Effect of Iron and Nickel Substitution on the Piezoelectric Properties of PZT Type Ceramics

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Abstract

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The effect of Fe and Ni doping on piezoelectric properties of a soft type piezoelectric material was investigated. The materials composition was as follows: Pb0.95Bi0.03Nb0.02Zr0.51Ti0.49-xMxO3, where M stands for the transitional metals Fe or Ni and x=0; 0.02; 0.04; 0.06; 0.08; 0.10. The material were prepared by conventional ceramic technique, using high purity oxides, mixed in planetary ball mill for 3 hours and double calcined at 850 oC and 900 oC for 2 hours with an intermediate milling of 4 hours and a final milling of 48 hours in order to get a final powder with crystallites in the nanometric range. X ray diffractograms showed that compounds were completely formed and they are situated in the nanometric range with an average crystallite size of about 95 nm. The pressed and sintered samples of these materials showed maximum densification of about 98 % of TD at an optimum sintering temperature of 1200 oC for both types of materials. The optimum amount of doping for both types of transitional elements was situated somewhere around x=0.06 with better results for nickel doped samples. Thus the maximum density for 0.06 nickel doped material was 7.88 g/cm3 while for iron doped one only 7.80 g/cm3. The piezoelectric properties followed consequently the same trend. Thus the electromechanical coupling factor kp for 0.06 nickel doped samples was 0.665 while for the correspondingly iron doped ones it was 0.658. The relative dielectric constant was about 4500 for nickel doped samples and 3400 respectively for iron doped ones. The corresponding values for the charge constant d33 were 620 pm/V and 525 pm/V respectively. These results were discussed in terms of the positions occupied by Ni and Fe into the lattice, the type of vacancies created by this and the shift of the morphotropic phase boundary. These materials seems to be very good candidates for piezoactive elements for piezoelectric micromotors