Keynote Lectures
Room Town & Country A - Session KYL-MoKYL

Keynote Lecture I
Moderator: Ivan G. Petrov, University of Illinois at Urbana-Champaign, USA

1:00pm **KYL-MoKYL-1 The Ion and Material Design Revolution – Songs of Innocence and Experience***, Arunprabhu Sugumaran Arunachalam Sugumaran,* Sheffield Hallam University, United Kingdom*; Ryan Bower, MIng Fu,* Imperial College London, UK*; David Owen, Papken Eh. Hovsepian,* Sheffield Hallam University, UK*; Peter K. Petrov, Rupert Oulton,* Imperial College London, UK*;* ***Arutiun P. Ehiasarian [A.EHIASARIAN@SHU.AC.UK]***[1]*,* Sheffield Hallam University, UK **INVITED**

High Power Impulse Magnetron Sputtering plasma thin film technology is sweeping through labs and manufacturing facilities across all continents.It has brought new understanding of plasma discharge mechanisms, film growth and performance in critical applications ranging from cutting tools to microelectronics, whilst spurring along the development of precise hardware and process control strategies.

Very high ionisation degree of the metal and gas is produced through high-density plasma, which in some circumstances is achieved by the self-organisation of the plasma into zones of elevated density along the magnetron racetrack.Strategies for controlled increase in current and reverse voltage post-pulsing enable even di-electric materials to be deposited in a stable reactive process. The highly energetic deposition flux created on account of the high ion-to-neutral ratio enables deposition of high-density films on temperature-sensitive substrates such as PET foil.Along with the microstructure densification and crystallographic orientation changes, film properties such as hardness, toughness, electrical conductivity and optical response are improved.Steps towards a digital twin of the deposition process based on optical emission spectroscopic monitoring and physics models are reducing process times and improving reproducibility.

Ion bombardment enables substrate pretreatment to enhance adhesion and preserve high-aspect ratio features by undergoing stages of high removal rate, followed by metal ion implantation.Diffusion surface treatments at low-pressure and under intense ion irradiation have overtaken the rate of conventional nitriding processes by a factor of 4 whilst improving the ductility of the surface.

Nanoscale multilayers introduce extra dimensions towards materials design, with a family of films to withstand high temperature oxidation, corrosion, wear, cavitation and tailored to applications in power generation and propulsion turbines, biomedical implants, automotive components, cutting and forming tools and space satellite components.Ion bombardment has been responsible for controlled segregation of metal in carbon films.Recently superhard nanolayer films have been used for plasmonic catalysis enabled by visible light which aims to enhance the activity of surfaces in promoting a broad range of chemical reactions including water splitting and associated production of bioactive reactive oxygen species. Pump-probe laser measurements confirm a significant increase in the lifetime of active electron species in the films due to trapping of hot carriers by oxygen vacancies. Graded structures, starting from a bilayer thickness of 2.4 and reducing to 1.7 nm exhibited a large grain size and increased hardness and toughness, as determined from nanoindentation, and resulted in improved resistance to cavitation erosion.Remarkably, ion-induced densification in HIPIMS-deposited films has demonstrated an improvement in fatigue performance of biomedical implants, power generation turbine blades and forming tools.

Despite these advances, questions remain in all of the fundamental and applied fields.

[1] **Bill Sproul Award and Honorary ICMCTF Lecture**

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