［様式－学 5］

Abstract of Main Thesis

June 30, 2011

Title of Thesis

Study on Fabrication Process of Polymer MEMS with Movable Structures Utilizing Hot Embossing

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Abstract on the Content of the Applicant's Thesis

This thesis presents the development of polymer MEMS (MicroElectroMechanical Systems) technology with unique and advantageous characteristics that are not available in conventional silicon MEMS. The developed fabrication technology, which relies on the hot embossing process, can produce polymer MEMS devices with movable microstructures. The advantages and practical applicability of the technology are demonstrated through the developments and characterizations of several polymer MEMS devices.

The proposed fabrication technology consists of four main steps, i.e. molding, direct bonding, releasing, and metalizing steps.

In molding step, hot embossing process was used. This process can be applicable for many kinds of polymer and can produce high precision microstructures. Mold fabrication technique, hot embossing equipment, and molding process have been developed. PMMA (Polymethyl methacrylate) microstructures with high aspect ratio of up to 15 (height/width ratio of 30μm/2μm) have been fabricated based on this molding technology.

In bonding step, surface activation direct bonding method using vacuum ultraviolet with wavelength of 172nm was applied. In this process, bonding material was not necessary. Moreover, in order to further improve the bonding strength and positioning accuracy, micro alignment-fitting structures were introduced.

In releasing step, conventional machining methods, such as elliptical vibration cutting and polishing, were applied to remove the PMMA layer remained from the hot embossing process. Reinforcement agent was used to protect the fragile microstructures during this machining process. Movable microstructures with minimum feature size of 5μm were released successfully without deforming or being broken. In metalizing step, sputtering process was used to form the electrodes for the polymer MEMS devices.

Based on this developed polymer MEMS fabrication technology, PMMA MEMS devices, such as electrostatic comb-drive micro actuators (minimum feature size of 5 μm), electrostatic scanning micromirror, thermal micro actuators and capacitive micro accelerometer have been fabricated and characterized. Thanks to the advantages of PMMA against silicon in terms of high flexibility, high thermal expansion, and so on, the fabricated PMMA MEMS devices have larger displacement and higher sensitivity than silicon MEMS counterparts.

As a conclusion, the developed polymer MEMS have shown good prospect for practical application compared with conventional silicon MEMS.