Functional Materials

MS.3.P074
Characterization of ZnO nanowire arrays obtained using a template assisted approach.

K. Bejtka[1], A. Chiodoni[1], M. Fontana[1], C. Ottone[1], V. Farías[1], V. Cauda[1], C.F. Pirri[1,2]

[1]Italian Institute of Technology, Center for Space Human Robotics, Torino, Italy
[2]Politecnico di Torino, Department of Applied Science and Technology, Torino, Italy

katarzyna.bejtka@iit.it
Keywords: metal oxide, ZnO, nanowire, nanowire arrays, template assisted growth, electron microscopy

Semiconductor oxides have attracted much attention as they possess a range of interesting properties, making them suitable for a variety of applications, including piezoelectric field-effect transistors and diodes, self-powered nano-generators and nano-sensors [1].

ZnO is considered a very important semiconductor because of its wide bandgap, good optical, electrical and piezoelectric properties [2]. This material can be grown in a reproducible way with a variety of nanostructures, e.g. nanowires (NWs), nanorings, nanobows and other forms. This variety provides a range of peculiar properties that are unique for many applications in nanotechnology [3].

Recently, ZnO nanowires have been synthesized using porous templates (e.g. anodic alumina or polycarbonate) with different methods, such as electrodeposition [4], sol-gel [5] and electrophoresis [6]. The use of templates in combination of these methods results in the growth of nanowires with diameter above 50 nm. The wire diameter can be further controlled by combining two templates, e.g. anodic alumina with mesoporous silica (4-12 nm in diameter).

In this study we report on the characteristics of ZnO nanowires synthesised by combining the use of the template approaches described above with a low temperature aqueous chemical growth method [7]. The growth mechanism of nanowires will be discussed and the Field Emission Scanning Electron Microscopy (FESEM) and Transmission Electron Microscopy (TEM) characterization will be shown.

The first type of structures uses commercial and self-anodized alumina membranes with pore diameter 200-300 nm and 50 nm, respectively. FESEM images reveal the complete filling of the template channels and an enlargement of their diameter, producing NWs with larger diameter than the respective template. The X-ray spectrum reveals that the structure corresponds to ZnO and crystalline alumina. The TEM images of a single NW show that the external side of the NW is amorphous. The template can be removed by chemical etching with sodium hydroxide, whilst the NWs maintain the template shape. However, the etching attacks the nanostructured material surface, generating a granular surface, as inferred from the SEM micrograph in figure 1.

The second group of structures, which uses flexible polycarbonate membrane (150-200 nm pore size) shows inert behavior during the synthesis, yielding to a wurtzite crystalline ZnO NWs, as evident by both X-ray and electron diffraction pattern at TEM.

In the third group of structures the wire diameter was reduced by use of double templating of self-anodized alumina membranes with mesoporous silica. Figure 2 shows TEM characterisation revealing that small crystals are formed in the pores of the mesoporous silica. The size of these nanocrystalline structures is below 5 nm.

This study demonstrates that the template-assisted method allows the filling of a variety of porous matrices with ZnO when inert templates take part. In contact with the alumina surface the precursor solution reacts with the template and a mixture of crystalline Al_2O_3 and ZnO fills the amorphous alumina channels. The interface between the two oxides phases is at present not well understood.

1. M. Choi, D. Choi, M-J. Jin, I.S. Kim, S-Y. Kim, J-Y. Choi J-Y, et al. Adv. Mater. 21 (2009), p. 2185.
2. C. H. Liu, W. C. Yiu, F. C. K. Au, J. X. Ding, C. S. Lee, and S. T. Lee, Appl. Phys. Lett. 83 (2003), p. 3168.
3. R. Mohammed, J. Song , O. Nur , Z.L. Wang, and M. Willanderet, Adv. Funct. Mater. XX (2010), p. 1.
4. M. J. Zheng, L.D. Zhang, G.H. Li, W.Z. Shen, Chemical Physics Letters 363 (2002), p. 123.
5. G. S. Wu, T. Xie, X.Y. Yuan, Y. Li, L. Yang, Y.H. Xiao and L.D.Zhang, Solid State Comm. 134 (2005), p. 485.
6. Y. C. Wang, I.C. Leu, M.H. Hon, J. of Appl. Phys. 95 (2004), p. 1444.
7. X. Hu, Y. Masuda, T. Ohji, K. Katoet, Thin Solid Films 518 (2009), p. 906.

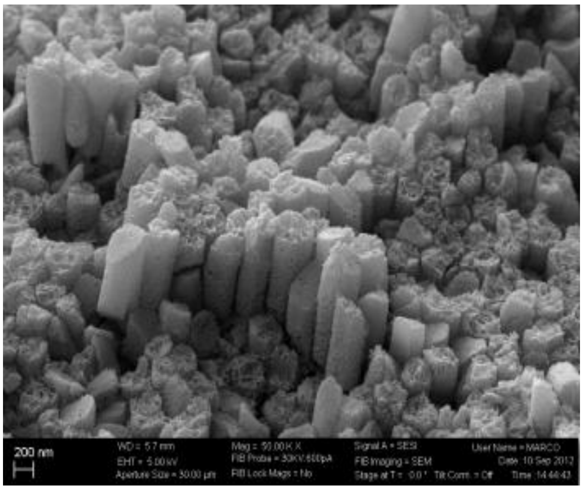

Figure 1. SEM image showing the morphology of the ZnO-Al_2O_3 NWs after template etching.

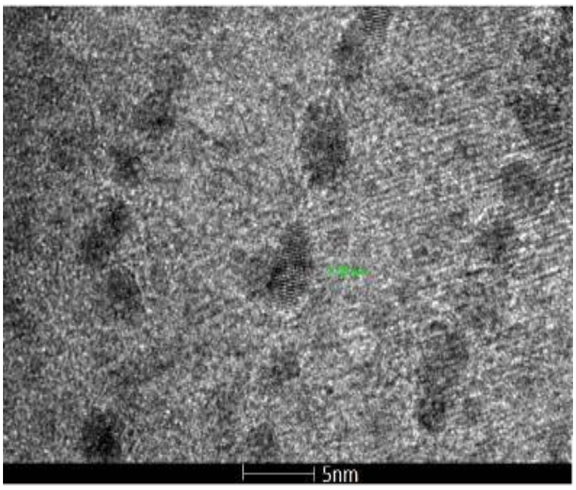

Figure 2. TEM micrograph showing the cross sectional view of vertically oriented ZnO nanowire array.