Lead Zirconate Titanate Thin Films for a 2D Ultrasound Array

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Ultrasound is now the second most widely adopted imaging modality in the medical profession; increasing the capabilities of ultrasound tools with small form factors is thus of considerable interest. Piezoelectric thin films are potentially enabling for miniaturized high frequency ultrasound devices with improved imaging resolution. Ultrasound arrays are also of interest for control of particle movement via acoustic tweezing, i.e. for applications such as separating healthy blood cells from circulating tumor cells based on their physical properties. In order to enable low voltage operation, the resonators are diaphragm structures.

To prepare piezoMEMS ultrasound arrays, lead zirconate titanate (PZT) thin films with 1% niobium with a high dielectric constant (> 1000), high remanent polarization (> 20 $\mu C/cm^2$), and low dielectric loss (< 4%) were sputtered on silicon on insulator substrates with Ti/Pt bottom and top electrodes. Diaphragm diameters of 30 µm, 40 µm, and 50 µm were defined via backside silicon deep reactive ion etching to create the resonating structures. In addition, four main types of top electrode patterning were investigated: 1D arrays in which each electrode covers a single row of 20 diaphragms, 1D arrays in which each electrode element covers a single diaphragm, 2D annular arrays in which the top electrode element encompasses 314 diaphragms arranged in a circular pattern, and 2D arrays in which one electrode element can excite multiple diaphragms. Each device had elements with a narrow distribution of capacitance, permittivity, and loss tangent (within 5% of one another). Acoustic measurements such as resonant frequency were carried out to confirm resonant frequencies of 15 MHz – 50 MHz for the devices. Data on the acoustic performance of these MEMS structures and their use for controlling particles will be reported.