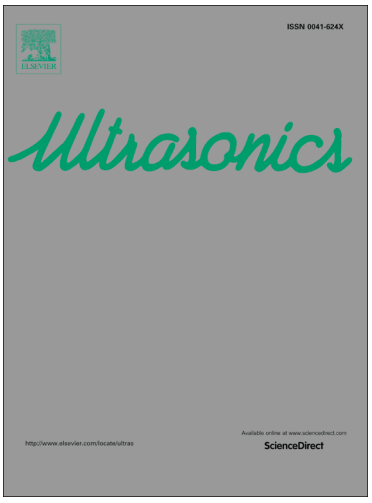

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Increasing the Field-of-View of Row–Column-Addressed Ultrasound Transducers: Implementation of a Diverging Compound Lens

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Abstract

The purpose of this work is to investigate compound lenses for row–column-addressed (RCA) ultrasound transducers for increasing the field-of-view (FOV) to a curvilinear volume region, while retaining a flat sole to avoid trapping air between the transducer sole and the patient, which would otherwise lead to unwanted reflections. The primary motivation behind this research is to develop a RCA ultrasound transducer for abdominal or cardiac imaging, where a curvilinear volume region is a necessity. RCA transducers provide 3-D ultrasound imaging with fewer channels than fully-addressed 2-D arrays ($2N$ instead of N^2), but they have inherently limited FOV. By increasing the RCA FOV, these transducers can be used for the same applications as fully-addressed transducers while retaining the same price range as conventional 2-D imaging due to the lower channel count. Analytical and finite element method (FEM) models were employed to evaluate design options. Composite materials were developed by loading polymers with inorganic powders to satisfy the corresponding speed of sound and specific acoustical impedance requirements. A Bi_2O_3 powder with a density of $8.9\,g/cm^3$ was used to decrease the speed of sound of a room temperature vulcanizing (RTV) silicone, RTV615, from $1.03\,mm/\mu s$ to $0.792\,mm/\mu s$. Using micro-balloons in RTV615 and a urethane, Hapflex 541, their speeds of sound were increased from $1.03\,mm/\mu s$ to $1.50\,mm/\mu s$ and from $1.52\,mm/\mu s$ to $1.93\,mm/\mu s$, respectively. A diverging add-on lens was fabricated of a Bi_2O_3 loaded RTV615 and an unloaded Hapflex 541. The lens was tested using a RCA probe, and a FOV of 32.2° was measured from water tank tests, while the FEM model yielded 33.4°. A wire phantom with 0.15 mm diameter wires was imaged at 3 MHz down to a depth of 14 cm using a synthetic aperture imaging sequence with single element transmissions. The beamformed image showed that wires outside the array footprint were visible, demonstrating the increased FOV.

Keywords: Ultrasound Imaging, Compound Lens, Composite Materials, Diverging Lens, Row-column-addressing

1. Introduction

The purpose of this work is to investigate the use of compound lenses for row–column-addressed (RCA) ultrasound transducers for increasing the field-of-view (FOV) to a curvilinear volume region, while retaining a flat sole to avoid trapping air between the transducer sole and the patient, which leads to unwanted reflections. Planar 2-D RCA