Novel Multipurpose Coatings (MpC) for Universal Use – about PVD and PACVD Excellence Coatings, Something Everyone Needs!

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Developments in recent years have shown that improving the properties of machining tools by application of suitable coatings is at its best when the tool geometry is most exactly matched to the task in hand. Key factors can include for example surface roughness and surface microstructure, especially in terms of the micro-geometry at cutting edges. Thanks to development of high-performance coatings, interface properties can be optimised in order to cope with demanding conditions such as elevated temperatures and friction with high wear. Thanks to this, machining operations can be accelerated with higher cutting rates, increased productivity and improved product quality.

Neuartige Mehrzweckschichten für den universellen Einsatz – PVD- und PACVD-Excellence Schichten für jeden Einsatz!

Entwicklungen der letzten Jahre haben gezeigt, dass die Verbesserung der Eigenschaften von Werkzeugen durch das Aufbringen von Schichten dann besonders hoch ist, wenn die Werkzeuggeometrie einer genaueren Betrachtung und Anpassung unterzogen wird. Dies betrifft beispielsweise die Oberflächenrauheit und -mikrostruktur, aber insbesondere die Gestaltung beispielsweise der Mikrogeometrie von Schneiden, Schneidecken, Schneid- oder Ziehkanten. In Kombination mit innovativen Hochleistungsschichten können dann die Grenzflächeneigenschaften optimierend auf die auftretenden Belastungen wie hohe Temperatur und Reibung und hoher Verschleiß angepasst werden. Daraus ergeben sich beispielsweise in der Zerspanung höhere Zeitspanvolumina, höhere Produktivität und verbesserte Bauteilqualitäten.

Yesterday coatings were often used for material refurbishment, today and tomorrow application tailored material and surface design will approach to higher performance levels. In the interplay between wear resistance and toughness the increasing demands on the surfaces have shown material developments their limits. At this point it became evident that an additional element had to force the breakthrough, the so-called hard coatings.

Excellence Coatings are essential for operating modern precision tools and components at their process-performance limits. The coating alone is only part of the success story, however. By tailored micro-structuring e. g. of a cutting edge, existing solutions can be lifted to a higher level of performance. We are just at the beginning of a paradigm shift, away from the pure material refurbishment by coating to the application and coating applicable compound design.

Theses 1

We synthesize layers which nobody badly wants, but everyone necessarily needs, Dr. Georg Erkens, CEO Surcoatec Deutschland GmbH, stated. *Definitely, that is not a homerun but from a service perspective not a bad situation at all. It includes some amount of conviction, high effort in bridging knowledge gaps and overcoming obstacles and hurdles and it requires high flexibility within the triangle end-user, manufacturer and coating service provider as well. At the end of the day this is all about productivity and performance increase as well as reduction of the loss factors friction and wear in an industrial environment*.

Thin films synthesized with PACVD and PVD are used and requested for different reasons in various areas of the industry, for instance in the pharmaceutical and chemical industries, in general engineering, in the energy sector, in the food industry for production, processing or packaging, in the automotive industry and for racing, as well as in many areas where high precision tools are produced and used.

PVD (Physical Vapour Deposition) and PACVD (Plasma Assisted Chemical Vapour Deposition) techniques are widely used for the deposition of a large number of compound and metallic coatings with specified mechanical, electrical and optical properties. In general, these techniques allow some control over the phase and atomic composition of the coating. In [4] the different processes are represented in a nice aggregated manner. More technical details are summarized in the annex.

In all the different industry sectors coatings improve productivity and efficiency by saving energy, and provide safety, durability, reliability and performance. All this is achieved by the targeted setting of the interfacial properties, meaning the properties of surfaces which are in contact with the respective environment. These properties are tailored in terms of their mechanical, physical, chemical, tribological, optical or haptic characteristics. But why does one need coatings for this purpose?

During the technical configuration of a component or tool the designer decides for a material that meets particular requirements as far as manufacturing, stability, stiffness and cost are concerned but the actual surface can´t tolerate the occurring loads and the severe wear. As a rule this is the time when the design engineer starts to think about a coating.

The approach to combining outstanding wear resistance and high toughness has been the key for the success story of all innovative hard coatings. The development of hard coatings was closely linked to the development of cemented carbides. Until the 1950s intensive work had been going into the development of so called *sandwich carbides* with the objective to get a hard and wear resistant surface with a graded transition to a tough core. During that time the achievements have had little success and have resulted in a compromise to get close to the objective namely the laminate of a carbide body and a coating. First

products were launched in the 1960s. That was the breakthrough of hard coatings. CVD coatings came first followed by PVD coatings later on [1].

The necessity for using thin films can be summarized as follows: *Modern surface technology especially the thin film technology represents the same for engineering as the semiconductor technology for the IT sector. It is essential*, Georg Erkens comments. *To operate components and precision tools at their limits laminates from base material and innovative thin films are of vital importance. The material engineer would have loved a solid state body which combines all the requested properties in itself. But in most cases that is not possible and if so most probably it won´t be affordable. This brings us to the second theses*.

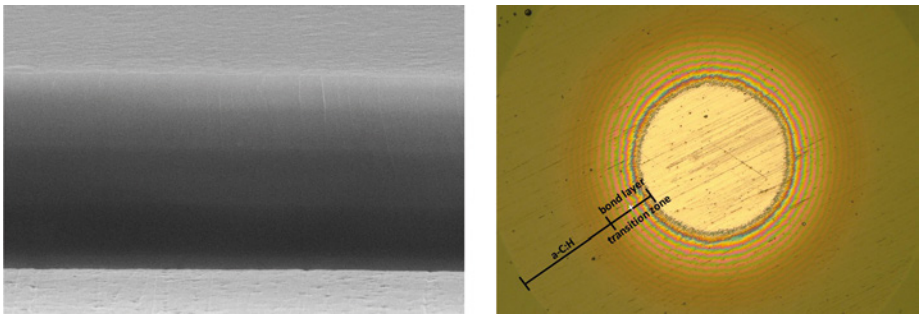

Fig. 1: DC99® DLC layer: dense, compact and amorphous with a smooth as deposited coating surface. To achieve such a morphology and thus the corresponding properties a surface finish Ra < 0.1 µm of the to be coated component is demanded; the ball crater (right hand image) illustrates the coating design of the DC99® DLC layer

Fig. 2: DC99® and STech® coated parts for the food industry; request: non-stick, reduced wear and friction, food-save (left) and DC99® DLC layer on a valve for the chemical industry; demand: anti-fouling properties, low friction coefficient and wear protection (right)

Theses 2

Material refurbishment was yesterday. Todays and tomorrows focus will be the application tailored material and surface design, more precisely, the application and coating deposition oriented to design and surface structuring. What does it mean in detail?

The idea to design a coated component from the outset has not been enforcing yet. Most design engineers develop tools and components down to the last details and most specific for a certain application. Later on they often have to notice that it is not working and behaving as intended. To use a different material or to redesign the part is often difficult with respect to machinability and cost. This is the point where in many cases only one technical lifeline exists. The approach to a supposed solution often is, *well, then let´s make a coating*.

As most components are not designed to this purpose, service provider are often facing new challenges. Parts have to be completely coated what generally is not possible in one cycle, complex masks are requested to protect areas against coating, undercuts should be coated which is not possible in most cases due to process characteristics, the surface roughness is too high or the material is temperature sensitive so the coating of best choice for the application can´t be applied as process temperatures exceed the limits given by the material, etc.

One of the most important issues that should be taken into consideration during the design phase right from the beginning are the changes of the overall surface properties a thin film induces, for instance the modified heat balance in the contact zone. Only this effect could make slight changes in the geometry necessary to lift the performance of the coated component or tool to full potential. Just a coating usually does not meet the demands. To get the best out of it a holistic lean approach is essential. One option could be that design engineers dig deeper into the thin film technology or they involve thin film experts already during the early design phases. Currently designers still try to refurbish components and materials with a lot of effort by means of coatings.

Various different coating types come into play here, such as PACVD DLC (Diamond Like Carbon) and silicon based layers from the DC99® and STech® series that are applied onto components mostly made of temperature sensitive materials to reduce friction and wear.

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Total numbers of pages are about 7,5 with 7 figures.