## Plasma and Vapor Deposition Processes
## Room Town & Country B - Session PP8-1-ThM

## Commemorative Session for Papken Hovsepian I

**Moderators: Prof. Arutiun P. Ehiasarian**, Sheffield Hallam University, UK, **Philipp Immich**, IHI Hauzer Techno Coating B.V., Netherlands

8:00am **PP8-1-ThM-1 How Industry and Research Are Connected to Accelerate Development***, **Philipp Immich [pimmich@hauzer.nl]**,* IHI Hauzer Techno Coating B.V., Netherlands **INVITED**

The relationship between Sheffield Hallam University and Hauzer has been long-standing, beginning with Dieter Münz, former CEO of Hauzer, becoming a professor at Sheffield in 1993. When Papken Hovsepian joined Hallam, the collaboration between become even more intense. Papken played a crucial role in the early discussions for the first EU projects focused on HIPIMS development.

In 2003, Hauzer conducted initial tests with Advanced Energy's power supply and AC Converters, marking the first empirical steps in HIPIMS alongside Papken. The EU INNOVATIAL project, which started in 2004, focused on HIPIMS development in collaboration with Sheffield Hallam University (SHU), which later licensed HIPIMS etching to Hauzer. Hauzer's involvement in significant European projects like Alticut and Nanocoat further strengthened this partnership. The first HIPIMS trials at Hauzer led to groundbreaking research and publications, particularly on superlattice coatings, a major focus of Papken's work.

The collaboration with Papken and later Arutiun Ehiasarian (Harry) was instrumental in Hauzer's success, resulting in numerous patents, including HIPIMS Bias and ARC handling. The initial impulse for the ABS conference days in 1995 was triggered by Dieter Münz, later involving strong participation from Papken in the HIPIMS Conference. Papken's motto was always about bringing industry and research together to learn from each other and accelerate developments.

In 2023, Hauzer celebrated its 40th anniversary by hosting the HIPIMS community for the 13th HIPIMS conference in Venlo for the second time since 2008, unfortunately a testament to the enduring relationship with Papken and his contributions.

Papken's legacy is deeply cherished by the Hauzer family, and his impact on the HIPIMS community and beyond will always be remembered. Thank you, Papken, for your invaluable contributions and for being an integral part of our history.

8:40am **PP8-1-ThM-3 Invited Paper***, **Ivan Petrov [petrov@illinois.edu]**,* University of Illinois at Urbana-Champaign, USA **INVITED**

9:20am **PP8-1-ThM-5 Invited Paper***, **Francisco Javier Perez Trujillo [fjperez@quim.ucm.es]**,* Universidad Complutense de Madrid, Spain **INVITED**

10:20am **PP8-1-ThM-8 Recent Progress in Coating Materials Design: Thermal Stability vs Chemical Stability**, *Amir Navidi, Deborah Neuss, Soheil Karimi, Marcus Hans,* Materials Chemistry, RWTH Aachen University, Germany*; Daniel Primetzhofer,* Materials Physics, Dep. of Physics and Astronomy, Uppsala University, Sweden*; **Jochen M. Schneider [schneider@mch.rwth-aachen.de]**,* Materials Chemistry, RWTH Aachen University, Germany **INVITED**

The roles of chemical, structural and interfacial complexity for the design of thermally stable and chemically stable protective coating materials is discussed. In this talk the thermal stability of nitride thin films of varying chemical complexity is compared. Furthermore, the oxidation behavior of monolithic transition metal diboride based coating systems are compared to coating architectures containing multiple interfaces. The role of thermal stability for the oxidation behaviour of the above mentioned coating systems will be discussed.

11:00am **PP8-1-ThM-10 HiPIMS and Magnetron Sputtered Carbon-Based Nanocomposites***, **Sven Ulrich [sven.ulrich@imf.fzk.de]**,* Forschungszentrum Karlsruhe, Germany **INVITED**

Carbon-based nanocomposites with adjustable multifunctional properties are suitable candidates for both tribological applications and energy technologies. Reactive DC magnetron sputtering and HiPIMS are selected as coating processes, using a metallic transition metal target, argon as the working gas and methane as the reactive gas. As shown in plasma diagnostic investigations, in contrast to DC magnetron sputtering, HiPIMS exhibits a high ion content of the film-forming particles and the energy deposited by ion bombardment during film growth can be precisely adjusted. The cpnstitution and microstructure were determined by a combination of several analytical methods: EPMA, ERDA, Raman spectroscopy at four different wavelengths, XRD, TEM and HRTEM were used to determine the composition and correlate it with the mechanical properties. It is shown that by varying the methane reactive gas flow, single-phase transition metal carbide coatings as well as nanocomposites consisting of nanocrystalline transition metal carbide grains in a hydrogenated amorphous carbon network can be produced. Thus, by choosing the optimized process parameters (switching function), multilayers can be produced from these two components.

**Keywords:** HiPIMS, Magnetron sputtering, carbon-based nanocomposites

11:40am **PP8-1-ThM-12 Superlattice Coatings: Unleashing Superior Properties Through Architected Nanolayers***, **Paul Mayrhofer [paul.mayrhofer@tuwien.ac.at]**,* TU Wien, Institute of Materials Science and Technology, Austria **INVITED**

Inspired by Helmersson, Hovsepian, and Münz's pioneering work on transition metal nitride superlattices, this concept has been a part of my research since 2003, particularly influenced by Papken Hovsepian's application-driven advancements. Here, we explore how nanolamellar microstructures can simultaneously enhance the hardness and fracture toughness of hard coatings. Superlattices, formed by alternating nanometer-thick layers, present opportunities to engineer mechanical properties superior to their individual constituents.

Careful interface design enables superlattices to achieve exceptional hardness, toughness, and thermal stability, essential for extreme environments. This concept applies effectively to nitrides, carbides, borides, and their mixtures. Mechanisms like dislocation blocking, coherent interface strengthening, and stress modulation contribute to this superior performance. The "epitaxial stabilization effect" further plays a key role, where pseudomorphic forces of the stabilizing layer act on the surface of the other layer during nucleation and growth, causing it to crystallize in its metastable but more similar structure rather than its thermodynamically stable but different structure. As a result, in addition to coherency stresses (due to lattice mismatches) and modulus mismatches, phases as well as stoichiometries that may exhibit higher inherent ductility, according to their decreased *G*/*B* ratio and increased Cauchy pressure, become accessible (like shown for superlattices containing $MoN_z$, $WN_z$, $SiN_z$, or AlN layers).

Upon loading, dislocation nucleation and interface-triggered phase transformations dissipate energy, enhancing fracture toughness. For instance, TiN/WN superlattices achieve hardness (36.7±0.8 GPa) and fracture toughness (4.6±0.2 MPa·$m^{0.5}$) with optimized layer thicknesses ($\Lambda$ = 8.1–10.2 nm). This work examines the influence of layer thickness, interface quality, and architecture on mechanical behavior, emphasizing the critical balance between toughness and hardness, alongside high-temperature stability. The findings underscore the potential of superlattice designs for protective coatings, high-performance tools, and structural components under severe thermal and mechanical loads.

In memorial of Papken Hosepian.

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