Understanding the growth mechanisms of complex semiconducting oxide nanostructures by electron microscopy

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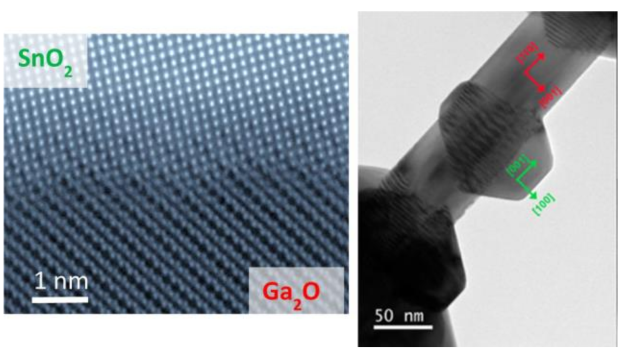
Oxide semiconductors are an exciting materials family with potential applications in a vast field of areas. In particular, the development of nanomaterials based on oxides has recently attracted attention in energy applications as sustainable materials to be used in energy related devices. The peculiar chemical and structural features of oxides results in the straightforward synthesis of not only single nanowires but also more complex nanomaterials, such as hierarchical structures or nano-heterostructures. The issue we must address is to get an effective control of the growth processes in order to design reproducible nanomaterials of practical interest in future devices. In this work, we use a thermal evaporation method to produce a high amount of complex oxide nanostructures. We have used electron microscopy characterization of the obtained nanomaterials with the aim of understanding their growth mechanisms and reaching the goal of having a synthesis route for pretty reproducible nano-architectures.

The characterized nanostructures are based on gallium oxide nanowires and several morphologies of tin oxide nanomaterial. Gallium oxide is an emergent semiconductor of interest in deep ultraviolet applications, due to its ultra-wide band gap (4.9 eV), and in high power electronics because of its high breakdown voltage (8 MV/cm). On the other hand, tin oxide has been widely used in transparent electronics and sensing applications. By a suitable combination of metallic gallium and tin oxide precursors, we have grown complex architectures formed by a central gallium oxide nanowire that can be decorated in several ways with tin oxide nanomaterial, namely, crossing SnO_2 wires, SnO_2 nanoparticles or SnO_2 ultrathin sheets [1,2]. In addition, Ga_2O_3/SnO_2 core-shell nanowires have also been formed under certain conditions. We have used high-resolution TEM, STEM and EDS mappings to assess the structural properties. Our results conclude that surface properties and impurities are key factors to achieve this kind of shape-engineering in the Ga_2O_3/SnO_2 system. Besides, we propose that these architectures could be extended to other materials in the oxide semiconducting family.



Left: ADF-STEM cross-section image from the Ga_2O_3/SnO_2 junction. Right: TEM image of a Ga_2O_3 nanowire decorated with SnO_2 particles.

References

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[2] M. Alonso-Orts, A.M. Sanchez, I. Lopez, E. Nogales, J. Piqueras, B. Mendez CrystEngComm, 2017, 19, 6127.

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