Fabrication and application of world's smallest polymer bonded permanent rare earth micro-magnets for MEMS/NEMS Devices

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Summary: The focus of this talk is on fabrication process and applications of polymer bonded rare earth micro-magnets in MEMS/NEMS devices. We report fabrication of worlds smallest polymer bonded micro-magnets down to a feature size of 5 µm.

Introduction: Over the last 30 years there has been an increasing interest among the MEMS and microfluidics communities to develop fabricate permanent rare earth micro-magnets. It is a well known fact that magnetic micro-actuation can generate significantly high forces over long working distances. This property is very attractive for many new and potentially disruptive commercial micro-devices, including: MEMS micro-motors, micro-generators, and bistable µ-switches for sensing and micro-positioning; RF-MEMS telecommunications (low-frequency switches, magnetic isolaters, couplers); and BioMEMS for separation of biomolecules immobilized on magnetic particles or beads, centrifugates, pumps and valves for on-chip fluid manipulation, and swimming mechanisms for microdevices [1].

Challenges: Various techniques which have been reported to micro-pattern magnetic materials, such as screen printing, resin bonding, wax bonding, polymer bonding, tape casting, sputtering and wet chemical etching [2]. However, these fabrication techniques are not compatible with Polymer MEMS fabrication technologies. Hence, fabrication of micro-magnets and its integration with MEMS devices still remains a challenge.

Solution: Last 10 years have seen a significant improvement in rare earth magnet powder manufacturing technology. Magnequench Molycorp Inc, pioneers in the field of isotropic rare earth magnet magnetic power manufacturing have developed magnetic powders with particle size of 1.5-2.5µm (MQFP-12-5-D10) [3]. Such magnetic powders have proved to be a game changer for Polymer MEMS Industry. Polymers (such as PDMS, SU-8, KMPR etc) can be doped with MQFP powders and can be easily micro-patterened by employing standard Polymer MEMS fabrication processes. The isotropic magnetic powders do not require alignment of particles during the MEMS fabrication process. Hence, making it easier to integrate micro-magnets in MEMS devices.

Examples[1]: We will discuses two examples in this talk: (1) Array of 5µm micro-magnets, (2) Permanent cantilever's capable of bidirectional actuation with a width of 25µm, height 25µm and length 100 µm.

References:

1. A. Khosla et al; "Micropatternable Multifunctional Nanocomposite Polymers for Flexible Soft NEMS and MEMS Applications" ECS Trans. 2012 volume 45, issue 3, 477-494
2. N Pamme, Lab Chip, 2006, vol. 6, pages 24-38
3. http://www.mqitechnology.com/isotropic-small-particle-size-grades.jsp

[1] The micro-magnets and micro-cantilevers were magnetized at Job Master Magnets Canada Inc, Oakville ON, Canada. http://www.jobmastermagnets.com