

A New Sm-PMN-PT Ceramic Based 2D Array for Low-intensity Ultrasound Therapy Application

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Background, Motivation and Objective

Two-dimensional (2D) arrays with small pitch (about 0.5λ in medium) can achieve the full 3D control of the ultrasound beam without grating lobes and enable the generation of multiple simultaneous focal spots, which is the desired tool for ultrasound non-invasive therapy on brain diseases. However, too large electrical impedance of 2D array elements due to their small size lead to low energy transfer efficiency between 2D array and electrical system, limiting their practical applications. In this work, a new piezoceramic with ultrahigh dielectric permittivity (about 8000) was used to develop a 2D array with low electrical impedance for low-intensity ultrasound therapy applications.

Statement of Contribution/Methods

A 2D array with 256 elements (16×16) and 1 MHz center frequency was designed. Array elements were spaced at a 1.1-mm pitch (0.71λ in water), enabling that the ultrasound beam has a large steering range. Sm-doped $\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3\text{-PbTiO}_3$ (Sm-PMN-PT) piezoceramic with ultrahigh dielectric permittivity (Fei Li *et al.* Nature Materials, 2018.) was used to decrease the electrical impedance of small array elements. A custom flexible circuit with matrix pads was designed to simplify the electrical connection between array elements and electrical system. For comparison, a 2D array with the same parameters based on commercial PZT-5H ceramic was also developed.

Results/Discussion

Although the acoustic field distributions of the two 2D arrays were nearly the same, the output acoustic pressure of 2D array made of Sm-PMN-PT was about 2.2 times of that of the 2D array made of PZT-5H ceramic under the same excitation voltage. This is mainly because that the electrical impedance of array element was decreased greatly as the Sm-PMN-PT replacing for PZT-5H. The -6 dB lateral resolution of the developed 2D array was about 1.6 mm when focus length is 15 mm. The obtained results indicate that the 2D array made of Sm-PMN-PT ceramic shows high performance and is promising for practical use in low-intensity ultrasound therapy applications.

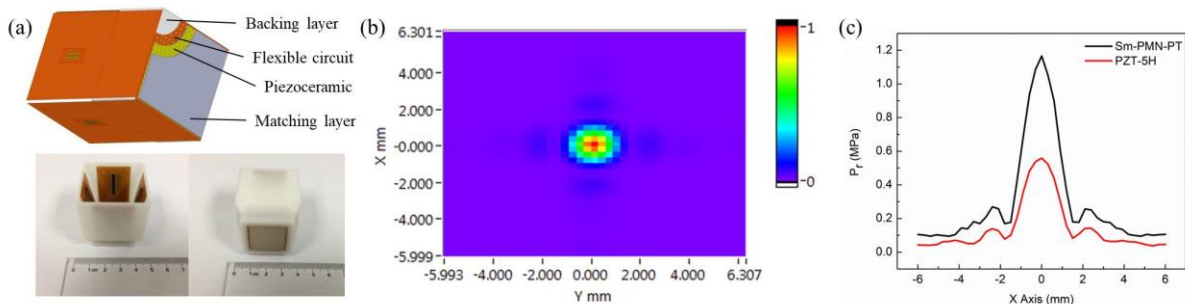


Fig. 1 (a) Schematic diagram and photograph of the 2D array, (b) acoustic field distribution map at X-Y plane for 2D array at focus (0mm, 0mm, 15mm), (c) acoustic pressure distribution at Y = 0 mm in (b) for two arrays under the same excitation voltage.