Losses and Heat Generation of Piezoelectric Ceramics by Polarization Orientation

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Piezoelectric materials have been popularly used for transducer devices, and high piezoelectric constant is essential for the device performance. After we discovered an enhancement of piezoelectricity on polarization-canted orientations, the idea was widely applied for the development of polycrystalline and singe crystal materials. However, a limitation of its usage in devices came from the relatively low mechanical quality factors which brings more heat generation in high power level.

Initially, the angle dependence of properties in soft $Pb(Zr,Ti)O_3$-based piezoelectric ceramics at low power level were reported with constant input voltage and negligibly small heat generation. Tetragonal, rhombohedral and near-MPB samples were prepared by PI Ceramics to have 0 ($E//P_S$) to 90 degree ($E\perp P_S$) angles for effective k_{31} and k_{33} vibrating modes. Elastic and piezoelectric losses were investigated with the difference of the mechanical quality factor at resonance and antiresonance frequencies, where the dielectric loss was measured in 100Hz by assuming to be the same near fundamental frequencies. With increasing the angle, we found that the change of piezoelectric losses is dominant compared to the change of dielectric or elastic losses.

In this poster, the high-power measurement of polarization angled samples will be conducted to compare heat generation and losses by the orientation. At first, the quality factor difference in constant mechanical output power will be shown. Retaining the output power by fixing the vibration velocity leads to stronger decibels in impedance measurement for samples with lower electro-mechanical coupling factors and helps determining the quality factor. With increased vibration velocity, heat generations on the frequencies for minimum voltage which corresponds to resonance, minimum current which corresponds to antiresonance and minimum input power which is in between resonance and antiresonance will be compared by polarization angle and crystal structures. The results will be discussed with the three losses in low power measurement.

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