NANO HIGHLIGHT

Thermally Actuated Untethered Impact-Driven Locomotive Micro-Devices

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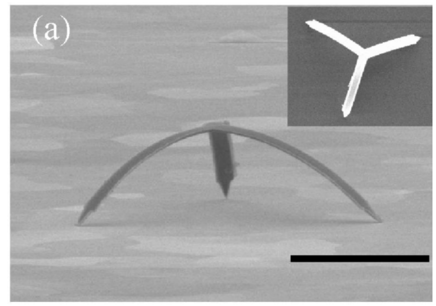
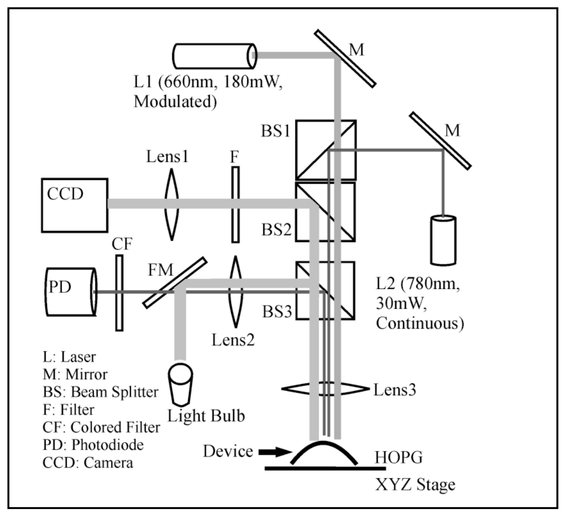
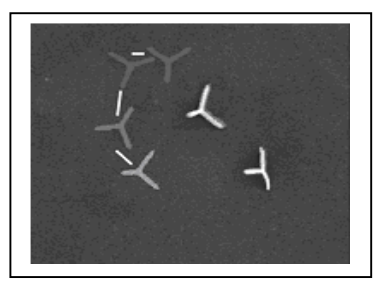
Biology accomplishes locomotion in many ways, including the motion of legs to move insects and animals over surfaces. What if we could accomplish such locomotion in silicon devices? The convergence of robotics with microelectromechanical systems (MEMS) offers the promise of devices that can roam over space and perform tasks remotely. Tasks such as the recovery and reconfiguration of micro-materials have been considered. The strategy for movement over surfaces has included the gait of multiple legs, the progressive motion through device deformation similar to crawling (scratch drive actuator) and the motion caused by the rapid transfer of momentum from an isolated segment to the entire device, which we refer to as impulse-drive. In the smallest size ranges, these devices have ranged from the mm scale in the case of the impulse-drive down to 200 μm for the scratch drive. We have fabricated simple 30 μm devices that can roam over a surface using thermal energy. The devices are created from thin layers of silicon and metal, and the interaction between the two materials causes the sheet to curve. We take advantage of this curvature to create a “spider” that stands on three symmetrical legs. When one of the legs is heated, the leg will curve even more because the metal expands more than the adjacent silicon layer. This is often referred to as a “bimetallic effect”. If one leg is rapidly heated by a laser pulse, then it will bend so fast that the rest of the device remains still while the bending leg slips forward. Then, as the device cools more slowly, the device moves forward as the legs regain their earlier shape. This is similar to how some wind-up toys skitter across a surface through a series of sudden jerks.







The detailed nature of the motion of the sliding spiders has been detected by the use of a second laser beam that reflects off of the spider leg. As the leg bends, the laser light reflection moves, and this beam motion can be used to deduce the shape of the leg during the heating and cooling stages. Using this technique, we have determined that the step sizes of the device are as small as 25 nanometers each, and that the largest velocities achieved are around 100 μm/s . By choosing which leg we shine the laser on, we can steer and direct the motion of the microspider.

References

[1] For further information about this project email Richard Superfine at **rsuper@physics.unc.edu**
[2] O. Sul, et. al. “Thermally Actuated Untethered Impact Driven Locomotive MicroDevices”, Appl. Phys. Lett, (in press)