Mill indexable inserts from ARNO provide generally improved performance and high resistance to extreme temperature differences in high-feed cutting. A coating based on HPN1 gives them a crucial extra performance margin.*

ization of the target material improves the coating structure and gives HiPIMS coatings better properties than coatings deposited using conventional methods. They have better adhesion and oxidation resistance, as well as a denser coating structure and increased hardness or lower internal stress.

## Less wear with HPN1

But how did HPN1 score in comparison with the other coatings for HFC milling at ARNO? ST52 steel specimens were machined with Duo-Mill SDMT 100415 indexable inserts ($v_c$ = 250 m/min, $f_z$ = 1.0 mm, $a_p$ = 1.0 mm). The measured tool lifetimes ranged from 18 to 38 minutes, with more or less severe wear. “The test results ranged from comb fractures to crumbled edges or complete edge failure, at least with most of the test samples. However, one coating stood head and shoulders above the rest: HPN1 from CemeCon. After 38 minutes it showed only minimal notch wear and wear markings with a width of 0.10 mm. That’s a 40 percent longer service life than the competitors, and with the least wear. For us, this meant mission accomplished,” concludes Meditz.

## ARNO in detail

The ARNO Group unites established companies with advanced production technology and a worldwide sales organization. With 160 employees, ARNO is active in all aspects of machining with its own sales companies in Russia, England, Italy and the USA, along with 25 technical sales field staff in Germany and a select network of knowledgeable dealers. Many years of experience in cutting technology, combined with constant refinement of existing tools and research on new materials, enable ARNO to offer outstanding tools year after year. ARNO tools are known worldwide for their reliability and performance.

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# The next generation coating technology is now

**Right here, right now the latest coating technology is already available and ready-to-market. What took several years to develop is now a reliable and highly efficient technology that sets its user apart from the standard: HiPIMS (High Power Impulse Magnetron Sputtering). CemeCon gives remarkable accents in development and offers them to the international tool maker community.**

Super smooth coatings, free from any droplets, and low compressive stress are the most beneficial characteristics of sputter coatings for cutting tools used for hard, high-speed and dry machining under massive loads. Additionally continuous development and improvement of materials create ever new challenges for machining operations. In particular, aerospace materials as titanium and high-temperature Superalloys that are common for power generation equipment require dense coatings with high thermal and oxidation stability.

## Expanded range of usage

Among users the recent years have seen a massive interest in sputter coatings which CemeCon drove forward within the last 20 years. The latest development in sputtering technology is represented by HiPIMS. An expert in this area, Prof. Arutiun P. Ehiasarian, Sheffield Hallam University, Great Britain, explains: "The high adhesion and density of HiPIMS coatings enhances protection ability against harsh environments with high temperature oxidation, wear and corrosion such as aerospace and power generation gas turbines, automotive engine components, hydraulic parts, cutting tools as well as in more delicate long life environments such as biomedical implants. The high density of the films brings performance enhancements in challenging applications."

HiPIMS is a pulsed PVD method that provides a high ionization of the sputtered target material. The feeding of high-energy power pulses in the megawatt range into the target causes a highly energetic plasma creating an outstandingly high power density of the sputter process. The effective bombardment of the growing film with highly ionized species improves the coating structure and characteristics compared to conventional methods. Furthermore the positively charged metal particles are being attracted by the negative bias voltage and, following the field lines, the sputtered material strikes the tool's surface perpendicularly. Thus a rather uniform coating distribution for 3D objects as cutting tools is achieved.


***CC800®/9 HiPIMS makes the advantages of HiPIMS a reality: dense coatings with high thermal stability and oxidation resistance, a favourable ratio of hardness and toughness, and a very uniform coating distribution. And, HiPIMS is a sputtering technology giving smooth coatings free of droplets.***

HiPIMS employs very high-power pulses followed by a relatively long subsequent "off time". Hence the technology ensures that the average cathode power remains low (1-10 kW), giving the target material time to cool down and providing high process stability.

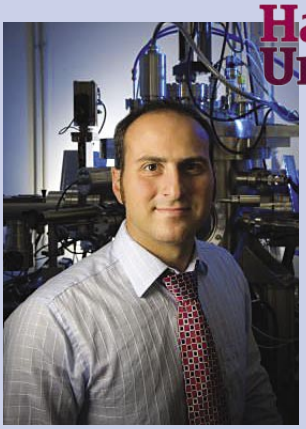
## Dense, hard and extremely tough

The main advantages of HiPIMS coatings include a denser coating morphology and an increased ratio of hardness to toughness compared to standard PVD coatings. Whereas comparable conventional nano-structured (Ti,Al)N coatings have a hardness of 25 GPa and a Young's modulus as a measure of the toughness properties of 460 GPa, the hardness of the new HiPIMS coating is higher than 30 GPa with a Young's modulus of 370 GPa. The desirable condition is high hardness with a relatively small Young's modulus indicating a high toughness of the coating, such as can be found in HiPIMS coatings.

The higher thermal stability of the HiPIMS coating is due to the denser coating structure but also to the completely new film lattice. In addition, the innovative coating method makes it possible to "anchor" the coating to the substrate and thus to improve the adhesion. This is particularly advantageous for interrupted cutting operations, as milling of Superalloys.

## The expert table

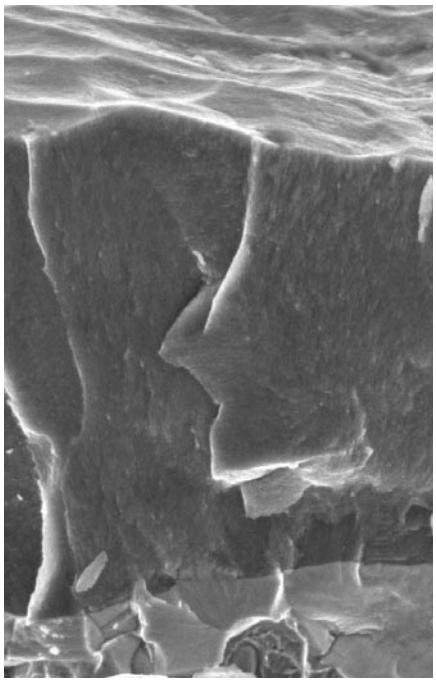
Sheffield Hallam University



**Prof. Arutiun P. Ehiasarian** is Head of the HIPIMS Technology Centre at Sheffield Hallam University and Director of the Joint SHU-Fraunhofer IST HIPIMS Research Centre opened in 2010. His research concentrates on development of HIPIMS PVD technologies and plasma studies to improve the properties and performance of coatings used for wear, oxidation and corrosion protection in automotive and aerospace industries.

Linköping University

**Prof. Lars Hultman**, born 1960, is a Professor of Materials Science and Head of the Division of Thin Film Physics at Linköping University, Sweden. His research interests are in the materials science and nanotechnology of thin films by vapor phase deposition, in particular ion-surface interactions, microstructure evolution, and properties of advanced functional materials. Prof. Hultman is Center Head of FunMat (Functional Nanoscale Materials), an excellence centre of which CemeCon is a member right from the beginning integrating scientific research and industrial application.



***HiPIMS coating HPN1: super smooth surface, dense coating structure, perfect interface to the cutting tool.***

## Exciting new developments

Prof. Lars Hultman, Head of the Division of Thin Film Physics at Linköping University, Sweden, is excited about the actual developments in thin film coatings: "We take part in a fast-paced development in the area of coatings. CemeCon as one of the pioneers of HiPIMS technology achieved outstanding industrial success by bringing the HiPIMS benefits – denser films, a superb adhesion, an excellent ratio of hardness and toughness – into market and to the users. CemeCon expands the possibilities of their coating portfolio by adding new and different coating architectures that offer tool makers new ways of designing their tools – an opportunity none of them should miss!" ■

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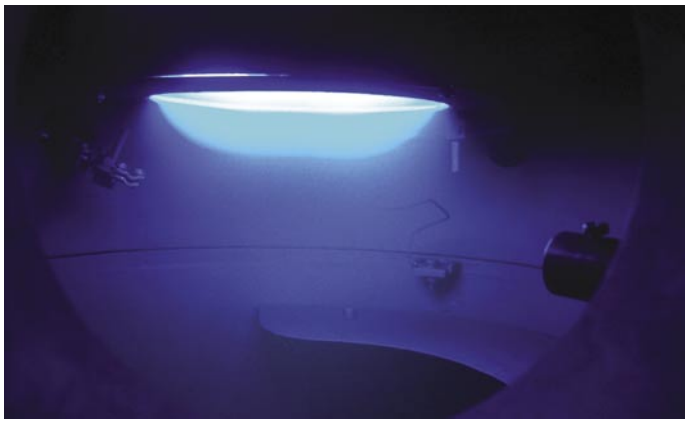
## Coating thicknesses from 1.5 µm to 6 µm with HPN1

# High potential for diversity

**HiPIMS is still a relatively young technology with as yet unexplored potential. As a pioneer in this technology, CemeCon is driving the development and now offers coating material HPN1 in a variety of coating thicknesses.**



*HiPIMS: with high pulses to adhesive coatings.*

"If there is a real future topic in coating technology today, it's HiPIMS", according to Dr. Werner Kölker, R&D Manager at CemeCon. Although the first HiPIMS coating systems were used by universities and research institutes, CemeCon has now delivered the CC800®/9 HiPIMS system to several tool manufacturers. "We commercialized the first industry-ready coating material HPN1 in 2010, and by now it's hardly necessary to explain the method used to produce these coatings." That's because HiPIMS has become established in the industry and is recognized as the technology of the future.

Since HPN1 was not intended to be the first and only HiPIMS coating material, CemeCon will introduce a new generation of materials in the very near future.

### Performance-enhancing "thickener"

The usual coating thickness on shank tools and cutting inserts with power nitrides is 3 µm. "This is the most suitable thickness for most users, and they can upgrade their tools accordingly. However, sometimes it could be a bit more – or a bit less", says Dr. Kölker.

Positive experiences with thicker coatings on PVD-coated cutting inserts encouraged CemeCon engineers to do the same with the new technology. Accordingly, CemeCon offers HPN1 with 6 µm coating thickness for cutting inserts. However, this requires edge rounding with a radius of at least 20 µm. "To enable manufacturers of cutting inserts to get the new technology on board as quickly as possible, we immediately added a variation of HPN1 with higher coating thickness and therefore more wear volume to our product line," adds Dr. Kölker.

### Reduction without sacrifice

On precision milling cutters and drills with very small diameters, sharp cutting edges are often needed. Or they are used in materials with a strong tendency to weld to the tool. Standard coating thicknesses are usually excessive for such cases. CemeCon also addresses this requirement and can deposit HPN1 with a thickness of just 1.5 µm on shank tools. "But users don't need to worry that the service life of their tools will only be half as much, since we adapt the coating to the overall tool design and tune it for the best performance," emphasizes Dr. Kölker.

### Short delivery times, high endurance

Both variants are available immediately, with delivery within one week. Dr. Kölker: "Our customers need the assurance that they can have small or medium-sized batches coated quickly. Naturally, we also offer this with HPN1 and its variants." For this purpose, CemeCon is expanding its production capacity and constantly working on additional processes as well as coating thicknesses adapted to a wide variety of applications.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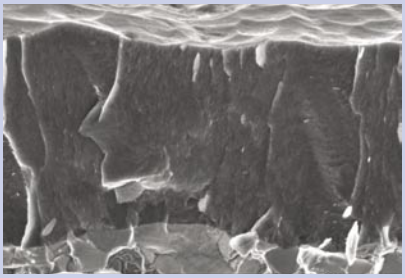
**Coating material HPN1 PLUS**

**General technical data:**

Coating material class: powernitride
Composition: (Al, Ti, Cr)N
Coating structure: nanostructured
Coating thickness: 6 µm (edge hone 20 µm)
Micro hardness: > 30 GPa
E-module: 368 GPa
Maximum application temperature: ca. 1.000°C



## Zecha micro-twist drill for titanium and high-grade steel

# A “Winner” in chip removal

**Deep hole drilling in titanium or special high-grade steel is currently a task for Winner types with diameters larger than 0.5 mm: Among other things, the current micro-twist drills from the “Winner” series of Zecha Hartmetall-Werkzeugfabrikation GmbH based in Königsbach-Stein prove their endurance with maximum precision thanks to an individual coating solution.**


***Even in materials which are difficult to machine, the Zecha Winner series micro-drills do not lose performance so easily. The individual coating solution supports the special geometry and thereby also the chip removal.***

Well-engineered geometries, specially selected substrates, and the appropriate coating pay off especially for deep hole drilling in the smallest diameters with high feed rates. The Zecha “Winner” combine all of these advantages, which is why drills from 8xD to 12xD in titanium alloys up to quality class 5 or martensitic high-grade steels are the ideal application for this tool series.

### Diameter range from 0.5 mm to 6.0 mm

The Zecha engineers have developed the “QuickChip” spiral geometry for more efficient chip removal at high feed rates without internal cooling. The steep helix-spiral angle of 35° on the cutting edge creates small chips, which are rapidly and safely diverted via the degressive spiral of 12°. Arndt Fielen, Sales Director at Zecha: “Our ‘Winner’ should receive a special surface finish and we wanted to reduce the axial pressure. We have achieved that with polished cutting edges as well as a self-centering tip.”

Since the drills are exposed to very high temperatures during the chip removal process, they are provided with an individual Zecha coating. “In order to underline the properties of the special geometry, we have selected a supernitride as the ideal basis for the coating of the Winner series,” Thomas Schaaff, Sales Manager at CemeCon, explains the approach to the coating design. “Since the coatings are produced by sputter technology, they are extremely smooth and facilitate a frictionless chip removal – and thereby precisely support the special features of the Winner. Due to their nanocomposite structure, the supernitrides simultaneously show the maximum toughness with their high degree of hardness as well as provide effective protection against friction and wear.”

With this combination of stable cutting geometry and an adapted coating solution, the Zecha drills enter every competition perfectly. Arndt Fielen sums up: “At least, long lifetimes are in demand for large scale production. Our ‘Winner’ tools do not give up even at high feed rates and complete such a service life marathon without losing performance!” ■

## Zecha in detail

Zecha has produced solid carbide micro-tools for the stamping, metal forming, and the cutting industry since 1964. The company also offers customized tool solutions for medical and dental technology for machining of titanium, high-grade steel and special materials. Whether from the diverse standard range of products or adapted to the application – Zecha tools secure an advantage for the user in terms of performance, quality and service life.

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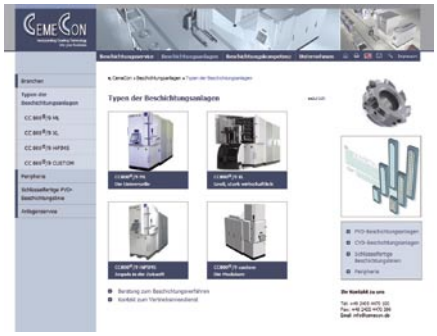
# CemeCon Events Calendar 2012/2013

| | |
|---|---|
| **10. - 15. September 2012** | **IMTS**<br>Chicago (USA) |
| **10. - 14. September 2012** | **PSE 2012**<br>Garmisch-Partenkirchen (Germany) |
| **18. - 22. September 2012** | **AMB**<br>Stuttgart (Germany) |
| **1. - 6. November 2012** | **Jimtof**<br>Tokyo (Japan) |
| **14. - 15. November 2012** | **10. Schmalkalder Werkzeugtagung**<br>Schmalkalden (Germany) |
| **14. - 17. November 2012** | **DMP**<br>Dongguan (China) |
| **27. - 29. November 2012** | **Fortbildungsseminar Moderne Beschichtungsverfahren**<br>Dortmund (Germany) |
| **13. - 14. December 2012** | **RSD 2012**<br>Gent (Belgium) |
| **24. - 30. January 2013** | **IMTEX**<br>Bangalore (India) |
| **22. - 27. April 2013** | **CIMT**<br>Beijing (China) |
| **29. April - 1. May 2013** | **ICMCTF 2013**<br>San Diego (USA) |



***The new CemeCon website will go online soon.***

## CemeCon keeps you up to date

For many years, CemeCon has offered its customers important and up-to-date information on its products and services. As one of the first on the market, the company facilitated, for example, access to the delivery status of orders independent of time and location using order tracking. Soon CemeCon will redesign its website; it will become more modern, more clearly arranged and even more informative. You will find more details on this in one of the next CemeCon newsletters.

Would you like to receive our newsletter? If so, you can register for it at:
http://www.cemecon.de/info/newsletter/index_en.html
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