$BaTiO_3$ Nanorods: New Insight by Raman Spectroscopy

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In our work we report on the synthesis of $BaTiO_3$ nanorods by sol-gel electrophoretic deposition into template membranes. As a template we used track-etched hydrophilic polycarbonate (PC) membranes with pore diameters of 200 nm and thickness of 10-25 μm. The template membrane was attached to aluminum working electrode while Pt mesh electrode was used as a counter electrode. For electrophoretic deposition of the sol into porous templates the potential of 30 V was applied between both electrodes for 30 min. After the deposition, the samples were annealed at elevated temperatures. This heating procedure was done in order to burn off the polycarbonate membrane and to make the nanorods dense and crystalline.

Obtained nanorods were characterized by Raman spectroscopy (RS) and X-ray powder diffraction (XRD), while their sizes and the morphology were observed by scanning and transmission electron microscopy (SEM, TEM). RS experiments were made using micro-Raman with 50x LWD objective and 1 mW or 10 mW laser powers at the surface of the sample.

XRD analysis (Fig. 1) indicated that nanorods consist of cubic (space group *m*-3*m*) $BaTiO_3$. However, in case of tetragonal *4mm* symmetry with *c*/*a* axis ratio close to one, it is tedious to distinguish between cubic and tetragonal structure by XRD [1]. This is why we applied RS in order to study tetragonal structure in $BaTiO_3$ nanorods [1]. Raman spectra from the $BaTiO_3$ nanorods recorded using 1 mW showed bands of tetragonal structure in samples annealed at 700 and 800 °C (Fig. 2). Additionally in the sample annealed at 700 °C the band corresponding to hexagonal structure was also observed (Fig. 2). Since the laser-induced thermal effects within the samples can induce structural phase transitions in it, the influence of the laser power to the observed structures was also studied. By increasing the laser power in the sample annealed at 800 °C to 10 mW, the phase transition to hexagonal structure was observed (Fig.2).

Based on RS results it was concluded, that $BaTiO_3$ nanorods exhibit tetragonal structure, contrary to the XRD results.

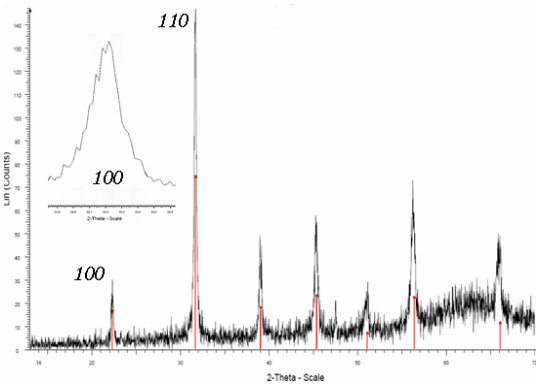

Fig. 1: XRD pattern of the $BaTiO_3$ nanorods.

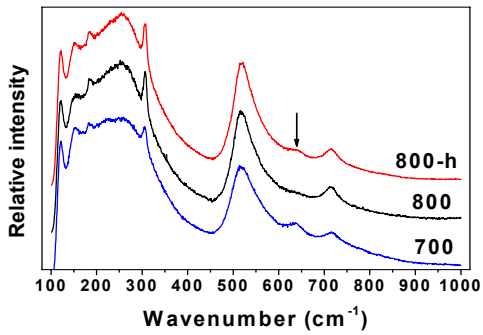

Fig. 2: Raman scattering spectra of BaTiO3 nanorods.

[1] W. Satoshi et.al., Jpn. J. Appl. Phys. 42 (2003) 6188-6195.