Environment Friendly MEMS Process

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Abstract

This work presents our recent research and development of environment-friendly MEMS fabrication technology based on an eco-friendly silicon deep reactive ion etching (D-RIE), and polymer-MEMS utilizing hot embossing process. In order to show the capability of this 'Green' fabrication technology, several typical MEMS devices have been fabricated successfully.

Regarding silicon dry etching technology, the often-used gas SF_6 which has very high Global Warming Potentials (GWP) should be replaced by other lower GWP gases, such as Ar/F_2. First, the gases were selected with consideration of the simple handle and less danger. Then, Si etching experiments corresponding to these gases were performed and analyzed systematically to find out the most suitable process which can reduce or replace SF_6 gas. Furthermore, the etching rate improvement was also studied based on process's real-time monitoring and feed-back control technology to optimize the timing of deposition and etching steps (Bosch process); therefore, bias RF power can be smartly controlled during the process.

In polymer-MEMS technology, we have developed a novel fabrication of a monolithic PMMA MEMS devices utilizing hot embossing, surface-activated direct bonding, polishing, and elliptical vibration cutting processes. The robustness and capability of the method are demonstrated through the fabrication of sophisticated PMMA freestanding micro structures and devices. An efficient technique using reinforcement material to protect the PMMA microstructures during release process was proposed. Small Young's modulus and high thermal expansion of polymer are the advantages for electrostatic and thermal actuators, respectively, because it will require less power than silicon counterparts to produce the same displacement. All PMMA acceleration sensor, actuators and mirror device have been fabricated to shows the advantages of polymer-MEMS technology. Fig. 1 shows typical MEMS devices made of PMMA polymer by using our polymer-MEMS fabrication process.

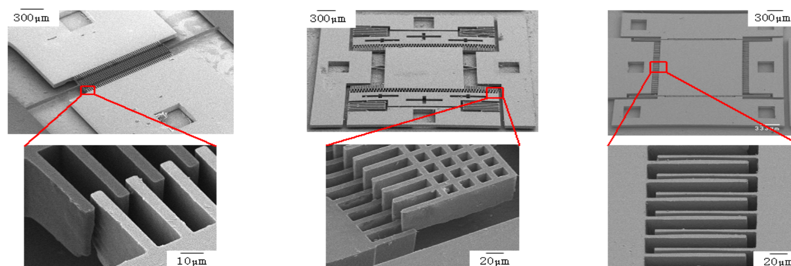

Fig.1: PMMA-MEMS devices [1, 2]: (a) electrostatic actuator, (b) micro mirror, and (c) accelerometer

Combination of the 'Green' D-RIE and hot embossing will ultimately promise a breakthrough towards completely eco-friendly MEMS technology.

References:

[1] S. Amaya, Dzung V. Dao and S. Sugiyama, "Development of Polymer Electrostatic Comb-Drive Actuator Using Hot Embossing and Ultra-Precision Cutting Technology", Journal of Micro/Nanolithography, MEMS, and MOEMS (JM3), Vol. 8, No. 043065, 2009.

[2] S. Amaya, Dzung V. Dao and S. Sugiyama, "Development of Monolithic PMMA Comb-drive Micro Actuator Utilizing Hot Embossing and Ultra-precision Machining", 22nd IEEE Conference on Micro Electro Mechanical Systems (IEEE MEMS), Italy, pp. 713-716, 2009.