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（博士課程）
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis is entitled as 'High-power ultrasonic transducers using polymer materials and their applications to functional ultrasonic devices,' and consists of six chapters.

In Chapter 1: 'Introduction,' background, motivation and purpose of this study are described. First, principle and applications of piezoelectric transducer are introduced. Lightweight ultrasonic transducers suitable for mass production have been increasingly required, and the author proposes to use low-density materials to replace the metals as vibrating bodies. Polymer materials generally exhibit low densities and good workability, but high mechanical loss for ultrasounds. Thus, the purpose of this study is to seek for low-mechanical-loss polymer materials to produce ultrasonic transducers, and make trial construction of functional ultrasonic devices with the polymer.

In Chapter 2: 'Measurement of mechanical quality factors of polymers in high-amplitude vibration,' to select the suitable polymer, a quantitative method was developed to estimate the mechanical quality factors (Q factors) under high-amplitude vibration. Being based on the original definition, Q factor was measured as the ratio of the stored energy to the dissipated energy. The reactive energy was calculated from the vibration velocity distribution, while the dissipated energy was obtained from the reduction in the acoustic active power. To obtain high precision, the optimal dimensions of the polymer samples were discussed. On the basis of the devised method, the Q factors of several functional polymers were measured as functions of strain and frequency. It was found that, at 28.30 kHz, the Q factors of poly phenylene sulfide (PPS) reached approximately 460, which was the highest value among the tested polymers.

In Chapter 3: 'Polymer-based airborne ultrasonic transducer,' PPS was employed for vibrating body to form an airborne ultrasonic transducer, and the structural design was optimally conducted. The transducer consisted of a longitudinal vibrator and a PPS thin film radiator, where the piezoelectric ceramic elements were sandwiched between the PPS vibrating bodies. Through the simulation, we chose the optimal vibration mode, and adjusted the dimensions. The rated sound pressure reached 38.9 Pa, which was 3.5 times the value of the commercial transducer under the same electric-field, while the ratio of the sound pressure to the weight was 1.8 times the values of the commercial transducers.

In Chapter 4: 'Structural parameter study on polymer-based ultrasonic motor,' we fabricated ultrasonic motors (USMs) with polymer-based transducers. The polymer-based USMs yield relatively high rotational speeds, low output torques and low power comparing to the metal-based USMs with the same dimensions. To improve the performance, we explored how the structural parameters of the transducers affected the motor performance. As the polymer-based transducers became thicker, the force factors of the vibrators increased, and the output torques of the motors was enhanced. However, the radial vibration components, which never contributed to the rotations of motors, also increased as the vibrators became thicker. The undesirable vibration components lead to high frictional loss, of which the negative effect on output torques of motors offsets the positive effect caused by the increase in the force factor. Since polymer materials have greatly different mechanical constants in comparison with piezoelectric ceramics, the vibrating body should be much thicker than the piezoelectric ceramics to yield a force factor comparable to metal-based transducer. Thus, the optimal thicknesses of the polymer-based motors are higher than that of metal-based motors with the same diameter, and the maximum output torques and power are lower than those of the metal-based motors.

Second in this chapter, we employed a triple-layered transducer consisting of a thin alumina plate sandwiched between the PPS vibrating body and the piezoelectric ceramic plate. Though the ceramic plate was thin, it could greatly increase the force factor because of the high elastic modulus.

In Chapter 5: 'Performance improvement through utilization of high-order vibration mode,' high-order vibration mode on the polymer-based transducer was tested, which exhibited a higher electromechanical coupling factor than the commonly-used bending mode in conventional USMs. The high-order vibration mode provides a horizontal nodal line that facilitates the vibrator fixing. Experimental results indicated that higher output torques and power were obtained on the polymer-based motors using the high-order vibration mode.

In Chapter 6: 'Conclusion and future work,' the results of the study are summarized. Then, future study plan is described.