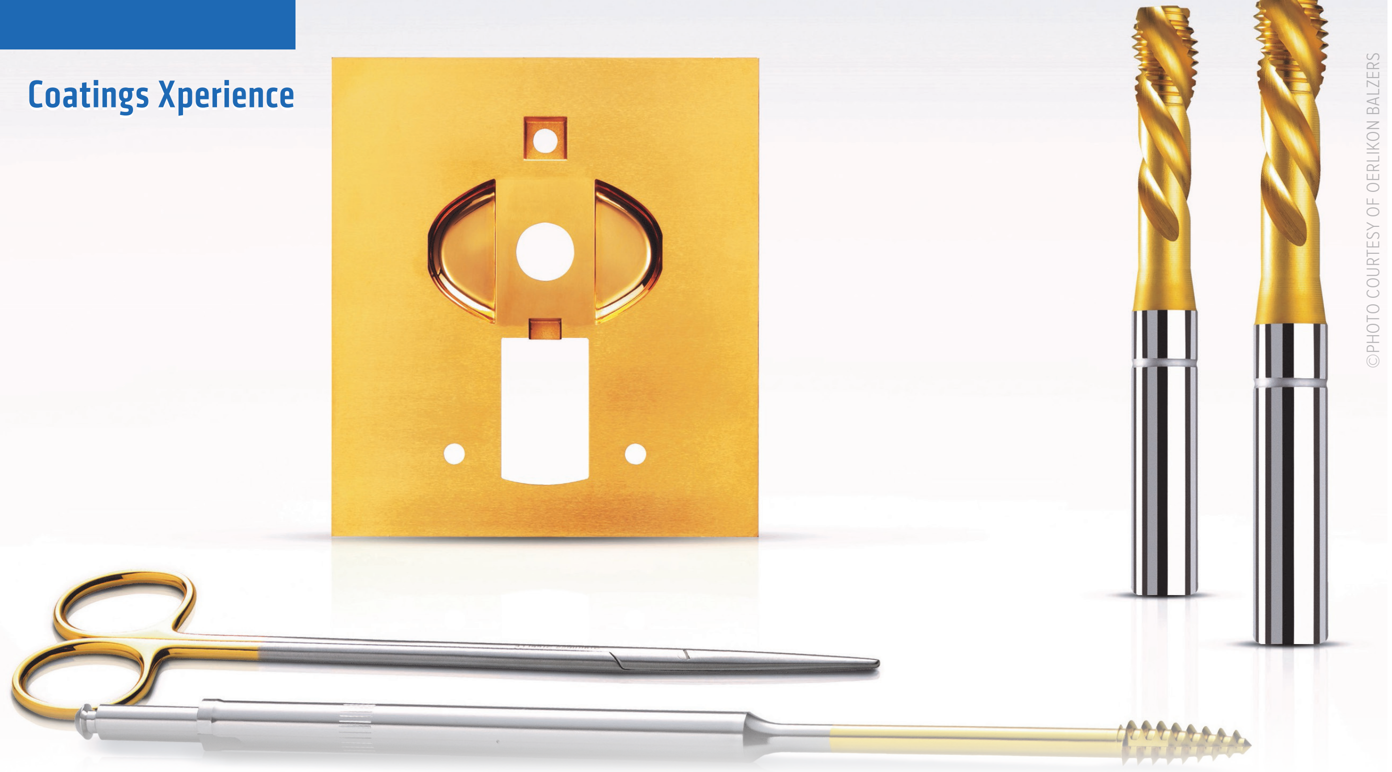

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Enhancing Surfaces with PVD Coatings

In many industrial processes and high performance products, specialized coatings are required to protect the surfaces of tools and components and improve their durability, productivity, and performance. Physical vapor deposition (PVD) is a technique for creating very thin (few thousandths of a millimeter) coatings that are extremely hard. These coatings improve the performance and durability of precision components in almost any industrial and consumer good, and also the life of tools for the metal and plastics processing industries, according to Wolfgang Kalss, head of Marketing & Product Management Tools at Oerlikon Balzers. "PVD coatings are used not only to influence the mechanical, electrical, and visual properties of surfaces, but also to protect functional surfaces from wear. Without them, most materials would reach their limits prematurely. Countless industrial manufacturing processes would be unthinkable without the use of PVD coated surfaces, especially on tools," he asserts. In addition to reducing friction-induced wear and thus minimizing material losses, protecting against thermal overloads, corrosion, and erosion, and altering the haptics and determining the aesthetic effects that surfaces produce, PVD coatings also offer opportunities for differentiation and identification.

Precision components in vehicles, machines, and devices are coated with PVD coatings to enable them to function more reliably and efficiently through the reduction of generated friction and increased durability.

PVD coatings are applied in self-contained systems of different sizes. In the PVD process, a high-purity, solid coating material (metals such as titanium, chromium, and aluminum) is either evaporated by heat (arc evaporation) or by bombardment with ions (sputtering). At the same time, a reactive gas (e.g., nitrogen or a gas-containing carbon) is added. The gas forms a compound with the metal vapor, which is then deposited on the tools or components as a thin, highly adherent coating. A uniform coating thickness is obtained by rotating the parts at a constant speed around several axes. The coating properties, such as hardness, structure, chemical and temperature resistance, and adhesion, can be precisely controlled by the choice of metal and gas.

Friction and wear are major factors limiting the performance and service life of tools. Mechanical engineering components also frequently operate under extreme conditions: high loads, high sliding speeds, or poor lubricating condition can lead to wear or excessive friction and thus reduced lifetime and/or efficiency. Applying PVD coatings to tools and precision components improves the productivity and quality of metalworking and plastics processing in many applications. Coated cutting tools, such as drills, mills, inserts, threading tools, reamers, broaches, and gear cutting tools, can tolerate significantly higher cutting speeds and feeds, reducing machining time and costs, according to Kalss. Their outstanding wear resistance also significantly extends tool life and reduces production costs. "High-speed cutting (HSC) and dry machining generate extremely high temperatures. Thanks to the outstanding thermal stability, hot hardness, and oxidation resistance of PVD coatings, the heat is dissipated through the chips, without adversely affecting the cutting edge," he explains.

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In the past, applying a coating was sufficient to increase tool life and/or productivity, but today and in the future, a more holistic approach is needed, such as combining surface preparation, edge preparation, selecting the right coating for each application, and post-treatment.

Precision components in vehicles, machines, and devices are coated with PVD coatings to enable them to function more reliably and efficiently through the reduction of generated friction and increased durability. For automotive and motor sports, application of PVD coatings to engineered components allows the use of lighter-weight materials for reduced fuel consumption and enables the realization of innovative power-train concepts that provide fuel and lubricant savings and reduce pollutant emissions, according to Avrath Chadha, head of Business Line ThinFilm Automotive for Oerlikon Balzers. They also enable more compact designs, reduce friction losses in the engine, and improve the wear resistance and service life of components, resulting in lengthened service intervals and reduced need for spare parts.

The key to the success of PVD coatings is finding the right coating solution for a specific application. For tools and components subjected to friction and wear, the first step is analysis of the entire tribological system—the parts and their required materials, the desired surface finish, the environment, and wear mechanism. "Early and systematic examination of the overall tribological system with all the elements involved, their properties, and the interactions between friction partners enables optimization of the coating," observes Andreas Reiter, Oerlikon Balzers' head of Sales & Marketing Precision Components. "At Oerlikon Balzers, we always aim to increase value through high quality innovative industrial solutions. We work together with our customers to identify advanced surface solutions that add value to their products and processes through consistent quality and performance. The quality is determined by controlled processes, high quality products and services, continuous improvement to zero-defect quality worldwide, and environmental responsibility," he continues.

Depending on the specific needs for PVD coating, application can be achieved in-house or at a coating service provider. As an example, Oerlikon Balzers provides three options for its customers: PVD coating at one of its coating centers, installation of PVD coating systems in a customer facility, and operation of in-house coating centers for larger customers with large part volumes. The company operates approximately 1100 coating systems in more than 100 coating centers located in 35 countries, providing efficient procedures, short delivery times, and local customer advice and support. Alternatively, its PVD coating systems can be completely integrated into customer production lines and managed by those customers. Some manufacturers, however, prefer to have Oerlikon Balzers set up in-house PVD coating centers on their premises that are completely integrated into their production systems but operated and managed by Oerlikon Balzers. In addition to the automotive and transportation sectors, the company is active in the aerospace; medical, food, and packaging; energy; consumer goods; and engineering markets.

It is also important to recognize that the performance potential of PVD coatings has by no means been fully exploited yet, according to Reiter. For instance, PVD coatings available today cannot offer complete corrosion protection yet, because corrosive media can penetrate the hard coatings through the most minute local defects and damage the base material. In addition, he notes that a lubricating film is still needed to enhance the friction behavior of the tribological system to avoid dry running. However, a hard coating dramatically reduces abrasion compared to uncoated components.

Fortunately, companies like Oerlikon Balzers are continually focused on innovation. The company has more than 120 highly qualified engineers, materials scientists, and physicists working in extensive analytical and test facilities to develop, in collaboration with leading universities and customers, future coating technologies. A recent example is the Scalable Pulsed Power Plasma (S3p) process, which combines the advantages of arc evaporation and sputtering technologies to address customer demands for greater smoothness, exceptional precision, excellent hardness, and very good adhesion, according to Alessandro Zedda, Oerlikon Balzers' head of Solution Innovations. "A unique process window and the separate scalability have opened up unprecedented options in coating design. Customized coatings that precisely meet the needs of the respective applications have become a reality with S3p," he says.

The company's new family of BALIQ wear-resistant PVD coatings is based on this new technology. The coatings have high process reliability and long tool lifetimes without post-machining treatments that result in noticeable cost and time savings. BALIQ UNIQUE coatings are colored PVD coatings that enable tool manufacturers to differentiate, classify, and visualize their products, according to Kalss. "Customers can now assign specific colors to their tool types or groups, select appropriate colors for particular applications, create a unique overall look for their product range and, moreover, use color to measure the degree of abrasion," he explains.

Looking forward, industry 4.0 concepts will be increasingly applied to PVD coating equipment and processes along the value chain. "In addition to enabling predictive maintenance, data science will accelerate the development of new coating materials," asserts Zedda. He also notes that in the future, technologies for the pre- and post-treatment of parts will gain importance. For instance, a new product from Oerlikon Balzers combines lacquer spraying technology with PVD coatings (ePD). "In the past, applying a coating was sufficient to increase tool life and/or productivity, but today and in the future, a more holistic approach is needed, such as combining surface preparation, edge preparation, selecting the right coating for each application, and post-treatment," states Kalss. In addition, to achieve the next level in service and higher customer satisfaction, he believes that door-to-door tracking is needed along with the easy use of digital order platforms and tool life cycle management systems that include multiple reconditioning cycles. ❄