# Development of the Transformable Ultrasonic Transducer for Multi-dimensional Imaging and Therapy

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## Background, Motivation and Objective

For the past decades, the design of medial ultrasonic transducers has been evolved many different generations: from 1D linear array, to 1.5D, 1.75D, and now the 2D matrix array, with the improved performance such as contrast and resolution, enhanced imaging dimension from the 2D imaging to 3D imaging, and transformed function from the diagnosis to the therapy. Owing to the development of piezoelectric material and electronic packaging technologies, there is an urgent need for the novel ultrasonic transducer design with more flexibility and transformability to fulfill the increasing demands for accurate diagnosis and treatment. In this study, we aim to develop a novel ultrasonic device that can easily transform its structure from the 1D linear array to the 2D matrix array, and ensure its performance and advantage in the corresponding configuration.

## Statement of Contribution/Methods

The 16 16-elements modules with the center frequency of 1MHz are initially fabricated to form a 1D linear array with 256 elements in total. Modified PZT 1-3 composite materials with a volume fraction of 51% are used to fabricate the transducer module. The pitch and kerf of the piezoelectric elements are 0.7mm and 0.2mm, respectively. The schematic of the ultrasonic transducer arrays transformation from 1D array to 2D array through the precise folding of electromagnetic-shielded foldable flexible circuit board is shown in Fig.1(A). The phantom with two cross-mounted iron nails was imaged to evaluate the performance of the transformable ultrasonic transducer at different configurations.

## Results/Discussion

The phantom was initially imaged at the 1D configuration with adjacent 2 modules of 32-elements by using plane wave compounding imaging method, in which the imaging plane is parallel to one nail and perpendicular to the other, shown in Fig. 1(B, D). The 2D cross section images of two iron nails as indicated by the red window (Fig.1(D)) were shown in Fig.1(F). As shown in Fig.1(C, E), 3D imaging was performed at the same location while the ultrasonic transducers were transformed to a 16×16 2D matrix array. The relative space position and exact shape of the two cross-mounted nails were clearly shown in the 3D image (Fig.1(G)). These results have successfully demonstrated the concept and feasibility of the transformable ultrasonic transducer, which can be potentially used for the future multi-dimensional imaging and therapy.

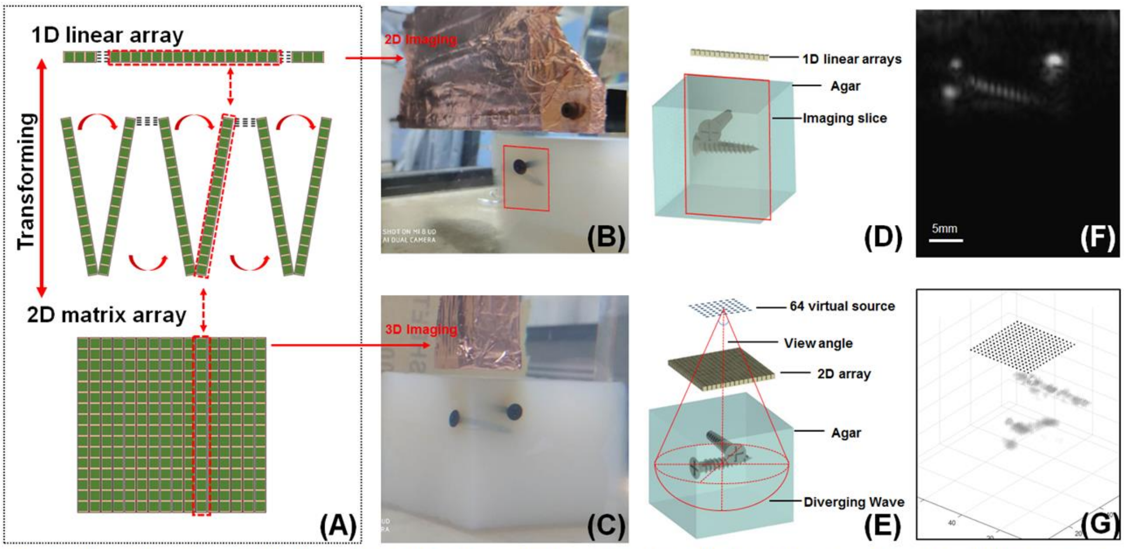


Fig. 1 (A) Schematic of the transformable ultrasonic transducer arrays transforming from the 1D linear array configuration to the 2D matrix array configuration; (B) and (C) Photography of the actual 1D linear array and 2D matrix array configurations covered with copper foil; (D) and (E) Schematics of the 1D linear array and 2D matrix array configurations; (F) Image obtained at the 1D linear array configuration with adjacent 2 modules of 32-elements; (G) 3D image obtained with the transformed 16×16 2D matrix array configuration.