Abs. 209, 206th Meeting, © 2004 The Electrochemical Society, Inc.

On the electronic structure of advanced metal oxide nanostructures

Lionel Vayssieres
Nanomaterials and Biomaterials Research Laboratory,
International Center for Young Scientists, National Institute for Materials Science, Tsukuba, Ibaraki, 305-0044 Japan

The hierarchical design of well-defined and highly oriented three-dimensional arrays of conventional 1-D semiconductor nanomaterials and their large scale manufacturing at low cost remains a crucial challenge to unfold the very promising future of nanodevices. In addition to economical manufacturing of nanomaterials, better fundamental knowledge of their electronic structure, physical, interfacial and structural properties, as well as their stability are required to fully exploit their fascinating physical and chemical potentials. To combine such essential requirements, the creation of structurally well-defined and well-ordered materials is essential. As an attempt to achieve such ambitious goals, a novel approach to nanomaterials processing has been developed.

A thermodynamical growth concept, based on the chemical and electrostatic lowering of surface energy and the resulting thin film processing technique are presented. Such strategy allows the generation, at large scale and low cost, of novel electrode materials. Advanced metal oxide nanostructures consisting of oriented multidimensional arrays featuring building-blocks of controlled morphologies, sizes, aspect ratios and orientations are genuinely fabricated without template, surfactant, undercoating nor applied field directly onto various substrates of large physical areas from the hydrolysis-condensation and heteronucleation of aqueous metal salts solutions at mild temperatures[1].

In-depth investigations of their electronic structure performed at synchrotron radiation facilities by x-ray absorption and emission spectroscopies, including polarization dependent[2] experiments and resonant inelastic xray scattering revealed important insight of direct relevance for semiconductor electrode materials for photoelectrochemical applications. For instance, quantum confinement effects in αFe_2O_3 oriented nanorod array (bottom of figure 1) grown on transparent conducting substrate (TCO) as well as the determination of orbital symmetry and orbital character of ZnO oriented nanorod-arrays and TiO_2 nanostructured thin films with controlled spherical size over two orders of magnitude in the nanoscale range will be presented. Finally, innovative advanced anisotropic semiconductor nanostructures have been developed very recently[3] and will be presented and their characteristics demonstrated (top of figure 1).

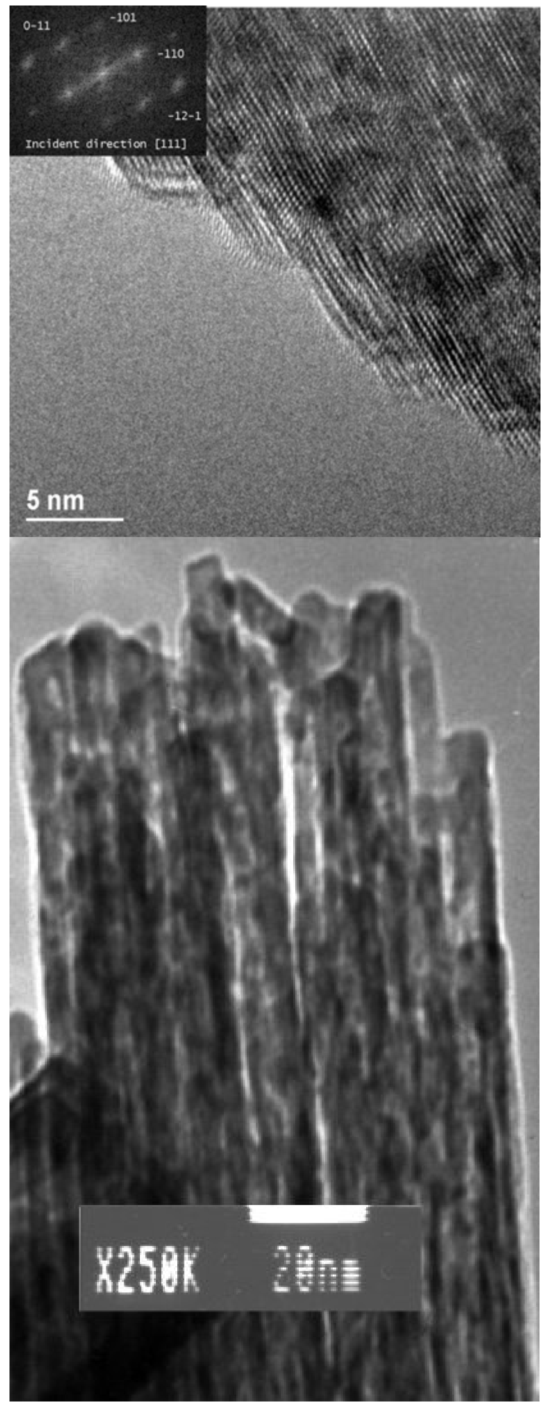

Fig. 1) Transmission electron microscope (TEM) images of crystalline 1-D metal oxide nanostructures; (top) nanorod bundles of *cassiterite* (rutile SnO_2); (bottom) nanorod bundles of *hematite* (αFe_2O_3).

References

1. L. Vayssieres *Int. J. Nanotechnology*. **2004**; 1(1-2), 1-41; *Adv. Mater*. **2003**; *Nanolett.* **2002**, *2(12)*; *Chem. Mater*. **2001**, *13(12)*, 4395-4398; *Chem. Mater*. **2001**, *13(2)*, 233-235; *J. Nanosci. Nanotech.* **2001**, *1(4),* 385-388; *Pure Appl. Chem.* **2000**, *72(1-2)*, 47-52; *J. Colloid Interface Sci.* **1998**, *205(2)*, 205-212.
2. J.-H. Guo et al, *J. Phys.: Condens. Matter* **2002**, *14(28),* 6969-6974.
3. L. Vayssieres and M. Graetzel, *Angew. Chem. Int. Ed.* **2004** in press.