Domain Investigation in Lead-free $Bi_{0.5}Na_{0.5}TiO_3$-$x$$BaTiO_3$ Ceramics by Piezoresponse Force Microscope

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Lead-free piezoelectric $Bi_{0.5}Na_{0.5}TiO_3$ (BNT) based material has attracted great interest as a promising alternate to Pb-based marerial because of its excellent properties, while the micro-scale domain distribution has not been understood clearly. A powerful tool for studying domain of piezoelectric materials in micro-scale, piezoresponse force microscope (PFM), has been used to study the domain characteristics in BNT based [BNT-xBT ($BaTiO_3$) solid solutions] ceramics in this work. The domain structures of BNT-x%BT (x=0, 2, 4, 6, 8) ceramics have been investigated in detail by PFM. Varied domain structures are observed in BNT-x%BT ceramics both before and after poling. Before poling, no clearly domain could be observed by PFM in pure relax BNT ceramic, while, clearly micro- and nano- domains are observed in BNT-xBT solid solutions (x from 0.04 to 0.08). Domain size of about 300~500 nm in BNT-6%BT (at the MPB) ceramic is much smaller than that in BNT-4%BT (left side of the MPB) and BNT-8%BT (right side of the MPB) ceramics. After poling, nanodomains are observed in pure BNT ceramic, and domain size increases with BT content in BNT-xBT solid solutions (x from 0.02 to 0.08). XRD and Raman measurements indicate the structure evolution in BNT-xBT solid solutions. Raman spectrums of BNT-6%BT ceramic change very little among the different domain regions while varied greatly after poling. Increasing the temperature up to depolarization temperature, initial domains in BNT-6%BT ceramic maintain the same, however, writing domains fade away. This work may improve the understanding on the high piezoresponse and depolarization temperature in BNT-6%BT (MPB) ceramics.