Ultrasonic Imaging Guided 3D Acoustic Tweezers Based on a 2D Matrix Array

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Background, Motivation and Objective

Acoustic tweezers, which can control the movement of microparticles by using acoustic radiation force with contactless and noninvasive manner, have attracted tremendous interest due to their widely applications ranging from material science to biomedical technology. Owing to the development of 2D ultrasonic array technology, 3D trapping and manipulation of the particles in millimeter range can be realized in water environment that is more similar to human tissue, which significantly enhanced the practical application value of acoustic tweezer. However, the observation of these processes is used camera, which can only apply in optically transparent medium. It is worth noting that one unique advantage of ultrasound in water is its imaging capability. In this study, based on the 2D array matrix array developed by our group, we aim to achieve the acoustic 3D particle manipulation guided by ultrasonic images.

Statement of Contribution/Methods

A 1MHz 256-element 2D matrix array, with a pitch of 2.8 mm and kerf of 0.2 mm, is designed and fabricated for ultrasonic image guided 3D acoustic tweezer. The array transducer is driven by the Verasonic Vantage system. A dynamic burst signal with different amplitude and phase is used to excite individual element to form the complex acoustic field and achieve the precise trapping and manipulating the PDMS particles within a 3D space. Meanwhile, the 2D array is also driven by a synchronized imaging sequence to form 3D ultrasonic image for real-time monitoring the exact locations of the targeted particles (Fig.1(A)). Within the imaging and trapping space, the freely moving PDMS particles can be initially located by the 3D imaging module, and then the system can set the focus to the particles' positions immediately to trap and control the movement of the particles.

Results/Discussion

Multiple foci acoustic field generated by the 2D array in simulation and experiment are shown in Fig. 1(C- F). The PDMS particles, with the diameter about 1.5 mm and a total number of ten, are successfully trapped and driven to move in a specified path by changing the position of multiple foci (Fig. 1(G), (H)). One particle and multiple particles manipulation have been successfully demonstrated by using this imaged guided acoustic tweezer system (Fig. 1(I- P)). These work has demonstrated the image guided acoustic tweezer system is promising in enlightening the significance for accurate acoustic manipulation in vivo.

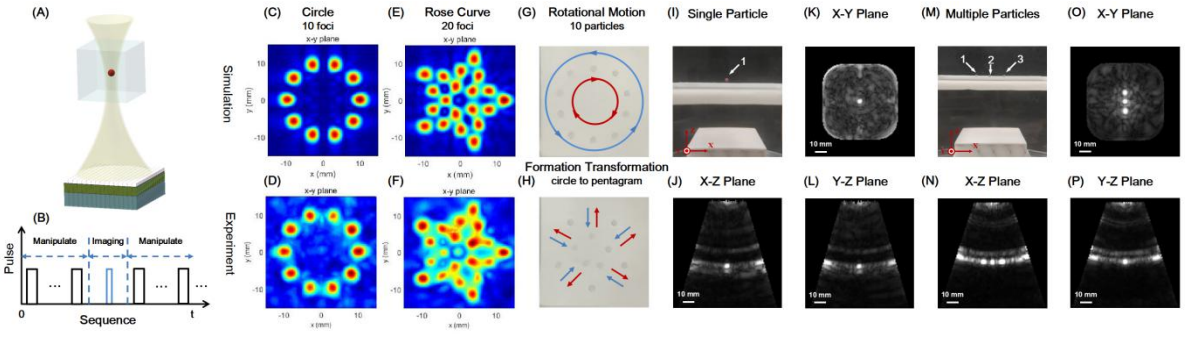

Fig.1 Schematic diagram of ultrasonic imaging guided 3D acoustic tweezers (A) and signal control sequence(B). Acoustic field simulation and experimental results of cycle (C, D), rose curve(E, F). Rotational motion(G) and formation transformation from circle to pentagram(H) of 10 particles. One particle(I- L) and multiple particles(M- P) manipulation have been successfully demonstrated by using this imaged guided acoustic tweezer system.