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Article / Book Information

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Thesis outline

Development of Soft Electromagnetic Microactuators

Chao QI

Chapter 1, "Introduction", starts with an introduction to the soft microactuators driven by different actuation mechanisms, especially soft electromagnetic microactuators (SEMMAs). Subsequently, the composition and fabrication of moving parts of SEMMAs using polydimethylsiloxane (PDMS) are described in detail.

Chapter 2, "A SEMMA utilizing an impact-driven membrane based on a cylindrical NdFeB magnet", aims to develop a disposable PDMS-based SEMMA without integrating magnets with PDMS. To do so, we proposed separating the magnet from the PDMS and driving the PDMS with the impact of the magnet. We used a retainer layer with a cylinder hole to limit the degrees of freedom of the cylindrical magnet. We used a multipole ring magnet rotated by a bulky motor to provide a varying magnetic field for the cylindrical magnet. Finally, we prototyped and evaluated a membrane-type actuator and applied it to disposable micropumps.

Chapter 3, "A SEMMA utilizing segmented NdFeB bonded magnets", aims to achieve a miniaturized PDMS-based SEMMA with simple integration and batch fabrication capability. We propose integrating bonded magnets with PDMS by dry-pressing wax powders and NdFeB magnetic powders in the PDMS molds. To improve the aspect ratio of the bonded magnets, we segmented one magnet into magnet stripes to reduce their self-demagnetization to improve the magnet's performance. To improve the packing density of bonded magnets to enhance the magnet performance further, we proposed combining a doctor blade technique with a micro pressor to fabricate the magnets. We then designed an actuator with a large force by searching the number of magnet stripes simulatively. Finally, we prototyped and evaluated a miniaturized membrane-type actuator.

Chapter 4, "A SEMMA utilizing a flexible coil", aims to develop a PDMS-based SEMMA with high flexibility and simple integration. We proposed integrating a flexible coil made of conductive polymer composite (CPC) with the PDMS by screen printing technique. Since CPC has not been utilized in SEMMA, we first investigated the suitable conditions for printing. Then we evaluated the basics of printed patterns. Afterward, the electrical stability of CPC was conducted, and thermal annealing was used to recover the increased resistivity of printed patterns caused by large mechanical deformations or loads. Finally, we prototyped and evaluated a flexible membrane-type actuator.

Chapter 5, "A SEMMA utilizing a FePt film as a magnetically structural material", aims to develop a simple SEMMA with a moving part using only one material as the structural and functional material. We proposed using a biocompatible thick-film FePt permanent magnet as the material for the moving part fabricated by the pulsed laser deposition (PLD) method. The FePt film plays a role not only in functional material but also in structural material. Due to the film exfoliation phenomenon, we fabricated the freestanding FePt films by PLD. We then tested the magnetic and mechanical properties of FePt films. Since part of the FePt acts as a permanent magnet, we adopted a magnetization method using laser-assisted heating to partially magnetize the FePt films. Finally, we prototyped and evaluated a cantilever-type actuator with a simple configuration.

Chapter 6, "Conclusions and outlook", summarizes the results of each chapter, as well as lists possible future research topics.