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Editorial

Metallic Films: From Nanofabrication and Nanostructuration to Characterizations and Applications

Francesco Ruffino [1,2]

[1] Dipartimento di Fisica e Astronomia "Ettore Majorana", Università di Catania, 95123 Catania, Italy; francesco.ruffino@ct.infn.it; Tel.: +39-095-378-54-66

[2] CNR-IMM via S. Sofia 64, 95123 Catania, Italy

Received: 1 December 2018; Accepted: 2 December 2018; Published: 4 December 2018

1. Introduction

Metallic films are key components in many modern technologies, from integrated circuits to sensors. In particular, nanostructured metal films find applications in the production of innovative devices and coatings [1–3]. These technologies, however, require exploitation of the electronic, magnetic, optical, mechanical, and thermal properties unique to metallic materials. Thus, it is of paramount importance to control the films of nanoscale structures, as a result of the fabrication or post-fabrication processes, to tailor their properties.

When metallic films thickness decreases, the physical properties of the films change so that, in thin films, new physical properties appear, which are not present in the corresponding bulk materials. A typical example of this is metallic film resistivity, which increases drastically, decreasing film thickness. However, several other metallic films properties can be largely tuned by thickness and nanostructure control, from mechanical ones to optical ones. In addition, recently, great interest has been given to the plasmonic properties of thin nanostructured and nano-patterned metallic films, in the fabrication of high-sensitivity optical sensors (exploiting, for example, Surface-Enhanced Raman Scattering). In this sense, the development of low-cost, versatile, simple and high-throughput nanofabrication and nano-patterning approaches for metallic thin films gained a key role in the production of real devices.

2. Content and Contributions

The Special Issue "Metallic Films: From Nanofabrication and Nanostructuration to Characterizations and Applications" aimed to collect a compilation of review articles and original research papers illustrating the latest developments in nanofabrication and nano-patterning of thin metallic films; the development of new 1D, 2D, and 3D metallic nano-architectures for specific applications; the use of advanced state-of-art characterization methods for the understanding of full metallic films and nano-architectures properties; exploitation of the physico-chemical properties of nanostructured metallic films in the fabrication of devices (from electronics to sensors).

In this context, the Special Issue published a series of illustrative examples on both theoretical and experimental scientific research and results regarding fundamental aspects and inter-disciplinary applications of nanostructured metal-based complex architectures.

In particular, in the paper "Broadband Dual-Phase Plasmons through Metallization of Polymeric Heterojunctions" [4], Huang and Zhang report on the controlled production of large-area dual-phase plasmonic gold nanostructures using the phase-separation pattern of a polymer blend film. They demonstrate that large-area gold micro-grains can be controllably produced using a template of the phase-separation scheme of the F8BT:PFB polymer blends. These complex-morphology plasmonic gold nanostructures exhibited interesting plasmon resonance response covering the whole visible band and extending to the infrared. These results enable perspectives for optoelectronic devices (such as lasers) operating in the infrared.

In the paper "Evolution of Ternary AuAgPd Nanoparticles by the Control of Temperature, Thickness, and Tri-Layer" [5], Kunwar et al. report on the fabrication of ternary AuAgPd alloy nanostructures on sapphire, exploiting the solid-state dewetting of sputter-deposited tri-metallic layers. They demonstrate the wide-range tunability of the shape, size, and density of the alloy nanostructures by the control of temperature, thickness, and deposition order of tri-layers, establishing a general process parameters-nanoparticles properties crossing framework. These morphological and structural properties were, in addition, exploited by the authors to design optical systems. Their optical characterization by reflectance spectra demonstrate, in fact, a reverse relationship between the average reflectance and the surface coverage of sapphire by alloy nanoparticles, and an absorption band and peaks were formed at specific wavelengths (in the UV, NIR, and visible regions) based on the surface morphology.

In the paper "Theoretical Study of Electromagnetic Interference Shielding of 2D MXenes Films" [6], Li et al. analyze, from a theoretical point of view, the electromagnetic interference shielding properties of a series of MXene films (two-dimensional transition metal carbides, carbonitrides, and nitrides). The developed theory and calculations allowed to the authors to derive, for these systems, complete transmission/reflection expressions with the effect of multiple internal reflections included natively, and is applicable to both normal and oblique incidence of the electromagnetic wave. These results pose the basis for designing waveguide systems based on 2D MXenes films.

In the review paper "Atomistic Simulations to Predict Favored Glass-Formation Composition and Ion-Beam-Mixing of Nano-Multiple-Metal-Layers to Produce Ternary Amorphous Films" [7], Yang et al. collect theoretical and experimental results on the properties of amorphous alloys (i.e., metallic glasses). The authors, in particular, were able to construct the interatomic potentials for the Ni-Nb-Mo and Ni-Zr-Mo ternary metal systems. Starting from this potential, they also performed atomistic simulations to predict the energetically favored glass formation regions and the amorphization driving forces. They supported the theoretical predictions on real ternary amorphous films produced by ion beam mixing with nano-multiple-metal-layers. The crossing of theoretical and experimental results provide new insights, opening the pathways for innovative applications of the metallic glasses systems.

I, also, contributed to the Special Issue with the paper "Experimental Analysis on the Molten-Phase Dewetting Characteristics of AuPd Alloy Films on Topographically-Structured Substrates" [8]. This work presents a laser-based method to produce alloy AuPd nanoparticles on a transparent conductive oxide (fluorine-doped tin oxide, FTO). In particular, the AuPd alloy NPs are produced on FTO substrate by inducing the molten-state dewetting process of a deposited alloy film and the effect of the film thickness and substrate surface topography on the size and distribution of the alloy nanoparticles. The strict correlation of the nanoparticles structural properties and the process parameters is established in view of the exploitation of the AuPd nanoparticles/FTO optical properties in localized surface plasmon resonances devices.

Acknowledgments: Finally, I would like to thank all authors of this Special Issue of *Metals* for their contributions and all referees for their valuable comments, suggestions, and time, as well as the editorial office for their constant and swift support throughout.

Conflicts of Interest: The author declares no conflict of interest.

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