Proceedings of Symposium on Ultrasonic Electronics, Vol. 33 (2012) pp. 83-84
13-15 November, 2012

Non-Contact Dispensing of Small Droplets Using Ultrasonic Levitation
超音波浮揚による液滴の非接触分注

Hiroki Tanaka[1‡], Yosuke Mizuno[2], and Kentaro Nakamura[3]
([1, 2, 3]Tokyo Institute of Technology)
田中宏樹 [1‡]，水野洋輔 [2]，中村健太郎 [3] ([1, 2, 3] 東工大)

1. Introduction

There are potentially large needs to deliver droplets without contact in pharmacy industry and biotechnology. We have been researching about ultrasonic levitation and succeeded in non-contact transportation of small object over long distances [1], [2] and circular trajectory [3].

In this experiment, we investigate the way of non-contact dispensing of small droplets after transporting. We use a vibrating plate and a half-pipe-shaped reflector to generate an ultrasonic standing wave between them and trap the droplets of ethanol at the nodal lines. The droplets are dispensed to a well-plate by turning off the vibration.

2. Experiment

2.1 Dispensing Device

Figure 1 shows a bending vibration plate and a reflector for non-contact dispensing. The bending vibration plate is 2 mm in thick, 250 mm in length, 15 mm in width and made of aluminum. One end of the vibrating plate is attached to the top of a horn with a tightening screw at 10 mm from the end, and the other end is free. The longitudinal vibration of the horn generates a standing flexural vibration along the plate. The reflector is half-piped acrylic resin 200 mm in length and 17.5 mm in radius. There are 3-mm-diameter holes along bottom line of the reflector, and the levitated droplet is dropped off through these holes. The vibrating plate and the reflector are installed with the separation distance of 18 mm to generate an intense ultrasonic standing wave in air.

Figure 2 shows a sound pressure distribution in the cross section simulated by FEM (ANSYS, CYBERNET). Positive and negative high sound pressures are indicated in red and blue in **Fig. 2**, respectively, and low sound pressure is in green. There is a peak of sound pressure near the center of **Fig. 2**. Between the red area and point-A in **Fig. 2**, upward acoustic radiation force works on the droplets.

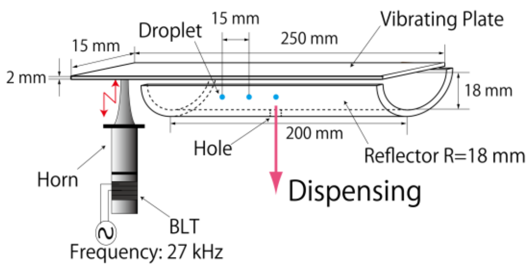

Fig. 1 Bending vibration plate and reflector for non-contact dispensing of small droplets.

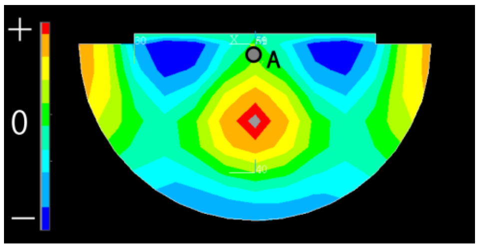

Fig. 2 Sound pressure distribution in the cross section simulated by FEM.

2.2 Microplate

In this experiment, we dispensed droplets to a microplate (Assay 96 Well Microplate Format, greiner bio-one) as shown in **Fig. 3**. The microplate is composed of 8-raw and 12-column two-dimensional array of small containers called 'well.' The diameter and volume of each well are 6 mm and 392 μl. Spacing between the adjacent wells is 10 mm.

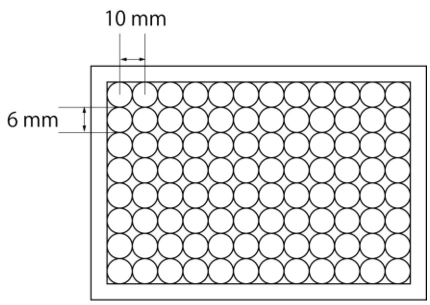

Fig. 3 Structure of the microplate for dispensing.

3. Results

3.1 Levitation of ethanol droplets

The driving frequency of transducer was 27 kHz. The gap between the vibrating plate and the reflector was adjusted to levitate ethanol droplets. When the gap measured from the vibrating plate to the bottom of the reflector was 18 mm, ethanol droplets were levitated stably. Fig. 4 shows the trapped droplets of ethanol at the nodal lines. The interval between the droplets in a row was 15 mm. We used an acoustic mode of 30 mm in wavelength in the pipe, which was easily generated at 27 kHz with the experimental setup used in this study.

The sound pressure between the vibrating plate and the reflector was measured by a 1/8 inch microphone (TYPE7118, ACO). When the sound pressure was 3.3 kPa, 4 kPa and 5 kPa (0-p value), we measured the volume of levitated ethanol droplets. The volume was calculated from the picture of the levitated droplets. Fig. 5 shows the relationship between the volume of droplets and sound pressure. The average of droplets volume was 1.7 μl.

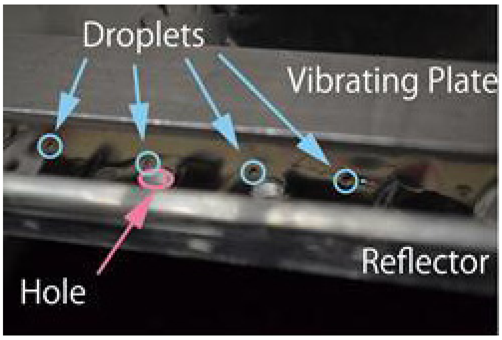

Fig. 4 Photo of levitated ethanol droplets.

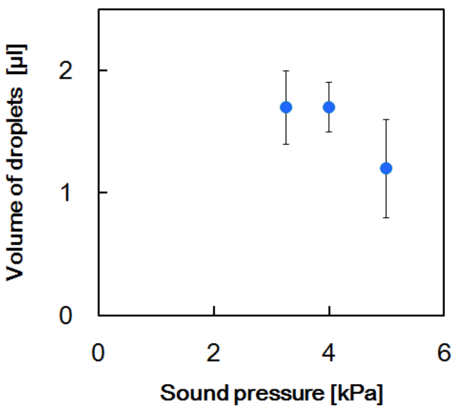

Fig. 5 Volume of levitated ethanol droplets vs. sound puressure.

3.2 Dispensing of droplet

When the droplet was levitated above the hole of the reflector, we stopped the vibration. The droplet fell freely through the hole and was dispensed to the well. This is shown in Fig. 6. In Fig. 6, blue points show the position of the droplets every 0.04 sec after turning off the vibration, and pink circle shows the position of the well. The droplet was able to be levitated above the hole on the reflector, and by only stopping the vibration, the droplet falls vertically due to the gravity.

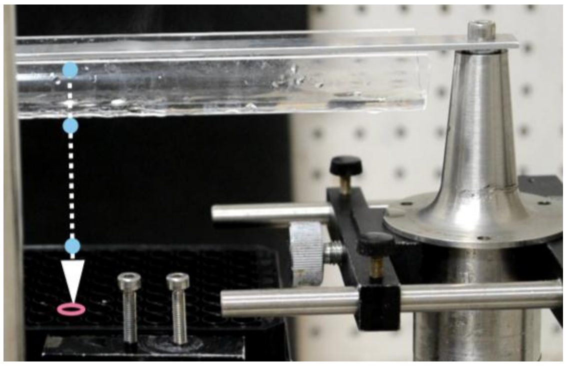

Fig. 6 Dispensing of ethanol droplet.

4. Conclusion

We succeeded in non-contact dispensing of small ethanol droplet with ultrasonic levitation. We used a bending vibrating plate and a half-pipe shaped reflector with small holes for dispensing. We could levitate a droplet above the small hole of reflector. Relationship between the diameter of the hole and the volume of the levitated droplet is left for futher study. In this experiment, we trapped the droplets at 15 mm interval, but we need to trap the droplets at 10 mm interval for dispensing many droplets at once because the intervals of microplate's wells are 10 mm. We need to design the dimension of the vibrating plate and the driving frequency to generate ultrasonic standing wave having the wavelength of 20 mm.

References

1. D. Koyama and K. Nakamura: *IEEE Trans. UFFC*. **57** (2010) 1152.
2. Y. Ito, D. Koyama, K. Nakamura: *Acoust. Sci&Tech*. **31** (2010) 420
3. D. Koyama and K. Nakamura: *IEEE Trans. UFFC*. **57** (2010) 1434.