Applied Acoustic Devices Using Ultrasound Radiation Force

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1. Introduction

High-intensity ultrasound is highly attractive in the fields of actuators, medical treatment, and nondestructive testing. In this report, ultrasound devices and techniques using ultrasound radiation force such as optical lenses and noncontact transport technique are introduced.

2. Ultrasonic Variable-Focus Optical Lens

Most camera modules require actuators and a gearing system to move the position of the lens in order to focus on an object. Crystalline lenses in the human eye change their shape to control the focal point. We have developed a variable-focus lens that utilizes ultrasonic radiation force and has no moving mechanical parts. The lens utilizes the refractive index difference between two immiscible liquids and its focal point can change by deforming the interface between the two liquids. The lens consists of a cylindrical lens cell filled with two immiscible liquids (water and silicone oil) and an annular ultrasound transducer (see Fig. 1) [1]. The liquid lens was designed from the theoretical model for the vibration of the lens and the numerical simulation by finite element analysis. The profile of the oil-water interface can be changed by controlling the ultrasound radiation force from the transducer so that the interface functions as a variable-focus lens. The focal point can be controlled by the input voltage to the transducer. There is an optimal kinematic viscosity of the oil that minimizes the response time; the shortest response time of 6.7 ms was obtained with oil with a kinematic viscosity of 100 cSt. By fabricating four-divided electrodes on the ultrasound transducer and exciting by a four-phase drive, non-axisymmetric sound pressure field in the lens can be generated, which induces non-axisymmetric deformation of the lens. The focal point can be varied in the axial and radial directions.

3. Ultrasonic Noncontact Transport

Ultrasound radiation force can be applied to noncontact manipulation technique for small objects such as electronic components, tablets, and liquid droplets. We have been investigating ultrasound noncontact transport system. The system consists of linear transporters and junctions in which small objects can be transported without contact. At the junction, the object transported from the linear transporter is received and ejected towards the other linear transporter. During transportation, objects can be trapped along nodal lines of an acoustic standing wave generated between a flexural vibrating plate and a reflector. By controlling the driving condition of an ultrasound transducer attached to the vibrating plate, the acoustic field between the two plates is controlled so that the trapped objects can be transported without contact as shown in Fig. 2 [2]. Liquid droplets such as ethanol can also be transported.

4. Conclusions

Ultrasonic optical devices and noncontact manipulation techniques using ultrasound radiation force were introduced. The lens was more compact and had faster response than conventional mechanical lens. Application of the ultrasonic manipulation technique to industrial fields is expected.

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References

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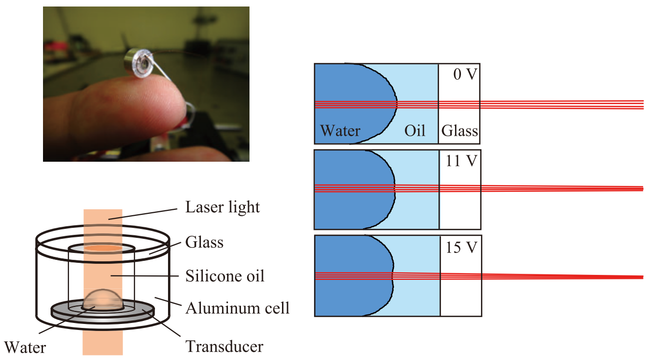

Figure 1 Ultrasonic variable-focus optical lens.

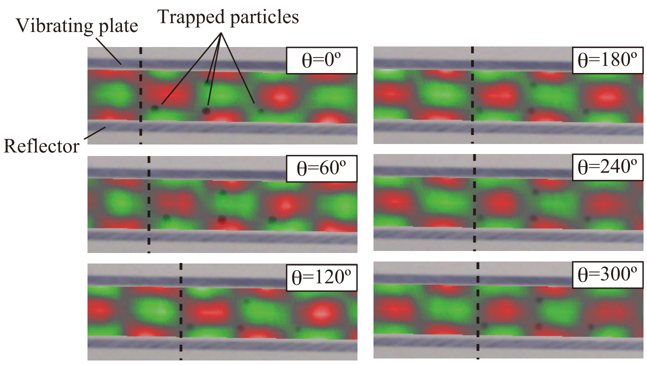

Figure 2 Ultrasonic noncontact transport of small particles.