Abstract

Fundamental research on novel nanostructured materials and their properties is essential for the next generation of highly efficient and inexpensive miniaturized devices. The unique dependence of dimensionality on the physico-chemical properties of the nanomaterials as well as the new phenomena exhibited at their interface has pushed efforts towards the controllable and reproducible fabrication of nanostructures with defined composition and structure. There is still no agreement concerning the optimal geometry, the combination of materials or the synthetic method that provides the best performance for a specific application. Therefore, the development of methods that allow large-scale synthesis and organization of nanostructures (self-assembly) into integrated arrangements is crucial to transfer them from fundamental research in laboratories to industry production.

Bottom-up approaches such as the VLS mechanism for growing nanowires offer a high degree of control over the composition, size, morphology, and growth location of the nanobuilding blocks. The M2M strategy ("molecules to materials") allows to design and fabricate materials, whose properties can be tailored *a priori* at a molecular scale. In this work, we show the potential of gas phase techniques (such as CVD, PECVD and ALD) for the design of highly pure 1D metal oxide nanomaterials with a high degree of control over structure and composition, and their direct integration in device applications. One-dimensional metal oxide nanostructures were carefully designed following considerations of crystal and band engineering, and tested towards their performance in different applications.

For this purpose, influence of the CVD parameters on the synthesis of V_2O_5, Nb_2O_5, and Ta_2O_5 nanostructures was investigated followed by the potential applications of nanostructured Nb_2O_5 thin films. Subsequently, SnO_2 nanowires were grown on various substrates and used as backbones to design novel heterostructures, with a high degree of control over their composition and morphology. In this context, SnO_2@SnO_2, Sn@SnO_2, C@SnO_2, and Fe_3O_4@SnO_2 heterostructures were studied in lithium ion battery applications, and Nb_2O_5@SnO_2 were used as humidity sensors. Further, the influence of SnO_2 on the magnetic properties of Fe_3O_4 in Fe_3O_4@SnO_2 core-shell architectures was examined. Similarly, the photodiode behavior of (α-Fe_2O_3@ZnO)/p-Si heterostructures, as well as the photocatalytic properties of $TiVO_x$@SnO_2 and $TiNbO_x$@SnO_2 layered heterostructures were analyzed to elaborate the role of interfacial properties on chemical potential, electronic barriers and modulation of junction characteristics.

The results obtained demonstrate that besides the size (confinement) and surface effects, the functional properties are greatly enhanced by phase-boundaries, which can exist between the substrate and the growing material or between two phases (*e.g.* core-shell or bi-layer structures). Whereas new concepts of material design offer opportunities to suppress or promote specific chemical interactions, the challenge associated with reproducible material synthesis, and integration into devices need further attention.