Transpiration Actuation: Extracting Work From Evaporation

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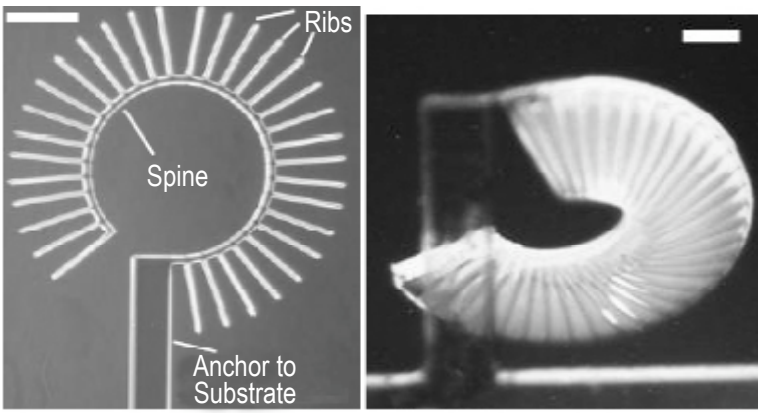

The goal of this project is to use evaporation to generate work. We have developed and fabricated a new class of microactuators built by exploiting surface tension, and inspired by the spore-release structure used in ferns. The devices are driven by the same Laplace-Young pressure mechanism that leads to conventional MEMS wet-release stiction. These kinds of actuators are ideal for applications where energy scavenging from the environment is desirable, and can be used to generate electrical power. The methodology in this work leverages advances made in the fabrication of microchannels and MEMS actuators. Deflection profiles can be programmed by device geometry. Many of the actuator technologies used in MEMS focus on electrostatic devices that require complex processing. This work combines the mechanical and fluidic domains in a simple process to provide low-power actuation. We have demonstrated millimeters of deflection using liquid evaporation alone. Devices that were 2mm in length deflected more than 4mm at the tip. Various geometric parameters have been varied and tested. These parameters, in addition to thickness and light intensity, can be controlled to program the deflection profile. By varying the spacing and geometry of water-trapping ribs along a center spine, the magnitude and distribution of force and deflection can be patterned into the structure. Individual devices were combined to interlock during actuation and self-assemble into a steady state configuration. Previous work in MEMS has utilized surface-tension-driven actuation to determine the mechanical strength of polymers, self-assemble microhinges using liquid-to-solid phase solder, and make electrical contacts. In this work, as force is derived from the room-temperature evaporation of water, it enables a low-power actuation scheme through environmental energy scavenging. This project is supported by Grant CMS 0556271 from the National Science Foundation.