Concepts and Key Idea

Though MEMS piezoelectric actuators can provide very high force output at low driving voltages, they have a very small strain, typically only a couple of tenths of one percent, leading to very limited applications in real world. A new method of amplifying the small strain of in-plane piezoelectric actuators has been developed. Very compact in-plane piezoelectric actuators with a few percent of strain will enable very compact MEMS devices replacing the existing bulky electrostatic actuators. The entire device is designed and fabricated using batch micro-fabrication techniques, averting the need for costly micro-assembly of the actuator with a piezoelectric element.

Design and Fabrication

The strain amplification is achieved through the fabrication of a compliant mechanism. A piezoelectric membrane, made of PZT, is situated in the middle of four parallel guiding linkages comprise the actuation mechanism. The pivot points are small length flexural pivots, or living hinges designed to approximate an ideal pivot, but without any backlash associated with a real pivot. Because the angles the pivots subtend are small, the pivots behave close to ideal. By amplifying the membrane displacement, the compliant structure sacrifices some piezoelectric force, however, the PZT membrane provides sufficient force that the output force is still desirable (order 100 µN). Each actuator has a form factor of 500 µm X 500µm X 30µm, and the expected output displacement is 6 µm. The actuator can easily be arrayed in n-parallel to gain an n-times force advantage or in series to gain an n-times displacement advantage, with the drawback of increased form factor.

The compliant mechanism is made of SU-8, which allows the entire device to be surface micro-machined. The PZT membrane is fabricated first, followed be the SU-8, followed by a release. A process for single-crystal silicon-based compliant mechanism has also been devised. Batch fabricated in-plane micro-piezoelectric actuators have not been done before to our knowledge. As this is an ongoing project, no experimental results of a final device are available.