Special Issue “Magnetron Sputtering Deposited Thin Films and Its Applications”

Frédéric Sanchette ^{1,*} and Alain Billard ^{2,*}

¹ ICD LASMIS, LRC UTT-CEA Nicci, Univ Technol Troyes, Antenne Nogent, Pole Technol Sud Champagn, F-52800 Nogent, France

² FEMTO-ST, Université de Bourgogne-Franche Comté, Plateforme SURFACE de Montbéliard, UTBM—90010 Belfort CEDEX, France

* Correspondence: frederic.sanchette@utt.fr (F.S.); alain.billard@utbm.fr (A.B.)

Received: 30 September 2020; Accepted: 26 October 2020; Published: 7 November 2020

1. Introduction

The physical vapour deposition processes, and in particular different variants of sputtering, have reached a maturity making possible industrial applications in numerous fields such as mechanics [1–4] and protection against corrosion or thermal oxidation [5–8], as well as in the fields of optics and microelectronics [9–12] or energy [13,14].

The versatility of these processes, however, continues to open up new avenues of research: co-sputtering allows the synthesis of complex structures or multilayers from the micrometric scale to the nanometric scale [2,6,15]. The emerging high power impulse magnetron sputtering (HiPIMS) [4,12,16] technology at industrial scale leads to a strong ionization of the metal vapour which thus makes it possible to manage the average energy of the incident species which conditions the mechanical [17], optical or electronic [18] properties. The glancing angle deposition (GLAD) process [19,20] makes it possible to nanostructure the coatings according to patterns managed by the relative movement of the substrates with respect to the target.

The coatings deposited by these low temperature processes are out of thermodynamic equilibrium. These are generally supersaturated crystalline or amorphous solid solutions which may require crystallization annealing treatment to achieve the equilibrium structure. The microstructures, generally submicronic, or even nanometric, managed by the deposition conditions and in particular the energy of the incident species, lead to properties, for example mechanical or electronic conduction, often far beyond those of the corresponding bulk materials. Likewise, the combination of several carefully chosen layers allows the production of multifunctional materials for a wide range of applications that can be extended by their architecture.

This Special Issue “Magnetron Sputtering Deposited Thin Films and Its Applications” provides an update on recent advances in the development of coatings for different applications.

2. Magnetron Sputtering Deposited Thin Films and Its Applications

This Special Issue consists of a review and 10 research papers related to Magnetron Sputtering Deposited Thin Films and Its Applications.

The review “Electrochemical Corrosion of Nano-Structured Magnetron-Sputtered Coatings” discusses the corrosion resistance of composite coatings at the nanoscale, especially for biomedical applications. The electrochemical behaviour of the layers depends in particular on three main factors: the composition, the morphology and the architecture, which themselves depend on the deposition conditions which affect the properties of the substrate-coating-electrolyte triptych.

In “Bifunctional TiO₂/AlZr Thin Films on Steel Substrate Combining Corrosion Resistance and Photocatalytic Properties”, the authors combine the anticorrosive properties of an Al-4 at.% Zr sacrificial

coating deposited by sputtering and a surface layer of titanium dioxide of photocatalytic anatase structure deposited by aerosol-assisted chemical vapor deposition for anti-biofouling applications. The photocatalytic performance of titanium dioxide linked to their increased specific surface area associated with the sacrificial nature of the Al–Zr layer regarding the steel substrate make this treatment a potential candidate for anti-biofouling applications.

The research paper “Synthesis and Properties of Orthorhombic MoAlB Coatings” is interested in the properties of MoAlB refractory layers deposited by confocal co-sputtering of MoB and Al targets at 700 °C on sapphire substrates. Single-phase coatings with an orthorhombic structure, with a minority phase dispersion rich in aluminium and oxygen, exhibit an oxidation resistance at 1200 °C similar to that of corresponding bulk material and much higher than that of a competing material for high temperature applications: Ti_2AlC .

“The Structure, Morphology, and Mechanical Properties of Ta–Hf–C Coatings Deposited by Pulsed Direct Current Reactive Magnetron Sputtering” studies the synthesis of refractory carbides of Hf and Ta in view to producing ternary carbides $(\text{Ta}, \text{Hf})\text{C}_x$ by reactive co-sputtering. The hardness of the binary carbides reaches 36 and 29 GPa, respectively for TaC_x and HfC_x , which also have a nanocomposite character due to the presence of an amorphous carbon fraction. Ternary carbides $(\text{Ta}, \text{Hf})\text{C}_x$, for their part, have a nanolayer structure with a period of the order of 2 nm and a hardness close to 23 GPa regardless of the respective Ta and Hf content.

In “Effect of Tantalum Addition on Properties of Cu–Zr–Based Thin Film Metallic Glasses (TFMGs)”, the authors study the influence of tantalum content on the mechanical properties and thermal stability of Cu–Zr–Ta TFMGs with a Cu/Zr ratio = 0.56. Hardness and Young’s modulus increase from 5.8 to 11.23 GPa and from 90 to 136 GPa respectively with the Ta content up to about 30 at.% Ta. In parallel, the Ta enrichment of the layers significantly increases the thermal stability of the coatings with a crystallization temperature of less than 300 °C. for the Ta-free layers becoming greater than 500 °C as soon as the Ta content reaches 30 at.%.

In “Tribological Performance of PVD Film Systems Against Plastic Counterparts for Adhesion-Reducing Application in Injection Molds”, the authors study the tribological performance of coatings of different nitrides, alumina and DLC deposited by HiPIMS or by conventional DC sputtering against different polymers (PA, PP, PS). This study demonstrates the favourable effect of a low surface energy and in particular of its polar component, as well as a moderate micro-roughness on the tribological properties of the films vis-à-vis the polymers tested.

The paper “Texture and Stress Evolution in HfN Films Sputter-Deposited at Oblique Angles” studies the influence of the incidence of metal vapor on the structure, morphology and stress state of HfN films with a thickness of the order of 1 μm deposited on Si substrates by reactive sputtering of a Hf target in an Ar-N_2 reactive atmosphere. Dense coatings submitted to high compressive stresses when the incidence is normal see a columnar structure develop with the decrease in the angle of incidence, which results in an increase in the roughness of the films and a decrease in their compressive internal stresses and their electrical resistivity.

The paper “Effect of Thermal Stresses Formed during Air Annealing of Amorphous Lanthanum Cuprate Thin Films Deposited on Silicon Substrate” investigates the influence of internal stress, in relation with thickness and deposition pressure, and the difference in thermal expansion coefficient of film and substrate on maintaining the integrity of air annealed perovskite films. The reduction in thickness and the increase in pressure make it possible to limit, or even eliminate, the presence of holes within the lanthanum cuprate layers during annealing, attributed to the difference in the thermal expansion coefficients of the film and the substrate.

The authors of “Transparent Conductive p-Type Cuprous Oxide Films in Vis-NIR Region Prepared by Ion-Beam Assisted DC Reactive Sputtering” discuss the effect of ion beam assistance of oxide ions on the optoelectronic properties of Cu_2O coatings deposited by DC reactive sputtering. The observed favourable effect is attributed to the creation of interstitial oxygen which promotes the mobility of

charge carriers. Despite poor transmittance in the visible, optoelectronic properties show potential for application in the infrared.

The paper “Influence of Sputtering Power on the Electrical Properties of In–Sn–Zn Oxide Thin Films Deposited by High Power Impulse Magnetron Sputtering” studies the electrical properties of ITZO films deposited by HiPIMS as a function of the power dissipated on the targets. Along with increasing the deposition rate, increasing the power significantly reduces the electrical resistivity of films down to about $2 \times 10^{-4} \Omega\text{m}$ by the increasing flux of energetic ionized species. The films also exhibit a lower roughness than that of films deposited by conventional sputtering, which is attributed to the strong ionization of the incident species.

The objective of “Pt–Ti Alloy Coatings Deposited by DC Magnetron Sputtering: A Potential Current Collector at High Temperature” aims to attenuate of the Ostwald ripening phenomenon which destroys the in plane electrical conductivity of submicron-thick platinum electrodes, by their titanium enrichment. It is thus shown that films 100 nm thick with Pt₃Ti formulation retain their integrity up to temperatures of 1000 °C.

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