Surface Engineering - Applied Research and Industrial Applications
Room Palm 1-2 - Session IA1-TuM

Advances in Application Driven Research and Hybrid Systems, Processes and Coatings

Moderators: Dr. Vikram Bedekar, Timken Company, USA, **Prof. Dr. Hana Barankova**, Uppsala University, Sweden

8:00am **IA1-TuM-1 Advancing Correlative Microscopy: In-Situ Integration of AFM-SEM-EDS for Multi-Modal Analysis**, ***Kerim T. Arat* *[karat@qdusa.com]***, *William K. Neils, Stefano Spagna,* Quantum Design Inc., USA

There is a growing interest in in-situ correlation microscopy, which brings the complementary strengths of different imaging modalities without the inherent complications of sample transfer. These approaches ensure high confidence in correlation accuracy and eliminate the risk of sample contamination and alteration during the sample transfer.

We have developed a correlative microscopy platform based on AFM-SEM [1]. These techniques can map the surface in high resolution, and the trunnion stage, with up to 80° tilt capability, allows monitoring of tip quality and tip-sample interaction [2]. However, these methods fall short in identifying the elemental composition of the sample.

To address this issue, we have extended the capabilities of the correlative platform with an energy-dispersive X-ray spectrometer (EDS). The spectrometer is based on a state-of-the-art silicon drift detector [3], which provides high energy resolution. Its graphene window offers improved transmission performance, especially at the lower energy range, allowing elemental detection down to carbon. The elemental identification algorithm uses a background subtraction method to remove non-characteristic signals and compares the resulting spectra to reference datasets based on the NIST database for standardless quantification [4]. Both hardware and software integration allow the correlation of elemental information with the other imaging modalities that the tool can provide (see the supplementary document), where one can superimpose topography and elemental information.

Integration of the X-ray detector adds a comprehensive analysis capability to AFM-SEM techniques applicable to a diverse range of fields such as materials science, semiconductors and biosciences. With this option, researchers can obtain an in-situ correlation of high-resolution, localized elemental information with high-resolution lateral and vertical topographical information.

[1] A. Alipour et al., Microscopy Today 31 (2023), p. 17-22. doi: 10.1093/mictod/qaad083

[2] “FusionScope by Quantum Design,” Open a world of easy-to-use correlative microscopy, 2022. https://fusionscope.com/ (accessed Apr. 27, 2023).

[3] D. E. Newbury and N. W. M. Ritchie, Journal of Materials Science 50 (2015), p. 493-518. doi: 10.1007/s10853-014-8685-2

[4] D. E. Newbury and N. W. M. Ritchie, Scanning Microscopies 9236 (2014), p. 9236OH. doi: 10.1117/12.2065842

8:20am **IA1-TuM-2 Non-stick Hydrophobic and Superhydrophilic Metallic Coatings: Their PVD Fabrications and Applications**, ***Jinn P. Chu* *[jpchu@mail.ntust.edu.tw]***, National Taiwan University of Science and Technology, Taiwan

The presentation will begin with an introduction to a non-stick, low-friction hydrophobic metallic glass coating and its applications. This amorphous coating, fabricated using PVD techniques, has been successfully applied in various fields, including medical devices. For the superhydrophilic coating, a 316 stainless steel layer is sputtered onto the substrate, resulting in a water contact angle of approximately 10 degrees on the coated surface. This coating also demonstrates antifouling and underwater superoleophobic properties, which are advantageous for use in separation membranes for oil/water emulsions. Furthermore, it has proven highly effective in enhancing electrochemical responses in electrodes used as electrochemical sensors.

8:40am **IA1-TuM-3 Novel CO_2 Laser Direct-Write Energy-Efficient Process for Functional Oxide-Carbon Composite Coatings and Their Energy Applications**, ***swati Jadhav* *[swatijadhav1602@gmail.com]***, *Pratibha jadhav, Ishwari Belle, Anuradha Ambalkar, Supriya Kadam, Satishchandra Ogale,* Indian Institute of Science Education and Research, Pune, India

The performance and operational longevity of several energy devices such as Batteries, Fuel Cells, and Electrolysers critically depend on the chemical and physical functionality, micro (nano) porosity, and robustness of the specialized coatings on metal current collectors. A large number of methods are available to obtain such coatings, but these are chemically complex and generally energy intensive. Moreover, several of these methods do not allow concurrent control of porosity and surface chemistry that drive the overall process efficiency, especially in surface catalytic phenomena. In this work we show that CO_2 laser (wavelength 10.6 mm) induced surface processing allows an excellent parametric control on achieving the desired results and that too with a dramatic reduction of energy inputs vis a vis the conventional methods. The key control parameters include laser power density, scanning speed, and coating constitution/thickness. The laser surface processing method is intrinsically direct-write type in scanning mode and as such allows in-plane micro-gradient patterning. We will show and discuss the results of several interesting cases wherein the effectiveness of this approach is demonstrated for composite oxide-carbon coatings obtained by using biomass (or biomass-derived) precursors and functional binary oxide systems. The biomass precursors include furfural alcohol, lemon grass, sugarcane bagasse while the oxide systems include NiO, CuO, TiO_2. Use of urea and thiourea in the composite is also examined to achieve doping of nitrogen and Sulfur in carbon to enhance its conductivity. The resulting engineered coatings are studied for energy applications such as Anode-free (AF) Li and Na ion batteries, and Electrocatalysis for water splitting applications (oxygen evolution reaction, OER and Hydrogen evolution reaction (HER)). For AF batteries the laser processed coatings render low Li/Na nucleation overpotential, good columbic efficiency and cycling stability of up to 800 cycles limited by Li/Na inventory. In case of water splitting application as well superior properties are realized in terms of overpotential and stability.

9:00am **IA1-TuM-4 PVD Coatings for the Hydrogen economy - Applications, Testing and Production**, ***Herbert Gabriel* *[h.gabriel@pvtvacuum.de]***, PVT Plasma und Vakuum Technik GmbH, Germany **INVITED**

Green hydrogen could be the fuel of the future. Generated by electroysers powered by photovoltaics and used in fuel cells could be part of the solution to the human mankind’s problems with the climate change.

The harsh environments in electrolysers and fuel cells require components to be coated for corrosion resistance, electrical conductivity and other related properties..

Most of the components are made of stainless steel or titanium, but still need for their performance and long lifetimes up to 100.000 hours coatings with high performance properties.

Depending on the application, whether PEMWE, PEMFC, AEM, SOFCs, SOECs or others, thin coatings made of materials such as C, Ti, Cr, Nb, Au, Pt, Ir, MCO, Al2O3....... are deposited in the nanometer to a couple of micron range.

Preferred coating processes are magnetron sputtering, respectively HiPIMS, high power impulse magnetron sputtering to deposit highly adherent and dense coatings.

Most components of fuel cells and electrolycers to be coated are thin 2-dimensional structures in high quantity. For this reason high productive so-called in-line systems with vertical orientation are the preferred coating systems for double-sided deposition.

Apart from a number of other QC – tests, adhesion, corrosion and ICR (interface contact resistance) prior and after corrosion testing are essential properties to continually be tested and monitored.

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