Thin and Single Element High Intensity Airborne Ultrasonic Transducer Utilizing Piezoelectric Transverse Effect

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Background, Motivation and Objective

Parametric loudspeakers and ultrasonic haptic devices both require high intensity ultrasound exceed 130 dB. Commercially available 40 kHz transducers are regularly used for such devices, in which several ten to hundred transducers are required to obtain sufficient sound pressure level (SPL). Therefore field of application is limited due to high cost.

On the other hand, in the industrial field, high intensity ultrasonic transducer which utilizes Langevin type transducer connected to the stepped circular flexural plate is known. Despite high SPL of more than 160 dB, we have to say that it is impractical except industrial use because of large size and heavy weight. Yet its circular flexural vibrating plate is intriguing with its phase matching step structure that enables high directional ultrasound radiation.

For consumer or automotive applications, there is demand for low-cost, light-weight and thin high intensity ultrasonic transducer. In this report, we present the device consists of circular flexural vibrating plate with stepped structure driven by monomorph bending actuator utilizing piezoelectric transverse effect, in order to realize thin and single element high intensity ultrasound source.

Statement of Contribution/Methods

Presented device is shown in Fig.1 (a) and (b). A 1 mm thick circular aluminum plate is connected to a monomorph actuator via pillar connector. On the other side of the circular plate, plastic step rings are placed. Length and width of the monomorph is 14 mm and 8 mm, while thickness of PZT and aluminum is both 1.4 mm. Resonant frequency of each part is roughly adjusted to 40 kHz, then fine adjustment in detail dimensions are carried out using FEM. Fig.1 (c) shows typical vibration mode. Actual device is prepared then experiment is performed. Similar mode to Fig.1 (c) is confirmed with LDV observation.

Results/Discussion

Fig.1 (d) shows axial sound pressure distribution. It exceeds 130 dB within distance of 20 cm, beyond that it decreases -6 dB per double distance. Beam width (FWHM) measured at distance of 30 cm is 13.6°. Beam pattern shows no remarkable side lobes. Electrical field applied to the piezoelectric plate is about 86 Vrms/mm, therefore there is enough room for increasing power level. Updated results on this device will be presented at the conference.

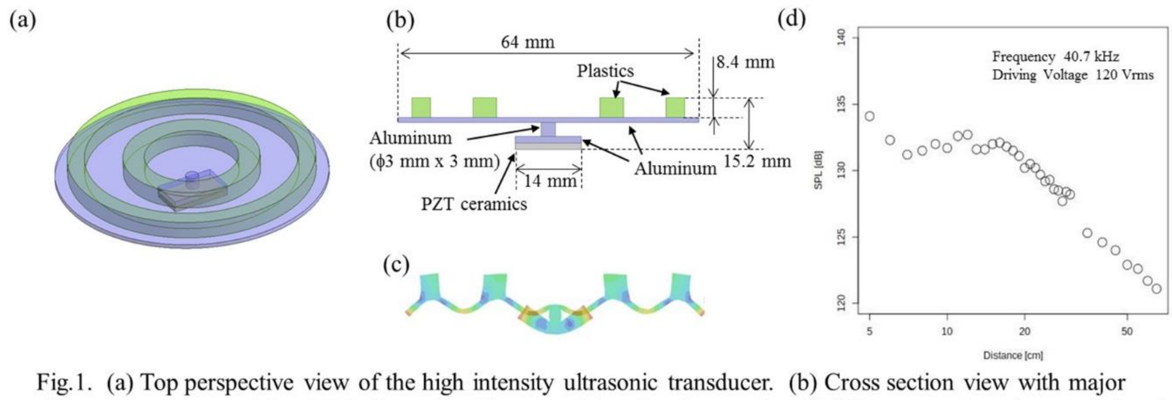

Fig.1. (a) Top perspective view of the high intensity ultrasonic transducer. (b) Cross section view with major dimensions and materials. (c) Deformation diagram of the vibration mode. (d) SPL propagation characteristic of emitted ultrasound.