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CONTACTLESS TRANSPORTATION OF DROPLET IN MID-AIR BY ACOUSTIC LEVITATION

Abstract

Non-contact liquid manipulation is of paramount importance for lab-in-a-drop applications, such as material processing, chemical analysis, X-ray crystallography, DNA transfection, blood analysis. Because the non-contact manipulation can prevent the wall effect, such as contamination, absorption, and heterogeneous nucleation from the wall. One of the promising manipulation methods is acoustic levitation, since it allows suspension of samples in mid-air. This is possible due to acoustic radiation forces acting on the sample to counteract the body force due to gravity. Acoustic manipulation is an attractive approach for contactless fluid manipulation in mid-air, such as droplet levitation, transportation, coalescence, mixing, separation, and evaporation. One of the previous studies on liquids is a microgravity experiment using parabolic flights. As a result, it has been clarified that droplets having a diameter larger than under the gravity on the ground can float, and the sound pressure at that time is a pressure that cannot float on the ground. Therefore, it is considered that this ALM can be performed in a practical range by performing it in a microgravity environment, and that it is possible to obtain a lot of knowledge. In this paper, acoustic levitation by ultrasonic phased arrays is utilized for its flexibility and for being economical, as compared to the existing single–axis acoustic levitators. Although the ultrasonic phased array system is promising for sample manipulation in mid-air, this method has not been fully investigated. This study aims to demonstrate contactless droplet levitation and transportation in mid-air via an ultrasonic phased array. We demonstrated the three-dimensional contactless droplet manipulation. Hereafter, the transportation of droplets was carried out with different speeds of focal point of sound. The droplets can be transported and manipulated one- and two-dimensionally. Base on the experiments, it was found that the oscillation amplitude of the droplet increased with the increase of the transportation speed of the droplet. The oscillation frequency of the droplet was almost constant with different transportation conditions. The effect of the droplet diameter was also investigated. In addition, vertical transportation of the droplet was exhibited in the vertical direction for developing the three-dimensional manipulation of droplet. Our findings promote the feasibility of contactless droplet manipulation with a phased array for potential applications.