Evaluation of liquid crystal orientation in an ultrasound large-aperture liquid crystal lens

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Background, Motivation and Objective

Nematic liquid crystals are widely used in optical devices such as liquid crystal displays. We proposed a novel technique to control the orientation of liquid crystal molecules using ultrasound vibration[1] and developed a variable-focus liquid crystal lens[2]. Although molecular orientation of liquid crystals can be controlled generally by applying electric fields, it is difficult to control the optical characteristics of large-aperture liquid crystal lenses. In this report, we developed an ultrasound large-aperture liquid crystal lens using tens-kHz-range ultrasound and evaluated the liquid crystal molecular orientation under ultrasound excitation.

Statement of Contribution/Methods

An ultrasound liquid crystal lens was fabricated; a liquid crystal layer with the thickness of 50 μm was sandwiched between two glass plates having a PZT transducer. The flexural vibration mode with one nodal circle was generated on the lens at 35 kHz by exciting the transducer. Acoustic radiation force to the liquid crystal layer was generated and the molecular orientation was changed, inducing the drastic changes of the light transmission. We evaluated the liquid crystal molecular orientation in the lens under ultrasound excitation and investigated the relationship between transmitted light distribution and the vibrational distribution.

Results/Discussion

The transmitted light distribution under the crossed-Nicol condition correlated with the vibrational distribution. The orientation direction of the liquid crystal molecules was predicted from the distributions of the transmitted light intensity. It was found that the liquid crystal molecular orientation was changed remarkably between the antinodal and nodal parts of the ultrasound vibration. The molecular orientation aligned axisymmetrically towards the antinode of the flexural vibration, resulting in the convex lens effect.

[1] S. Taniguchi, et al., Appl. Phys. Lett.,108 101103, 2016.
[2] Y. Shimizu, et al., Appl. Phys. Lett.,112, 161104, 2018.

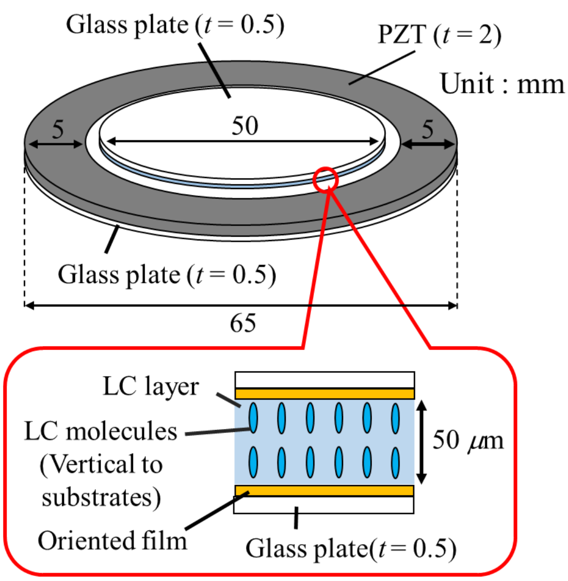

Fig.1 Configuration of an ultrasonic liquid crystal lens.

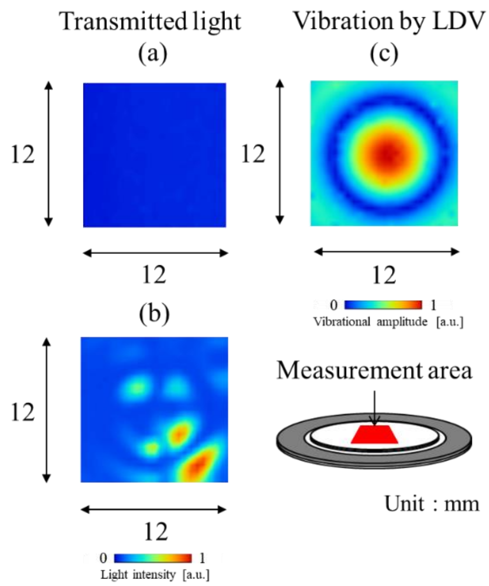

Fig.2 Transmitted light distributions through the lens (a) without and (b) with ultrasound vibration at 35 kHz and (c) the vibrational distribution.