High-Force, Large-Displacement Micromotors

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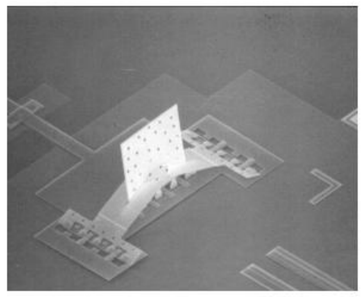
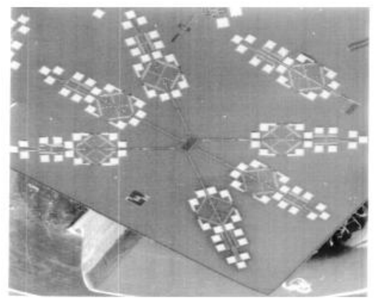
Overview: A parallel process for fabricating 3-dimensional micromechanisms has been developed with integrated on-chip, high force thermal micromotors. Fabricated devices include a three-degree-of-freedom (3-DOF) platform manipulator for adaptive optics, a 6-DOF platform manipulator for high-dexterity surgery, a 1-DOF Fabry-Perot interferometer for optical strain sensing, and other applications where mechanical robustness, large displacements in three dimensions, precise motions, and integrated actuation are desired. Poly-Si surface-micromachining has been used for initial devices, and a 3-wafer DRIE/SOI/SFB process has been developed for high aspect-ratio micromotors and associated micromechanisms. A variety of devices demonstrated to-date are shown below:



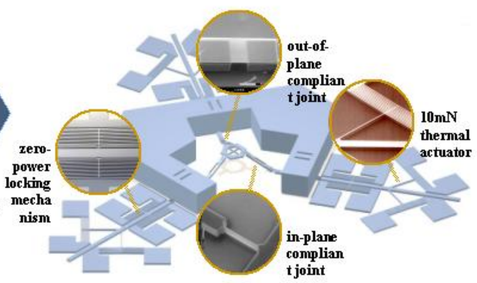
1-DOF Fabry-Perot interferometer for optical strain gauge demodulation



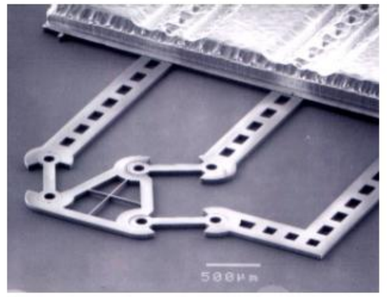
Surface-micromachined 6-DOF surgical micromechanism

Macro-scale parallel manipulator

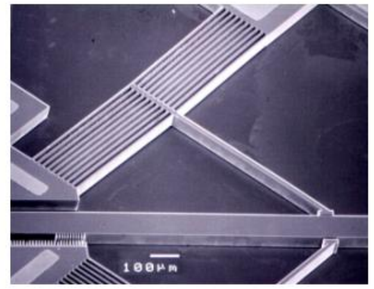
- *Miniaturize*
- *integrate*
- *Automate*



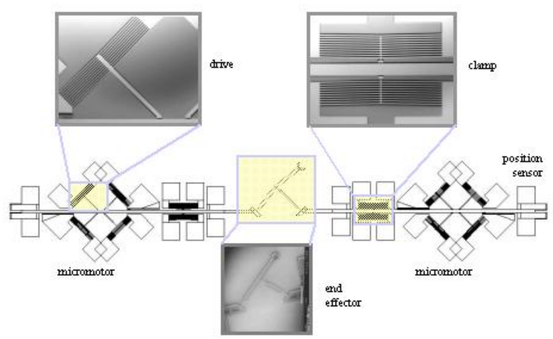
Single-crystal silicon spatial micromechanism
3DOF, $(200\mu m)^3$ workspace.



Three micromotors driving a 3-DOF planarmicromanipulator

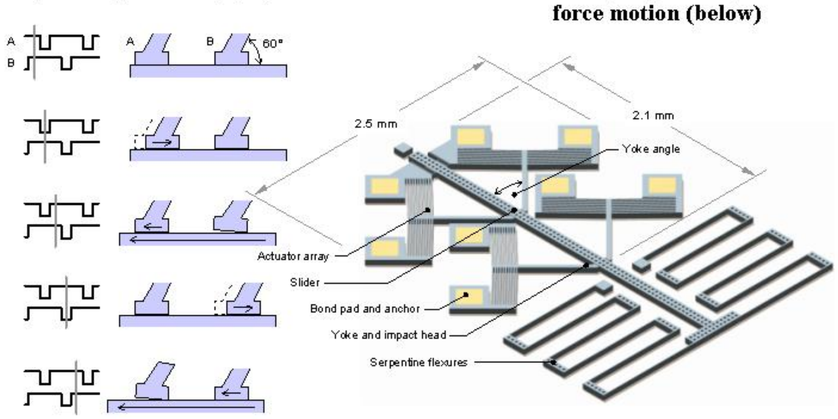


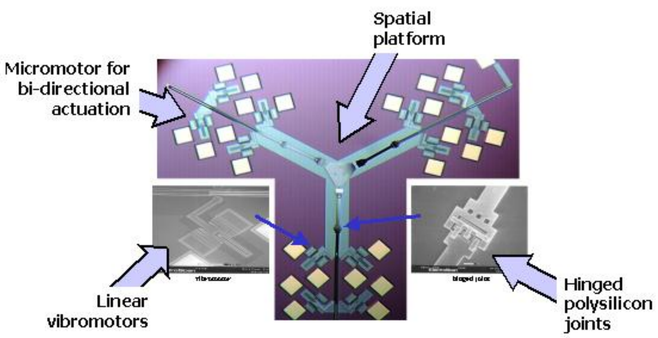
SEM showing detail of electrothermal micromotor actuators and slider



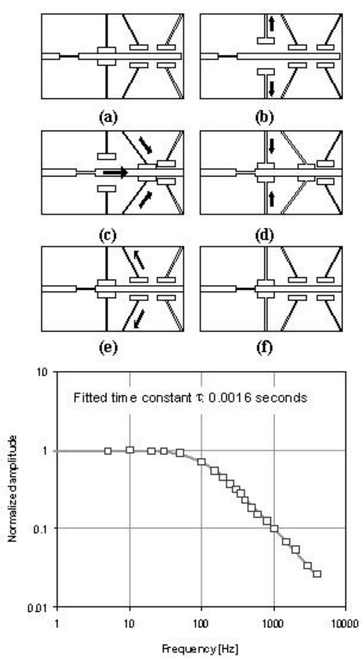
2-DOF micromechanism with integrated linear thermal micromotor

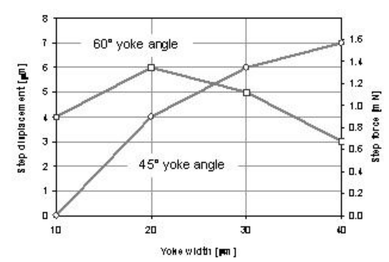
Control signals for micromotor operation - several configurations have been explored, including zero-power clamped actuator arrays for low-power operation (right) and double-arm actuation for high-speed, high-force motion (below)



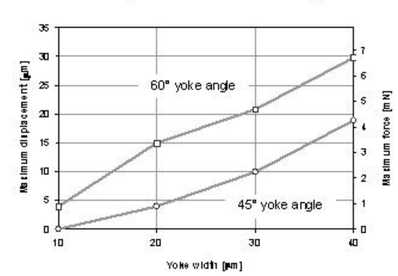


Surface micromachined 3DOF spatial micromechanism using linear vibromotors





Displacement and force for one actuator step versus yoke width and angle



Maximum displacement and force vs. yoke width and angle