Topical Symposia
Room Town & Country A - Session TS6-3-TuA
A Session to Acknowledge the Contributions of Joe Greene to the ASED, ICMCTF, AVS, and IUVSTA III

Moderators: Ivan G. Petrov, University of Illinois at Urbana-Champaign, USA, **Angus Rockett**, University of Illinois at Urbana-Champaign, USA

1:40pm **TS6-3-TuA-1 Perspective on Thin-Film Metallic Glasses: Road to Industrial Production (Virtual Presentation)**, ***Jinn P. Chu (jpchu@mail.ntust.edu.tw)***, National Taiwan University of Science and Technology, Taiwan **INVITED**

This presentation provides brief overviews on the recent application-oriented researches on thin film metallic glasses (TFMGs) in various fields such as biomedical, biosensors, and nanotube arrays. For instance, TFMGs have been shown to improve the mechanical properties and the surface properties (such as non-stick characteristics) of the underlying substrates. The surface topography of TFMGs has also been revealed to affect chemical activity, cell-adhesion, and wetting-related properties of surfaces. In addition, the first-ever metallic-glass nanotube array on Si has been successfully fabricated by a widely-used lithography and sputter deposition process for very large-scale integration. These research works actually suggest that thin film is the most suitable approach to answer many unrevealed questions on its bulk metallic glass counterpart. Nevertheless, the remaining question is where the researches on TFMGs are headed. This article also highlights future challenges and opportunities associated with the further development of TFMG for the industrial production.

2:20pm **TS6-3-TuA-3 Hollow Cathode Discharges: The Influence of the Electrode Material and Cathode Geometry**, ***Stephen Muhl (muhl@unam.mx)***, IIM UNAM, CDMX, Mexico; *R. Sangines,* CNyN (CONACYT) UNAM, Ensenada, BC, Mexico; *J. Cruz,* CNyN UNAM, Ensenada, BC, Mexico **INVITED**

I first meet Joe Greene in 1999 in a Mexican Vacuum Society meeting, and in 2011 he invited me to submit a review article on my hollow cathode work to Thin Solid Films. That task greatly increased my knowledge of hollow cathodes, but also showed me that I did not really understand how they worked.

Traditionally, in a low-pressure gas discharge, electrons emitted from the cathode are accelerated by the cathode sheath. They produce light emission in the cathode glow, then stop producing it in the cathode dark space until they get to the edge of the negative glow. The secondary electrons and ions are accelerated by the sheath producing additional ionization and this avalanche maintains the discharge. However, recent work has shown that this is wrong in that the cathode glow is not generate by electrons, and that the basic description has many problems.

Hollow cathodes include almost any cathode with a cavity-like geometry, cylindrical, planar or spherical. In 1916, F. Paschen showed that such a system can produce a high electron flux and plasma density, in part, by reducing the loss of electrons in the similar way as in a magnetron. In general, there are three types of hollow cathode discharge, at low power and/or low gas pressures, it is a typical low-current high-voltage plasma. For certain combinations of gas pressures and hollow cathode diameters, with high applied powers, the negative glow of the plasma almost completely fills the interior the cathode and the plasma current, and density can be orders of magnitude greater than that of a typical discharge. Finally, if the cathode material is not cooled the discharge can transform into a dispersed arc, the hot electrode produces thermal-field electron emission as an additional source of electrons, and this even further increases the plasma density and current.

The conventional explanation for the hollow cathode effect involves high-energy “pendulum” electrons which are reflected between the opposing sheaths on either side of the inside of the cathode; the long trajectory of these electron is considered to produce an increased number of secondary electrons, with this resulting in the higher plasma density and current. Here we describe some problems associated with this well-accepted model and present an alternative explanation based on doubly charged ions. Finally, we report the results of recent studies of the dependence of the I-V characteristics of an argon discharge on the geometry of a cylindrical cathode, the metal used to make the cathode, spatially resolved optical emission spectroscopy of the hollow cathode and measurements of the ion flux as a function of the experimental conditions.

4:00pm **TS6-3-TuA-8 Ti-Nb Based Alloy Coatings Produced by Magnetron Co-sputtering**, *D. Gonzalez,* Universidade Federal de Sao Carlos, Brazil; *V. Amigo-Borras,* Universitat Politècnica de València UPV, Spain; *V. Mastelaro,* Universidade de Sao Paulo, Brazil; ***Pedro Nascente (nascente@ufscar.br)***, Universidade Federal de Sao Carlos, Brazil **INVITED**

The AISI 316L stainless steel (SS) has been widely used as implant material due to its adequate biomechanical and biocompatibility properties. Its advantages compared to other used metallic materials, such as the CoCr alloys and titanium and its alloys, are its formability, weldability, and affordability. One of its main disadvantages is the release of harmful corrosion products in the human body. This limitation can be overcome by the coating of the SS with an alloy that has a higher corrosion resistance and a better biocompatibility. Ti, Nb, and Zr are non-toxic and non-allergenic elements that exhibit excellent biocompatibilityand low cytotoxicity; in addition to these qualities, they have total solubility among themselves. We report on binary Ti-Nb and ternary Ti-Nb-Zr alloy coatings deposited on AISI 316L SS by magnetron co-sputtering. The composition, phase formation, structure, morphology, texture, film growth, and mechanical and tribological properties of the $Ti_{80}Nb_{20}$, $Ti_{75}Nb_{20}Zr_5$, $Ti_{60}Nb_{20}Zr_{20}$, $Ti_{50}Nb_{20}Zr_{30}$, and $Ti_{40}Nb_{20}Zr_{20}$ (at.%) coatings are investigated. For low Zr content, two phases are detected: Predominantly the β phase and, in a lesser degree, a nanoscale metastable ω phase. For Zr amounts equal or higher than 20 at.%, only the β phase is detected. The coating with higher Zr content presents lower elastic modulus and hardness values. The coating morphology is affected by the increasing addition of Zr, from a growth characteristic of the zone I to a growth characteristic of the zone T of the structure zone diagram (SZD). The texture also is influenced by the Zr amount, going from {111} to {101} for the direction of the film growth, due to the increase in the strain energy and the total mass of the species in the plasma. The Ti-Nb-Zr coatings exhibit high ductility and high adhesion,, which are characteristics of a high combined plastic deformation on the coating/substrate system, and no delamination is observed. These findings indicate that the Ti-Nb-Zr coatings are promising candidates for biomedical applications.

4:40pm **TS6-3-TuA-10 Bill Sproul Award and Honorary ICMCTF Lecture: Modelling Reactive Sputtering: Back to the Future**, ***Diederik Depla (Diederik.Depla@ugent.be)*** [1], *J. Van Bever, K. Strijckmans,* Ghent University, Belgium **INVITED**

When looking back on our endeavor in the field of reactive magnetron sputtering, the authors may conclude that the technique is conceptual simple. This simplicity however conceals the underlying complex relationships between the simultaneously occurring processes. Hence, experimental results are often surprising or unexpected. Modelling of reactive magnetron sputtering is therefore indispensable to unravel this complexity. This conclusion was also drawn by others in the early days when this technique was first applied. Though less complete as compared to the historical research by J. Greene, a short historical overview of modelling attempts will be presented. However, it will provide a framework to discuss some essential and common features of the models, including the Reactive Sputter Deposition (RSD) model developed by our team. For the latter model the implemented processes will be reviewed. Some important results, such as the double hysteresis behavior and the presence of non-reacted oxygen atoms will be discussed. If these results are confronted with experiments, the general trends can be explained. If it either comes to the details, it is clear that new developments will be needed in the future. In this way our endeavor in modelling is luckily not finished.

[1] **Bill Sproul Awardee**

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