Electrostatically Driven Micro-Hydraulic Actuator Arrays

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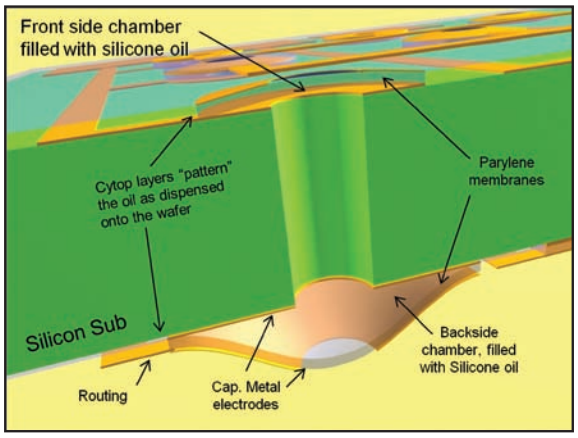
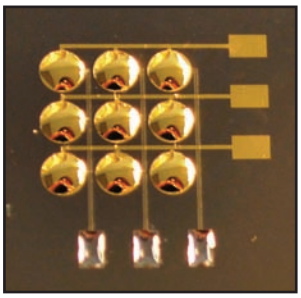
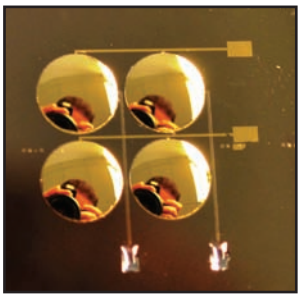
High-force, large-deflection actuators are critical for devices such as valves and pumps used in micro-fluidic systems, for surface bump manipulation in tactile displays, and for micro-airfoil control. However, existing transduction methods such as piezoelectric, electro-magnetic, or electrostatic are limited in their ability to provide such actuation in low-power integrated microsystems.

We have now demonstrated an all-electric individually addressable micro-hydraulic actuator array that meets these goals using hydraulic amplification and electrostatic control. A novel high-yield, wafer-level fabrication technique allows bubble-free encapsulation of a liquid that acts both as an hydraulic fluid and as a capacitor dielectric (top image.) The fabricated microsystem consists of 2 × 2, 3 × 3, and 4 × 4 arrays of actuator cells (bottom image.) A curved electrode capacitive actuator with a diameter of 2.2mm driven at 200V produces 30μm deflection on the front side at 14kPa of pressure, which corresponds to a 11mN force generated by the capacitive actuator on the back side. Actuation occurs from DC to 15Hz. This architecture offers considerable performance advantages over the previously introduced micro-piston hydraulic actuator array, and the liquid-encapsulating fabrication technology is transferrable to other MEMS applications. ■



Schematic cross section of the hydraulic actuator.





Fabricated arrays of liquid-encapsulated actuators.