Surface Engineering - Applied Research and Industrial Applications
Room Pacific E - Session G3-TuA

Innovative Surface Engineering for Advanced Cutting and Forming Tool Applications

Moderators: Stepan Kyrsta, Oerlikon Luxembourg, **Christoph Schiffers**, CemeCon AG, Germany

1:40pm **G3-TuA-1 A New Tool in Coating Design: Managing Intrinsic Stresses in HiPIMS***, **Christoph Schiffers (christoph.schiffers@cemecon.de)**, T. Leyendecker, W. Kölker, S. Bolz, B. Mesic,* CemeCon AG, Germany

Until now, the residual stresses of a coating could not be adjusted independently of other properties. The classical work around was adding layers of soft materials such as CrN to the film design. Such a multilayer is not ideal when high oxidation resistance and high hardness is needed for the application.

The unique feature of HiPIMS is the ability to actively design the intrinsic stresses in a coating material. In-depth plasma analysis shows that the short HiPIMS pulses consist of several phases. Synchronizing the HiPIMS pulses on the cathodes with a pulsed Bias is the technique for attracting the ionized target species and forming the coating out of them while suppressing unwanted contributions such as gas ions.

Having control over the intrinsic stresses of a coating material by the timing of the HiPIMS synchronisation adds a fully new option to the coating designer's toolbox: stress management of the material. This triggers a paradigm shift: hardness by the composition of the material and a dense, low stress coating morphology by the HiPIMS process.

Managing intrinsic stresses in HiPIMS gives new coating options such as 12 µm thick films for heavy duty insert milling applications as well as precisely defined stresses for making TiAlSiN coatings on micro-tools even more wear resistant. Managing stresses in HiPIMS is about mastering stress and strain for the coating's application.

2:00pm **G3-TuA-2 Self-lubricating CrAlMoN High Performance Tool Coatings for Machining of TiAl6V4***, K. Bobzin, C. Kalscheuer, M. Carlet,* ***Nina Stachowski (stachowski@iot.rwth-aachen.de)**,* Surface Engineering Institute - RWTH Aachen University, Germany*; W. Hintze, C. Möller, P. Ploog,* Institute of Production Management and Technology - Hamburg University of Technology (TUHH), Germany

Titanium alloys such as TiAl6V4 enable a significant performance improvement in different industry sectors. However, machining of titanium alloys presents a considerable challenge due to the low thermal conductivity of λ = 5.8 W/mK, Young's modulus of 110 GPa ≤ E ≤ 140 GPa as well as the strong adhesion tendency. This leads to high thermal and mechanical loads on the cutting edge resulting in early tool failure. Currently uncoated cemented carbide tools are commonly used for turning of TiAl6V4. However, self-lubricating physical vapor deposition (PVD) coatings like CrAlVN and CrAlMoN provide a promising approach to increase tool life. For this purpose, the coating ability to form lubricating oxide phases is essential. Self-lubricating oxide phases form under tribological loads, e.g. during machining processes due to the oxidation of specific transition metals such as vanadium or molybdenum. These oxide phases contribute to a decrease of thermal and mechanical loads in the contact between cutting edge and workpiece which may lead to an increased tool performance in TiAl6V4 cutting. In the present study, self-lubricating CrAlVN and CrAlMoN coatings were investigated on cemented carbide tools. The coatings were deposited by hybrid direct current magnetron sputtering / high power pulsed magnetron sputtering processes. Coating morphology, thickness, chemical composition, indentation hardness, indentation modulus as well as oxide phase composition were analyzed. Moreover, friction and wear behavior of the coated cutting tools were determined using a pin on disc (PoD) tribometer at ϑ = 20 °C, ϑ = 600 °C and ϑ = 800 °C against a TiAl6V4 counterpart. Additionally tool life and deformation behavior of the coated cutting inserts was analyzed after turning of TiAl6V4. The CrAlVN and CrAlMoN coatings possessed a dense morphology and a smooth surface topography. Both coating variants exhibited a good adhesion to the cemented carbide tools. For increased test temperatures, the tribological analyses showed a reduction in the coefficient of friction. In case of the CrAlVN coated samples, a friction reduction was observed at ϑ = 800 °C. In contrast thereto, a friction reduction was already found at ϑ = 600 °C for CrAlMoN. As compared to the uncoated reference and to the CrAlVN coated cutting inserts an increase in tool life for CrAlMoN coated cutting inserts was achieved for turning of TiAl6V4.

2:20pm **G3-TuA-3 Coating Design for Components for Extreme Applications***, **Ricardo Alexandre (ricardo@teandm.pt)**,* TEandM, Portugal **INVITED**

Coating design plays a paramount role in coating performance enabling performance increases in industrial components and tools. Thru the decades, coating design development has evolved from simple single layer coatings to more and more complex designs, starting from bilayers to current advanced nanostructures. When we look at extreme applications are these coatings able to protect and functionalize the surface successfully? At what extend production processes can be impacted? What about complying with demanding and restrictive product specifications? The application, at industrial scale, of sophisticated coating designs poses limitations? What kind? These are questions challenging, not only, coating developers, but also job coaters in direct contact with the market applications, where clients bring about complex and demanding surface treatment challenges driven by productivity focused production processes and sophisticated products. In order to bring some light into these questions four case studies will be presented. These case studies combine extreme working conditions (wear, corrosion, temperature, etc.) with product/process demanding specifications. Coating designs, its performance impact and industrial scale coating challenges and limitations will be discussed.

3:00pm **G3-TuA-5 The Use of Coatings to Minimize Soldering in Aluminum High Pressure Die Casting***, **Nelson Delfino de Campos Neto (ndelfino@mines.edu)**, A. L. Korenyi-Both,* Colorado School of Mines, USA*; C. Vian,* Stellantis, USA*; S. P. Midson, M. J. Kaufman,* Colorado School of Mines, USA

In the aluminum high pressure die casting (HPDC) process, the molten aluminum alloy is injected into reusable steel dies at high speeds (gate speeds of between 25 and 45 m/sec) and high pressures of 70 to 100 MPa or higher. To try to prevent the liquid metal from soldering (sticking) to the steel die, lubricants (parting agents) are sprayed into the die surface prior to each shot, but some level of soldering often still occurs. In addition, the rapid cooling of the die surface by the lubricant spray can promote heat checking, thereby dramatically shortening the life of the die. During aluminum HPDC, core pins located near the gate experience extreme conditions, such as higher temperatures and greater soldering and abrasion/erosion due to interactions with the flowing liquid metal. One possible solution for minimizing soldering and to address the extreme conditions adjacent to the gate is the application of hard coatings to these more vulnerable regions of the die. However, the decision-making process for selecting appropriate coatings for application to dies is often still very subjective. Several researchers have attempted to use laboratory tests for evaluating the effectiveness of various coating materials, but these laboratory tests typically lack the high gate speeds and pressures that are inherent to the die casting process. While more complex and realistic tests have been performed using laboratory-based or production die casting machines, only a limited number of die coatings have been examined, mostly produced by the PVD process. In the study reported here, a commercial die used to produce large automotive die castings was examined, as it incorporated two core pins located directly in front of the gate. A range of PVD, PACVD and diffusion coatings were applied to the core pins, and both qualitative and quantitative measurements were used to identify the amount of aluminum soldered to each coated pin. Characterization of the soldered interfaces was performed to understand coating failure, and to indicate best die coatings for aluminum HPDC applications.

4:00pm **G3-TuA-8 Bringing Together Research, Job Coating and Market Needs***, **Carles Colominas (carles.colominas@iqs.url.edu)**,* Flubetech, Spain **INVITED**

Job coating must be carried out through high tech but well-known technologies, to minimize technical and economic risks. A combination of high degree of specialization, customer orientation and a deep understanding of plasma technology allows PVD job coating companies to provide a proper coating service for a wide variety of applications, ranging from cutting tools to plastic or aluminum injection or biomedical implants. However, today's highly demanding and increasing market needs (local and global) push job coating companies to adapt to new circumstances to take advantage of new opportunities and finding new niches, like electric mobility or additive manufactured parts. Research projects must be essentially applied and focused and strategically and rigorously selected to provide benefits in the short and medium-term.

In this talk, several projects developed by our SME job coating company on cutting tools, metal forming, plastic injection, energy and biomedical fields will be presented. Developments include doped amorphous carbon films and multi-layered ceramic coating systems deposited by regular magnetron sputtering, high power impulse magnetron sputtering (HiPIMS) and duplex coatings by cathodic arc deposition. In all cases, coatings were developed using industrial PVD machines. Different aspects will be discussed, including the substrate influence, adhesion to the substrate, coating microstructure control, deposition temperature, tribological properties and chemical inertness (oxidation and wettability by liquid aluminum).

4:40pm **G3-TuA-10 CrON-based Coatings for Plastic Processing Applications***, **Anders O. Eriksson (anders.o.eriksson@oerlikon.com)**, T. Vermland, D. Fopp-Spori, J. Tischhauser,* Oerlikon Balzers, Oerlikon Surface Solution AG, Liechtenstein

Polymeric materials are used in a wide range of applications including packaging, bottle caps, furniture, window frames, as well as automotive parts and high-end components. The manufacturing process often includes injection molding or extrusion processes. To achieve long lifetime, performance, and stability in high volume manufacturing processes, coatings are applied on the parts of the tooling that are in contact with the polymer melt. Increasing requirement for high-strength light-weight materials, for example driven by E-mobility, promote the use of polymers with high percentage of glass-fiber or carbon-fiber reinforcement. The use of biopolymers is also increasing. Consequently, the conditions for tools and components are becoming harsher and typically involve a combination of abrasive wear, corrosion, and plastic adhesion. To allow performance enhancements in the contemporary plastics processing industry, we describe the development of a coating solution based on CrON. The selection of coating materials, tuning of coating architecture, and coating properties will be discussed and correlated with application requirements and performance.

Preferred for Session G3

Author Index

Bold page numbers indicate presenter