A 1mm Diameter Autonomous Tubular Microrobot


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Our research has been focused on developing the mechanisms necessary to make sub-millimeter robots a reality. We are exploring how to make programmable matter; a modular robotic system designed to scale to millions of units. Similar to how audio and video technologies reproduce sound and moving images, respectively, we are investigating ways to create a physical artifact that will be able to mimic the original object's shape.

Our microrobot design incorporates two sub-systems: 1) a photolithographically fabricated bi-layer structure (Figure 1) which depends on residual stress to bend into a tubular shape upon release from the substrate, 2) a high voltage (up to 100V) CMOS chip (Figure 1) which includes circuitry for high voltage generation (charge pump), logic, and a high voltage driver (Figure 3). The tube and the chip are bonded using a flip-chip assembly to form the robot (Figure 2).

The microrobot uses electrostatically coupled electrodes near the surface of the robot for all required functionality: it gathers power from an external grid (Figure 3, “powered floor”) using capacitive coupling, and locomotion is achieved by making use of the electrostatic forces created by the charged electrodes (Figure 3, “actuation electrodes”).

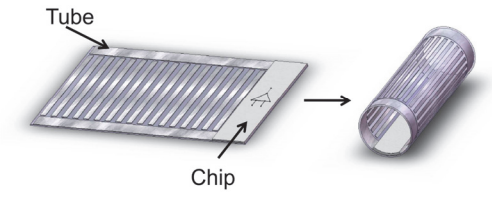

Fig. 1: Tube and chip bonded to form the microrobot.

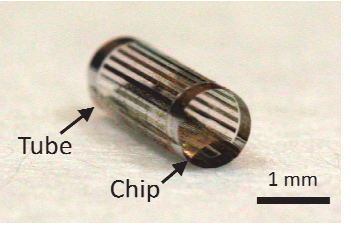

Fig. 2: The fabricated microrobot (metallic pads are the electrodes).

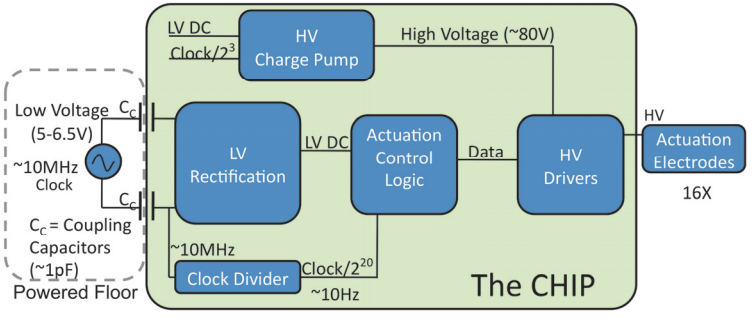

Fig 3: Chip system level schematic.