BaTiO$_3$ (BTO), is a well-known and widely investigated dielectric material. It is mainly used in capacitors due to its high dielectric constant. The dielectric properties of BTO are controlled by purity and microstructure which are dependent on the methods of preparation. Recent advances in nanotechnology such as MLCC, MEMS, DRAM have resulted in miniaturization of devices [1, 2].

In this work barium titanate nanostructures were synthesized by hydrothermal processing of titanium based precursor in aqueous solution of BaCl$_2$ and NaOH. Several titanium based precursors were used: TiO$_2$ nanopowder, titanate nanotubes (H$_2$Ti$_3$O$_7$), and TiO$_2$ nanotubes array prepared by anodisation of titanium foils. Structural and compositional properties were investigated by XRD, SEM, EDX, TEM, HRTEM, SAED and Raman spectroscopy (ex–situ and in-situ), while electric measurements were studied by impendence spectroscopy.

In the case of synthesis from TiO$_2$ nanopowder precursors, obtained BaTiO$_3$ nanoparticles were found to be about 50 nm in size (Fig. 1a and 1b), while in the case of H$_2$Ti$_3$O$_7$ nanotubes precursor the average size of the particles are somewhat larger. In both cases TiNT, homogenous particles in tetragonal phase were formed. In the case of hydrothermal treatment of TiO$_2$ nanotubes array precursor (Fig. 2a), BaTiO$_3$/TiO$_2$ composites were obtained, where BTO formed the film at the TiO$_2$ nanotubes array (Fig. 2b).

Tetragonal phase of BTO, having 4mm symmetry with c/a axis ratio close to one, is hard or impossible to distinguish from cubic phase by using standard diffraction techniques, so the phase purity and the structure were studied by Raman spectroscopy (RS) as a main technique [3]. In situ low and high temperature RS was used for study of ferroelectric phase transitions from tetragonal to cubic phase. TEM and HRTEM techniques were used to study structure and morphology of all prepared samples. The surface electrical conductivity (Fig. 3a and 3b) and dielectric constant will be discussed in the relation to RS measurements.

References:
Fig. 1: Hydrothermally prepared BTO nanoparticles from TiO₂; a) TEM image, b) HRTEM and SAED image

Fig. 2: SEM images of a) TiO₂ nanotube arrays prepared by anodization of Ti foil, b) Hydrothermally prepared BTO/TiO₂ nanocomposites from TiO₂ arrays

Fig. 3: Impedance spectroscopy measurements; a) Schematic view of experiment setup, b) Conductivity measurements dependence of temperature