Recent Advances on BNT-Based Piezoelectric Materials

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Environmental and safety concerns with respect to the utilization, recycling, and disposal of Pb-based piezoelectric materials have induced a new surge in developing lead-free piezoelectric materials. Bismuth sodium titanate-based $(Bi_{1/2}Na_{1/2})TiO_3$ (BNT) piezoelectric ceramics is among the most promising candidates with moderate piezoelectric properties for multilayer actuators (MLA), and piezoelectric transformers and transducers for High Intensity Focused Ultrasound applications. This talk focuses on three-four areas of research in BNT-based piezoelectric ceramic:

i. Development of a hard piezoelectric composition by either Mn doping in B side or by establishing non-stoichiometry composition in the Bi, ii. Study of co-firing with copper metal electrodes at low temperature and in a controlled oxygen atmosphere, iii. Establishing a processing property relationship to optimize electromechanical properties, and iv. To fabricate single element transducer for therapeutic applications.
We have successfully established BNT-BKT-BLT/BT compositions with low dielectric loss and quality factor of 1200 with higher performance than Pb-based piezoceramic for piezoelectric transformer applications. Compatibility of Bi-based ceramics and copper electrodes was demonstrated by co-firing at 900ºC in a controlled atmosphere with an oxygen partial pressure of 6.1x10-8 atm. A combination of additives for low-temperature sintering was used for firing at 900ºC in the air or controlled atmosphere with minimal effect on the piezoelectric properties compared to high-temperature sintering. Finally, we have designed and fabricated plain circular HIFU transducers with various center frequencies using Mn-doped BNKLT88 piezoelectric as the active element. The unfocused 5 MHz transducers showed linear behavior up to 140 V where a maximum peak-to-peak acoustic pressure of 6.5 MPa was achieved.

In summary, we have demonstrated that BNT-based piezoelectrics can be regarded as promising alternatives for lead-based materials for high power applications.