Fabrication and Acoustic Characterization of BNT-Based Ultrasonic Therapeutic Transducer

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It has been shown earlier that $0.88[Bi_{0.5}Na_{0.5}TiO_3]$-$0.08[Bi_{0.5}K_{0.5}TiO_3]$-$0.04[Bi_{0.5}Li_{0.5}TiO_3]$ ceramics doped with 1.5 mol.% Mn (abbreviated to BNKLT88-1.5Mn) has excellent high power performance. High mechanical quality factor (Q_m= 970) accompanied with high coercive field (E_c=52 kV/cm) contributed to the heightened high power performance. Mn doping effectively suppressed the heat dissipation, reduced the input power and remarkably increased the vibration velocity under high drive condition. Mn-doped BNT-based piezoelectrics with maximum vibration velocity of 0.6 m/s exhibited superior high power performance compared to PZT4 and PZT8 which are routinely utilized in manufacture of high intensity focused ultrasound (HIFU) transducers. For the first time, BNKLT88-1.5Mn piezoceramics has been used to fabricate unfocused single element HIFU transducer with center frequency of 3 MHz. The acoustic properties of the transducer such as the frequency spectrum and acoustic pressure field were characterized and compared with Lead-based counterparts. The plain lead-free 3 MHz transducer showed linear behavior up to 99 V where a maximum peak-to-peak acoustic pressure of 3 MPa was achieved. The acoustic intensity and pressure as high as 300 W/cm^2 and 3 MPa at natural focal point with MI of 1.09 was achieved. This result indicates the suitability of using hard lead-free BNT-based ceramics for HIFU transducers.