Surface Engineering - Applied Research and Industrial Applications
Room Pacific E - Session G4-MoA

Hybrid Systems, Processes and Coatings

Moderators: Satish Dixit, Plasma Technology Inc., USA, **Sang-Yul Lee**, Korea Aerospace University, Korea (Republic of)

1:40pm **G4-MoA-1 Modelling Layered Materials Systems Using the Einstein-Hilbert Action***, **Frank Papa (frank@gpplasma.com)**,* GP plasma, USA*; T. vom Braucke,* GP plasma, World Formula Apps, Canada*; N. Bierwisch,* Saxonian Institute of Surface Mechanics SIO, Germany*; N. Schwarzer,* Saxonian Institute of Surface Mechanics SIO, World Formula Apps, Germany

Complex thin film systems can be simulated by a general approach for any coating system by first characterizing it with a set of properties. Once these properties are allocated to certain aspects, we have a method to holistically simulate it. While such a holistic description is only with words, surprisingly, over 100 years ago the great mathematician David Hilbert already found a way to put a set of properties, attributes, degrees of freedom or – as all these other terms are just coding - dimensions into a mathematical formalism, it being the Hamilton extremal principle [1]. He realized that a given set of attributes is nothing else but a set of dimensions and thus, forms a mathematical space or space-time. However, Hilbert only applied his calculus to ordinary 4-dimensional space-time and to then derive the Einstein-Field-Equations [1, 2]. This methodology was further elaborated and generalized in [3, 4] providing a top-down method to describe a large complex system, that can be fed by measurement data to probe a response at various scales of a system under different scenarios. We provide a preliminary theoretical outlook toward materials science applications.

[1] D. Hilbert, Die Grundlagen der Physik, Teil 1, Göttinger Nachrichten, 395-407 (1915)

[2] A. Einstein, Grundlage der allgemeinen Relativitätstheorie, Annalen der Physik (ser. 4), 49, 769–822

[3] N. Schwarzer, "The World Formula: A Late Recognition of David Hilbert ‘s Stroke of Genius", Jenny Stanford Publishing, ISBN: 9789814877206

[4] N. Schwarzer, "The Math of Body, Soul and the Universe," Jenny Stanford Publishing, ISBN: 9789814968249

2:00pm **G4-MoA-2 Control of Phase Transition of VO_2 Films and VO_2-based Terahertz and Infrared Devices***, **Heungsoo Kim (heungsoo.kim@nrl.navy.mil)**,* Naval Research Laboratory, USA*; D. Lahneman,* National Research Council Fellow , USA*; R. Auyeung, K. Charipar, C. Rohde, A. Pique,* Naval Research Laboratory, USA

Vanadium dioxide (VO_2) undergoes an insulator-metal transition (IMT) at ~67 ˚C, which is associated with a structural phase transition (SPT) between an insulating monoclinic phase and a metallic tetragonal phase. This SPT leads to a sharp change in conductivity and index of refraction, which make VO_2 an ideal material for various active devices. High quality VO_2 epitaxial thin films have been synthesized on various single crystal substrates with various buffer layers via pulsed laser deposition. By adjusting the growth conditions of the buffer layers, we were able to modify the interfacial strain between VO_2 film and buffer layer, and consequently can control the T_{IMT} in VO_2 films. We have exploited the phase transition of VO_2 to modulate terahertz (THz) transmission by combining split ring resonator structures with phase changingVO_2 films. We have also demonstrated a VO_2-based passive solid-state radiator for spacecraft thermal control. In this design, we were able to provide dynamic thermal emissivity control by the thermochromic phase change in VO_2 film, which can vary the amount of emitted power of the multilayer device. We will present details on the properties of strained VO_2 films and results from VO_2-based devices.

This work was supported by the Office of Naval Research (ONR) through the Naval Research Laboratory basic research program.

2:20pm **G4-MoA-3 Hybrid HIPIMS and Controlled Pulsed Arc for Deposition of Hard Coatings***, **Jiří Vyskočil (jiri.vyskocil@hvm.cz)**, P. Mareš,* HVM Plasma, Czechia*; Z. Hubička, M. Čada,* Institute of Physics CAS, Czechia **INVITED**

A new hybrid PVD deposition system was developed based on the combination of HiPIMS pulsed glow discharge and pulsed cathodic arc discharge (HiPIMS+arc). The presence of cathodic arc discharge in the HiPIMS is a typical situation when the glow discharge randomly transits to an arc discharge during the active part of the pulse cycle. In these typical cases, the transition appears randomly and cannot be controlled. The new hybrid HiPIMS+arc discharge works with modified pulsed high power supplies which allow the initiation of pulsed arc discharge during HiPIMS pulse at the defined time. The initiated arc during the active part of HiPIMS pulse is quenched at the end of this active part of pulse when the magnetron cathode is disconnected from the negative voltage of power supply. Several modifications with HiPIMS sequence of active pulses with arc were tested as well. The hybrid HiPIMS+arc was applied for the deposition of ta-C thin films by use of a graphite magnetron target. Carbon ta-C films were deposited on silicon substrates at different working gas pressures and different puls configurations. Deposited films were analyzed by Raman scattering and microhardness measurements and the ratio of sp^3/sp^2 bonds was determined. The surface morphology was obtained by SEM and AFM and the presence of microdroplets was analysed for particular conditions. Achieved ta-C film parameters for this deposition source were compared with other deposition methods.

Plasma diagnostics was done in the HiPIMS+arc system by an energetically resolved ion mass spectroscopy and by a RF ion flux density monitor as both methods worked with the time resolution. Ion energy distribution functions of C^+, C^{++} Ar^{++}, Ar^+ were observed at the position of substrate for different deposition conditions in HiPIMS+arc plasma system. Measured parameters of plasma with energies of ions of carbon and argon and the values of total ion fluxes on the substrates were correlated with properties of deposited ta-C films.

Author Index

Bold page numbers indicate presenter