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Editorial

Advances of Nanoparticles and Thin Films

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Nanoparticles and thin films are currently among the most active research fields in materials sciences for technological applications. "Nanotechnology", a concept first introduced in 1959 by Nobel laureate, Richard P. Feynman in his visionary lecture entitled "There's Plenty of Room at the Bottom" [1], is an essential pillar in technological development resulting in nanometers scale systems (nanoparticles and quantum systems, nanostructures and heterostructures, thin films and 2D materials, etc.). The interest in nanoscale systems arises not only from the purpose of miniaturization, but also from the fact that new properties are emerging at this length scale and that these properties change with their size, surface-to-volume ratio, and shape. The understanding and control of nanoscale properties has enabled scientists and engineers to design, theoretically model, produce, and characterize materials and advanced functional and multifunctional devices with current relevance. They will continue to contribute to many applications and an enormous body of research (e.g., information technology, electronics, spintronics, displays, memory units, sensors, biosensors, actuators, active surfaces with different characteristics, catalysis, energy harvesting, energy storage, environmental and safety concerns, healthcare, bioengineering, medicine, the drug industry, etc.) [2–5]. The development of these systems of organic or inorganic nanomaterials also induced the advancement of the technical equipment and methodologies for their production and characterization, even down to the atomic and single molecular scale, using, for example, tools such as Scanning Tunneling Microscopy [6,7]. The nanofabrication methods are classified in top-down and bottom-up approaches, which are based on physical and chemical and on dry and wet processes. The top-down methods are scaling-down techniques that imply the division of the bulk material into nanoscale structures following the physical routes, or lithography (including the standard: photolithography, phase-shift optical lithography, X-ray lithography, electron-beam lithography, focused-ion-beam lithography, and neutral-atomic-beam lithography, and softer ways: microcontact printing, nanoimprint, molding, and dip-pen lithography [8]) and chemical routes (including procedures such as: templated etching, selective dealloying, anisotropic dissolution, and thermal decomposition [9]). The bottom-up methods are scaling-up techniques that are based on self-assembly. They rely on the assemblage of atomic or molecular building-block units into larger structures, such as systems of nanowires [10,11] or 2D organic structures [12–14] driven by physical and chemical forces. All of these procedures involve physical deposition techniques (including physical vapor deposition techniques (PVD) such as vacuum thermal deposition, electron-beam deposition, laser-beam deposition, arc evaporation, molecular beam epitaxy, organic molecular beam epitaxy, ion plating evaporation, and sputtering methods) and chemical deposition techniques (including the sol-gel technique; chemical bath deposition, such as deep coating, spin-coating, and Langmuir–Blodgett deposition; the spray pyrolysis technique; plating, such as electroplating and electroless deposition; and chemical vapor deposition (CVD), including low-pressure CVD and plasma-enhanced CVD) [15].

The consistency of nanoparticle research is derived from the attempt to tailor new materials with desired properties via scrupulous consideration related to electronic phenomena induced by multiple valence ions, their location in the peculiar structure, the use of cutting-edge preparation procedures, and the ability to discern all appearing effects via a directional selection of the complementary investigation methods. It is known that synthesis methods are vital to the design of nanoparticles. The most used techniques for this type of material are chemical methods [2]. A disadvantage of these methods is the use of precursors that are most often toxic, thereby limiting the scope of the application of the material. Since many nanoparticles are used in medicine and/or the cosmetic industry, new synthesis methods (the so-called green chemistry) have been developed that use safe and environmentally friendly nontoxic reagents [16,17]. A modern trend in the design of nanomaterials, especially magnetic nanomaterials, is the formation of hybrid structures of nanoparticle–polymer types that allow the functionalization and control of properties through the structure and composition of the polymer [18]. Nanoparticle biosynthesis is an ecological, green, and non-toxic method of processing that involves microorganisms. It is particularly used in the synthesis of iron oxide, silver, nickel oxide, copper oxide nanomaterials, etc. [19–21]. The significant progress in recent years is linked on the one hand to the development and refinement of nanoparticle synthesis methods, and on the other hand, to the development of more complex characterization techniques and specific and efficient analysis methodologies. The experimental development coupled with the development of theoretical models allowed the elucidation of unexpected mechanisms and the proposal of new solutions that would lead to materials with high-performance properties in relation to the various applications. Finally, optimization and reproducibility are two fundamental concepts for the consistency of new phenomena and/or mechanisms.

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