Dielectric and Piezoelectric Properties of the Lead-Based Perovskite Ceramics

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In the work, the effects of preparation routes and heat treatment on dielectric and piezoelectric properties of ceramics in the vicinity of morphotropic boundary (MB) in the system $Pb(Mg_{1/3}Nb_{2/3})O_3$ - $PbTiO_3$ - $Pb(Mg_{1/2}W_{1/2})O_3$ (PMN-PT-PMW) were studied.

Ceramic samples were prepared by the solid state reaction method and by the "columbite" method followed by hot pressing. Pure perovskite phase compositions were obtained using highly disperse magnesium oxide precursor. Phase content and structure parameters of the specimens were controlled by means of X-ray diffraction and electron microscopy methods. The optical second harmonic generation (SHG) and dielectric spectroscopy were used to study diffuse phase transitions in the PMN-PT-PMW ceramics. Piezoelectric properties of the poled samples were measured by the resonance-antiresonance method.

It was shown that the ordered PMW additives strongly influence structure, dielectric and piezoelectric properties of the rhombohedral and tetragonal compositions near MB in the PMN-PT system. For the tetragonal samples, the Curie temperature's values were found to decrease, but the unit cell volumes, dielectric permittivity peak values and piezoelectric coefficients to increase with the PMW content increasing.

Diffuse phase transitions were quantitatively analysed using fitting of the dielectric permittivity versus temperature curves by the power distribution functions. Additional information on the diffusiness of phase transitions was obtained by establishing of a quantitative relation between the SHG intensities and volume share of a substance in the polar state. This approach let us to obtain explicit data on temperature intervals of the phase transition diffusiness as well as the spontaneous polarization correlation lengths in the vicinity of these transitions. Agreement between the parameters obtained in frames of two different approaches is discussed for a variety of compositions in terms of structure and microstructure parameters, and also lead vacancies amount.

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Integrated Bioanalysis Using Nanoparticles and Ferroelectric MEMS

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Miniaturized bioanalytical instruments [1] show enormous potential for health care diagnostics and the discovery of biomarkers associated with disease. In addition to potential low cost and portability, these instruments may show tremendous advantages in performing multiplexed bioanalysis, that is, acquiring multiple sets of biochemical information from a single starting sample.

This paper describes several opportunity areas for ferroelectric materials and devices in bioanalytical systems and microinstruments. These include 1) piezoelectric devices for the manipulation of fluids (reagents and sample); 2) acoustic focusing devices for the collection, concentration, and movement of nanoparticles; 3) ultrasonic injectors for the electrospray introduction of liquid samples in a mass spectrometer; and 4) mass sensitive piezoelectric biosensors.

Each of the above ferroelectric device components represents key enabling technologies for integrated bioanalysis systems. In addition, two other technologies are being integrated with the above ferroelectric devices: microfluidic processors [2] based on polymeric lab-on-a chip MEMS concepts and nanoparticles [3] with specific attached biochemistries relevant to biomarker discovery. While a complete bioanalytical instrument has not been implemented at this time, this paper will primarily focus on the design requirements and characterization of ferroelectric components described above and their systems introduction into bioanalysis platforms based on microfluidic chips and encoded nanoparticles. Two platforms will be described: miniaturized mass spectrometer and nanoparticle-based multiplexed biomarker discovery system.

References

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