A novel dual-frequency focused ultrasound transducer for super-harmonic imaging

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1. Background, Motivation and Objective

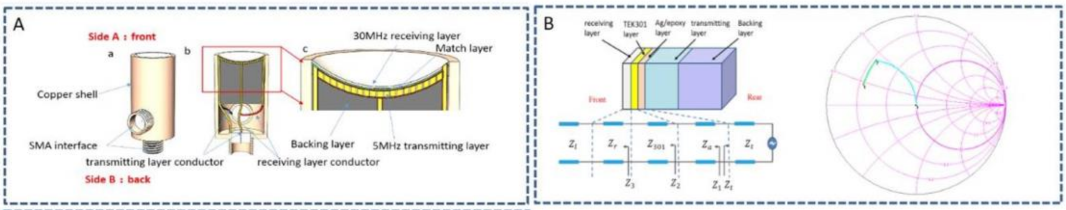
Cardiovascular disease is "the first killer" to threaten human health. Nowadays, it has been found that cardiomyocytes microcirculation disorder is regarded as one pathogenesis of many cardiovascular diseases. Unfortunately, to evaluate the cardiomyocytes microcirculation is still a challenge, because no commercial technology can satisfy the requirement of the cardiomyocytes microvascular imaging. Dual-frequency super-harmonic contrast-enhanced imaging method is a promising way to display microvascular structures. For such technology, the ultrasound transducer with the capability of low frequency ultrasound transmitting and high frequency ultrasound receiving is indispensable. The aim of the present study is to demonstrate the feasibility of a novel dual-frequency (5MHz/30MHz) focused ultrasound transducer with PVDF/PMN-PT composite two layers structure for superharmonic imaging applications.

2. Statement of Contribution/Methods

In this study, we present the design and fabrication of a dual-frequency (5MHz/30MHz) focused ultrasound transducer based on PVDF film and PMN-PT 1-3composite, and the superharmonic imaging of a microvascular phantom with a diameter of 200μm.

3. Results and Discussion

The PMN-PT single crystal 1-3 composite and PVDF thick film were employed as 5MHz transmitting layer and 30MHz receiving layer, respectively. For acoustic impedance matching between transmitting layer and receiving layer, the transmission line model and Smith chat were employed, and the thicknesses of Ag/epoxy and Epoxy 301 were adjusted. Furthermore, the dual-frequency transducer was focused by a pressing technology using a stainless steel ball with a diameter of 8mm. In the imaging experiment, the phantom tube with a diameter of 200μm was immersed in deionized water and was placed at the focal point of the transducer, and microbubbles were injected in the tube phantom. The 3D reconstruction image of phantom was displayed in Fig.1. These promising results indicate that the obtained novel dual-frequency transducer is competent for superharmonic imaging. This research opens a path for cardiomyocytes microvascular imaging.



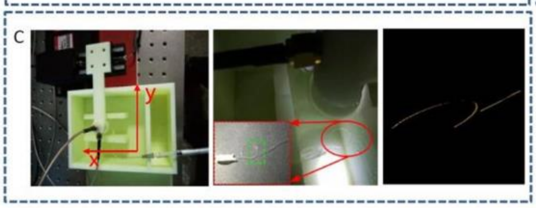


Figure 1 (A) The schematic diagram of the obtained dual-frequency transducer; (B) The acoustic equivalent transmission line network and Smith chart; (C) The superharmonic imaging system and phantom 3D reconstruction image.