Metal oxides 3-D arrays by aqueous chemical growth

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A novel concept based on a general thermodynamic model of nucleation and growth monitoring by chemical and electrostatic control of the water-oxide interfacial tension and an aqueous thin film processing technique has been developed to fabricate very large 3-D arrays of crystalline metal oxides onto various substrates at mild temperatures[1]. The goal is to design at low-cost a new generation of functional *purpose-built* metal oxide materials at nano-, meso- and micro-scale with controlled particle size, morphology and orientation (fig.1). Such well-designed materials should lead to a better fundamental understanding of their electronic structure[2] and physical/chemical properties as well as to develop novel and optimized devices[3].

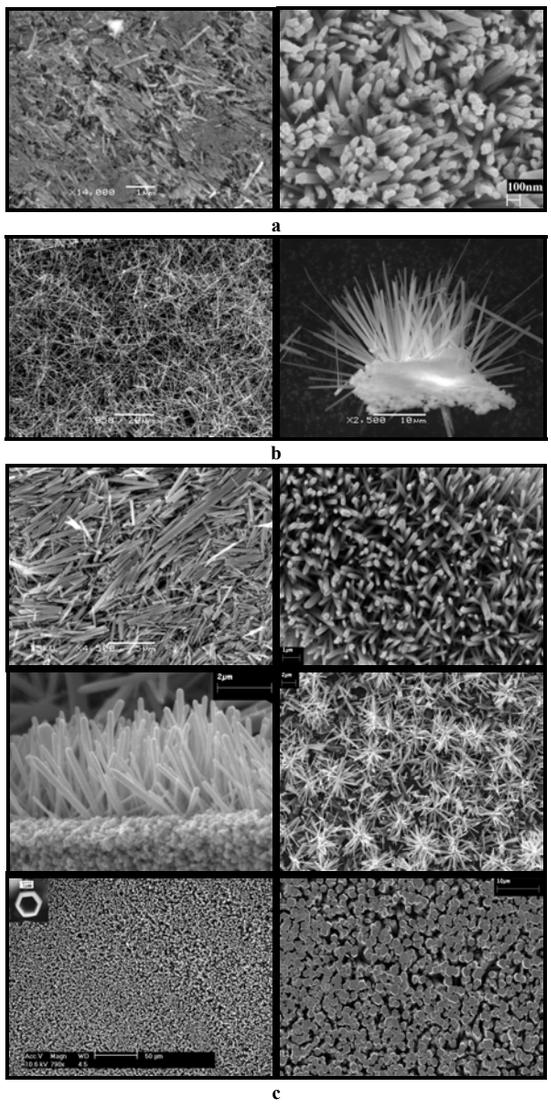

Fig. 1) SEM micrographs of 3-D arrays of some transition metal oxides (α-Fe_2O_3 (a); γ-MnOOH (b); ZnO (c)) consisting of anisotropic crystallites grown by aqueous chemical growth onto various substrates.

Patterning, assembly and integration of 1-D nanomaterials as functional 3-D network is an important challenge scientists have to face to develop future practical nanodevices. Non-lithographic fabrication of large patterned 3-D arrays at low-cost is achievable with the aqueous chemical growth technique and figure 2 shows various examples of such ability on crystalline ZnO nanomaterials. Well-defined stars and stripes of ZnO nanorods of various patterns are obtained by chemical and/or physical activation of the silicon wafer substrates. Further investigations are currently under scrutiny.

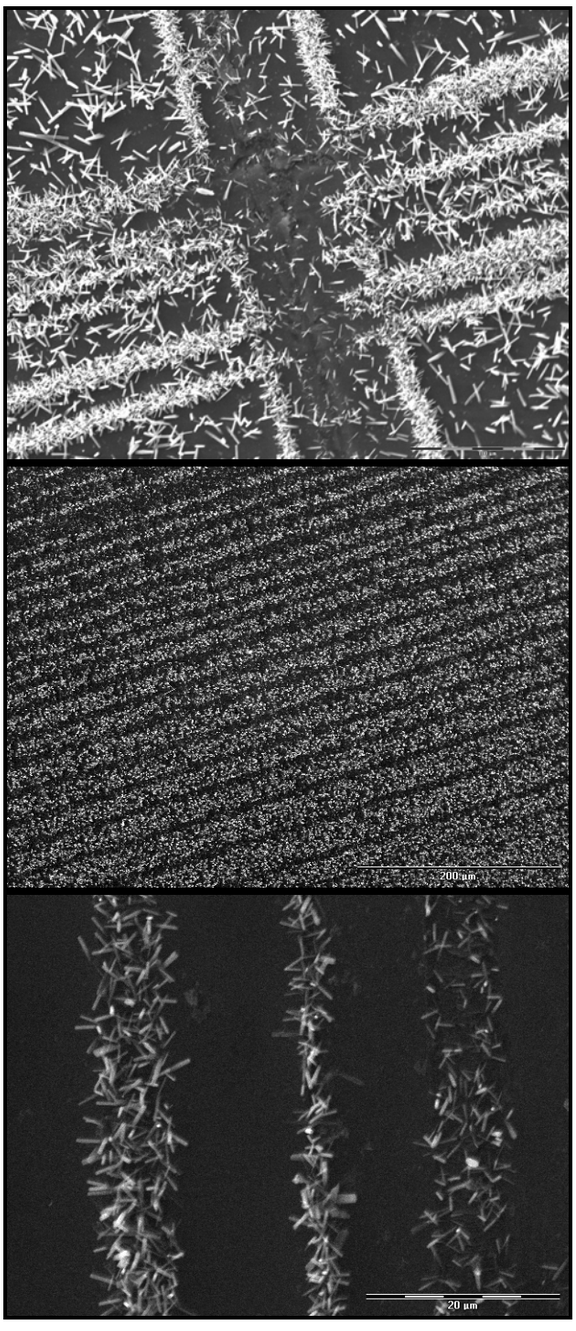

Fig. 2) SEM micrographs of patterned 3-D arrays of crystalline ZnO on Si/SiO_2 wafer substrate by aqueous chemical growth.

References

1. L. Vayssieres et al**,** *Int. J. Nanotechnol*. **2003**; *Nanolett.* **2002**, *2(12)*; *Adv. Mater*. **2002**; *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. T. Lindgren et al, *Sol. Energy Mater. Sol. Cells* **2002**, *71(2)*, 231-243; K. Keis et al, *J. Electrochem. Soc*. **2001**, *148(2),* A149-155*;* N. Beermann et al, *J. Electrochem. Soc*. **2000**, *147(7),* 2456-2461.