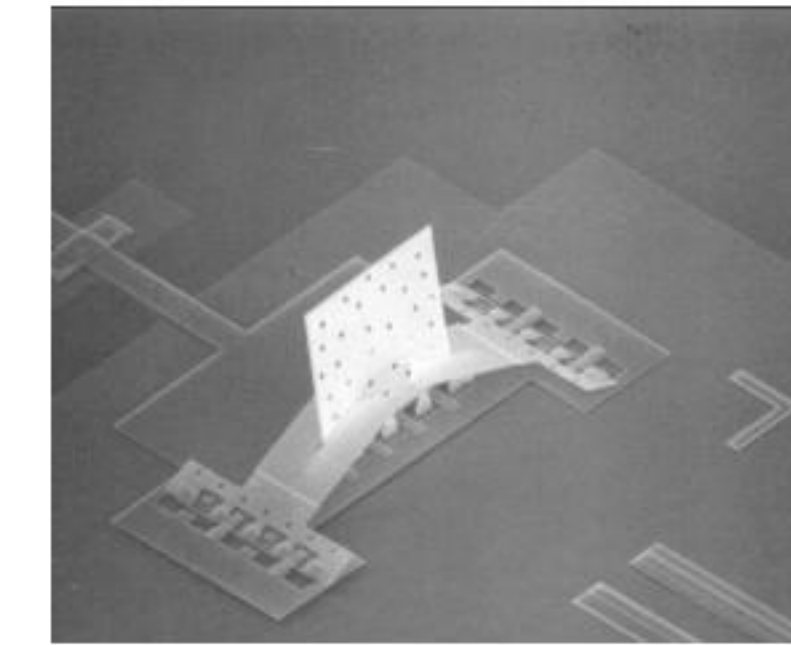
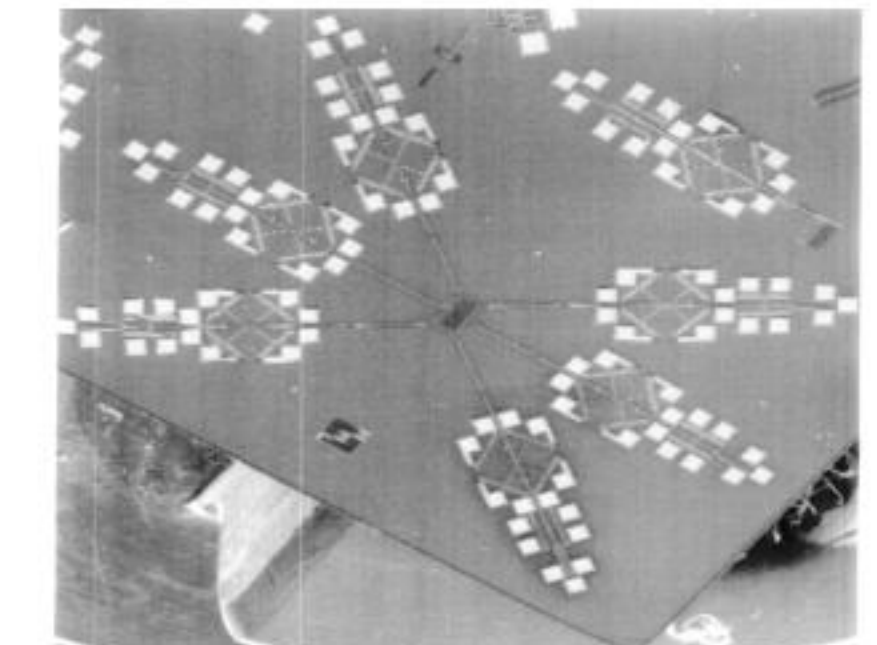


Overview: A parallel process for fabricating 3-dimensional micromechanisms has been developed with integrated on-chip, high force thermal micromotors. Fabricated devices include a three-degree-of-freedom (3-DOF) platform manipulator for adaptive optics, a 6-DOF platform manipulator for high-dexterity 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:



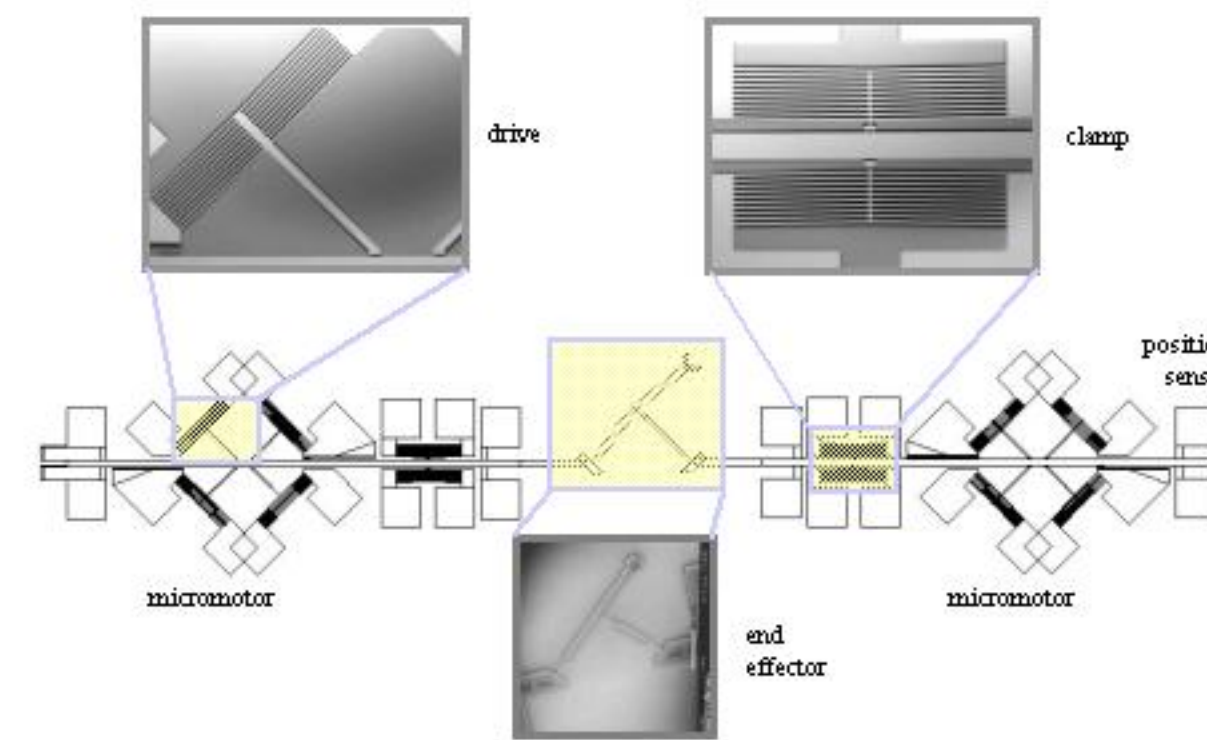
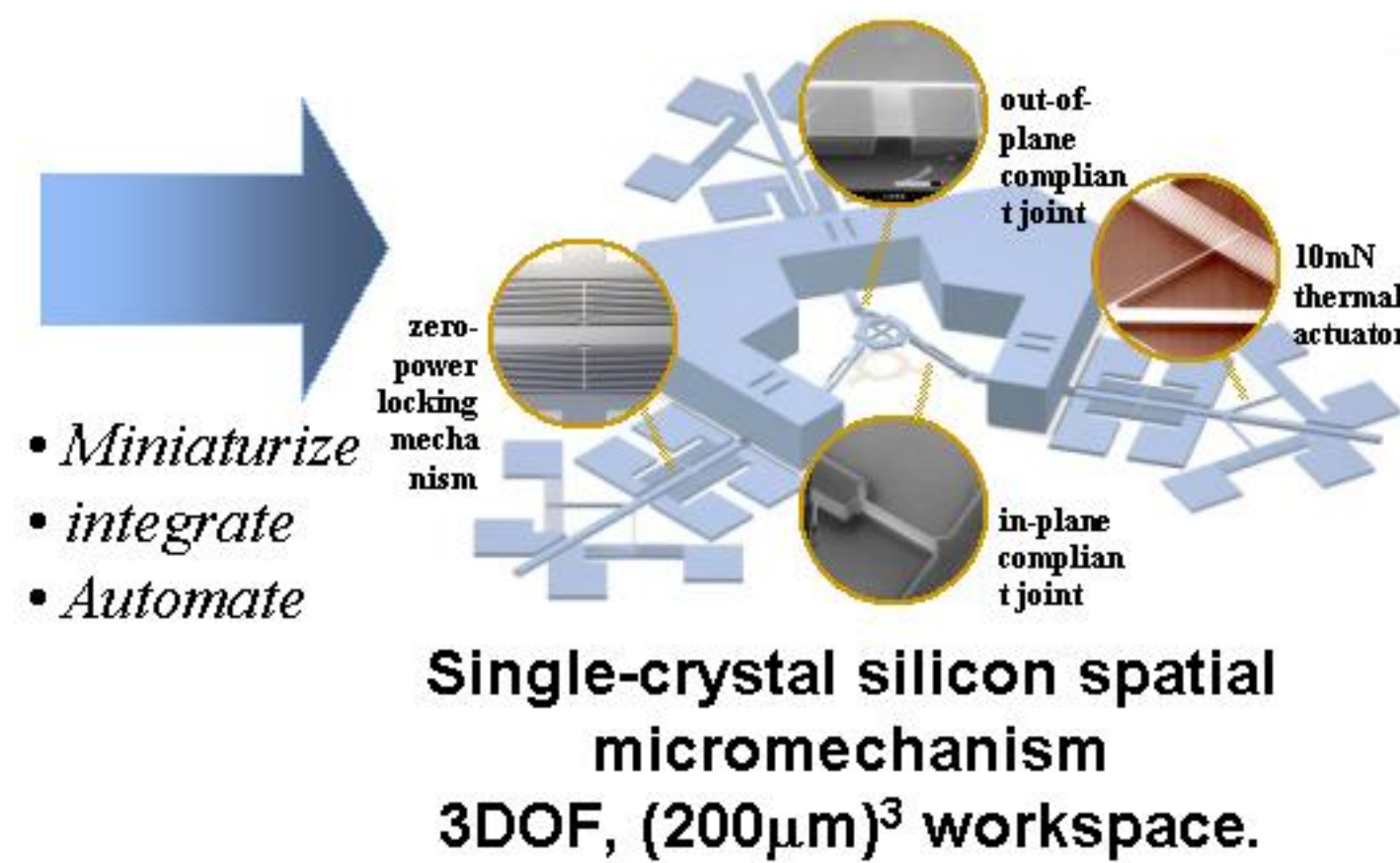
1-DOF Fabry-Perot interferometer for optical strain gauge demodulation



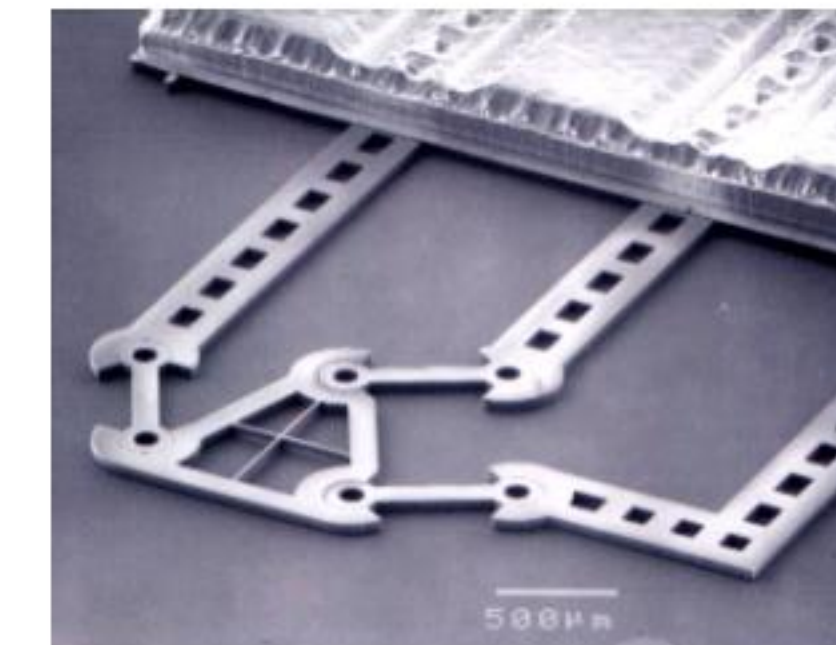
Surface-micromachined 6-DOF surgical micromechanism



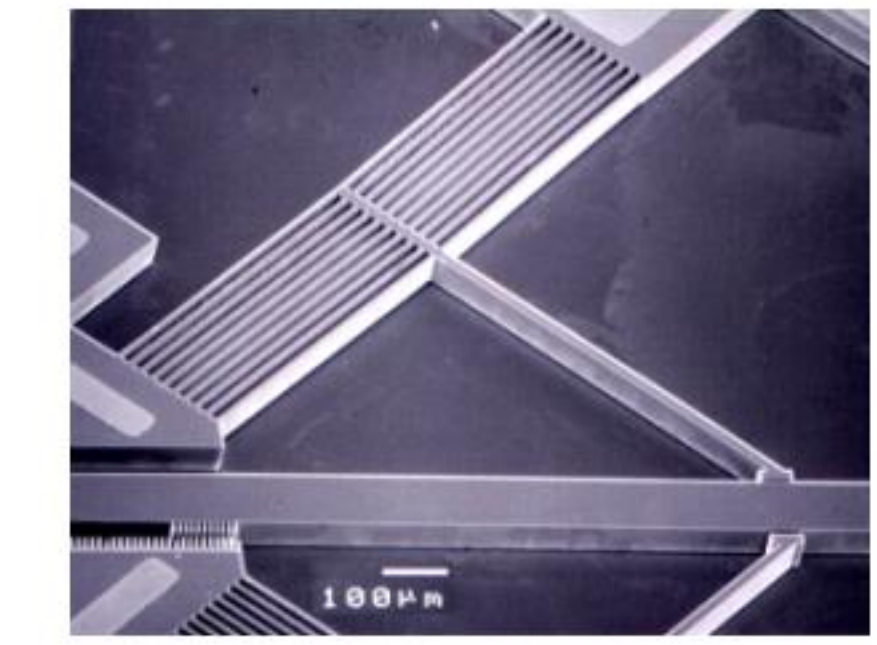
Macro-scale parallel manipulator



2-DOF micromechanism with integrated linear thermal micromotor

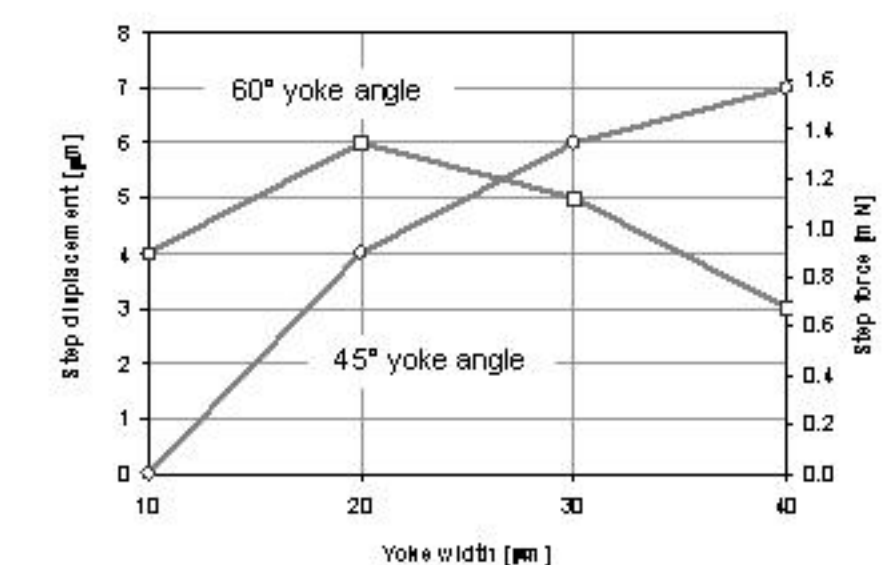
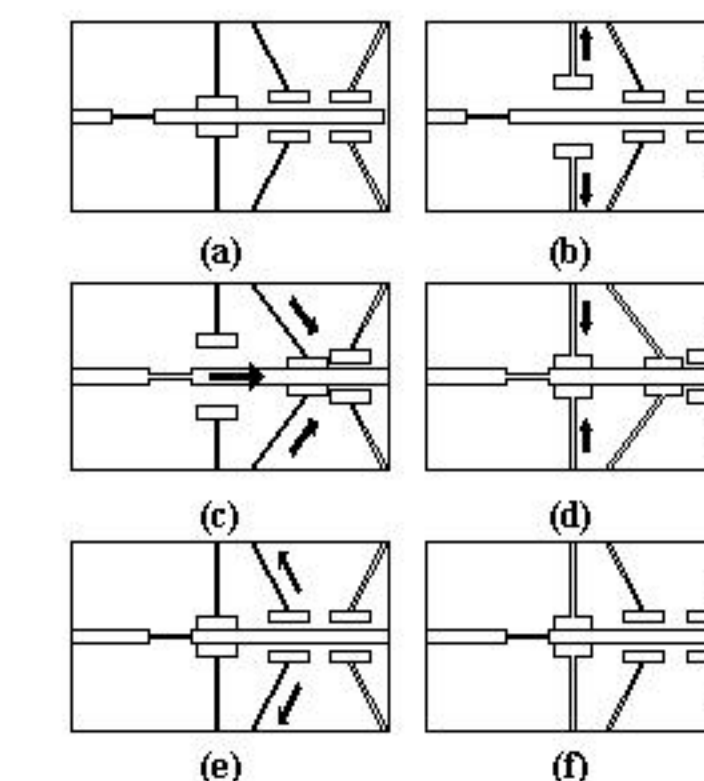
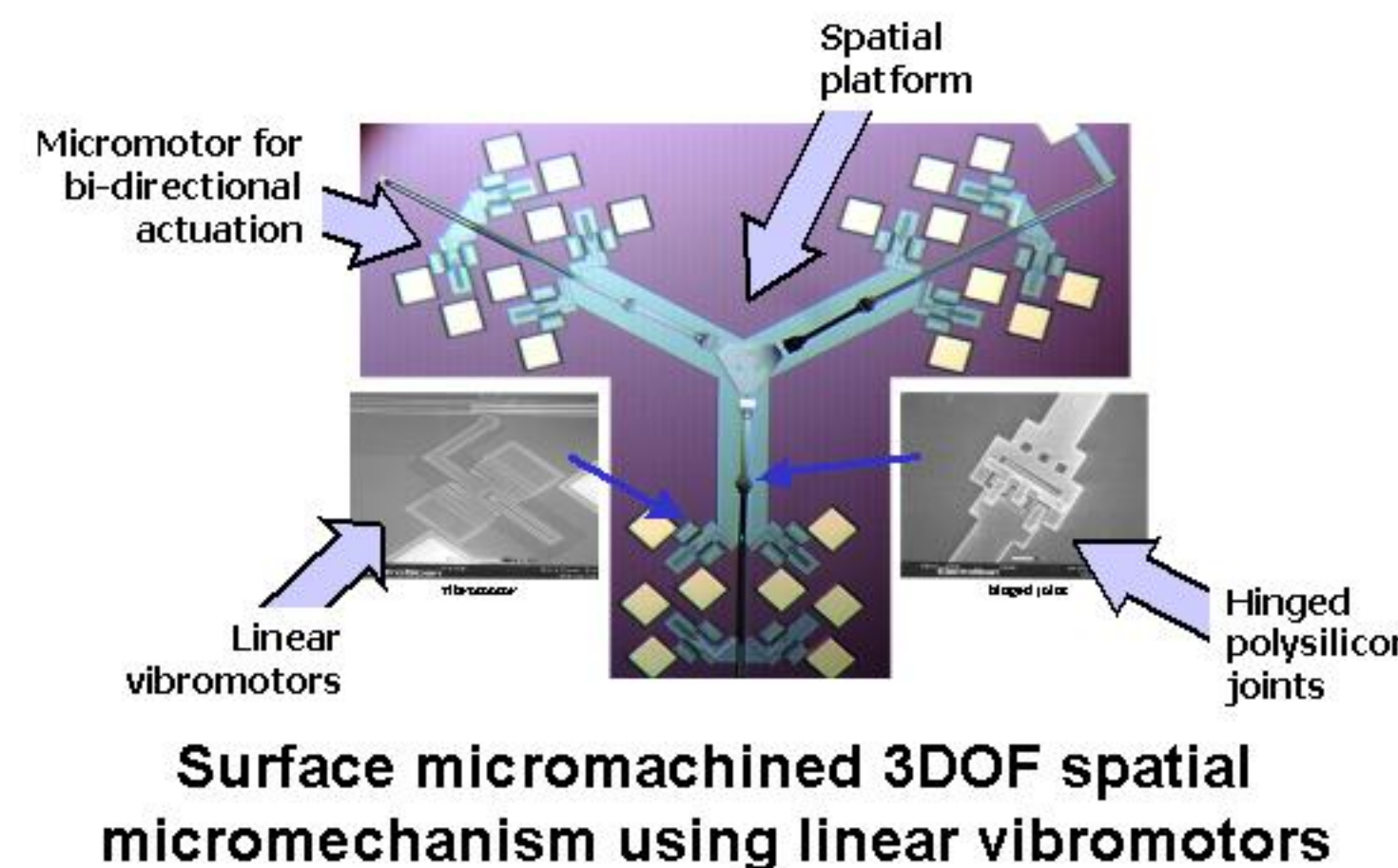
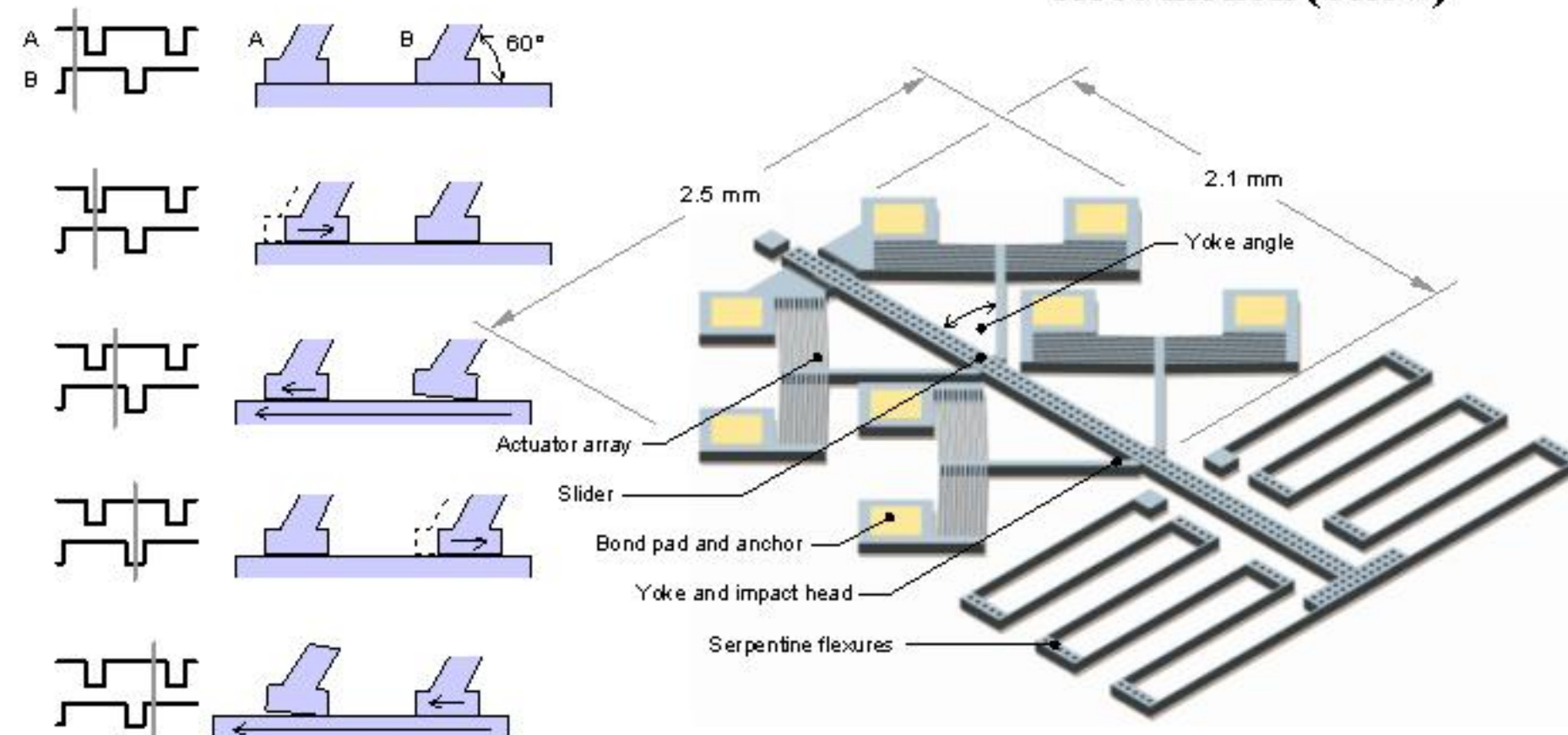


Three micromotors driving a 3-DOF planar micromanipulator

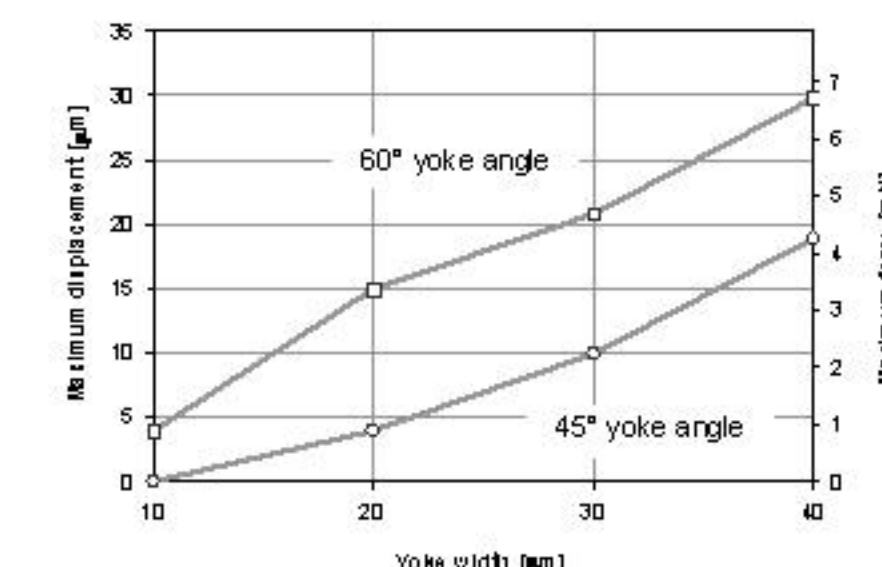
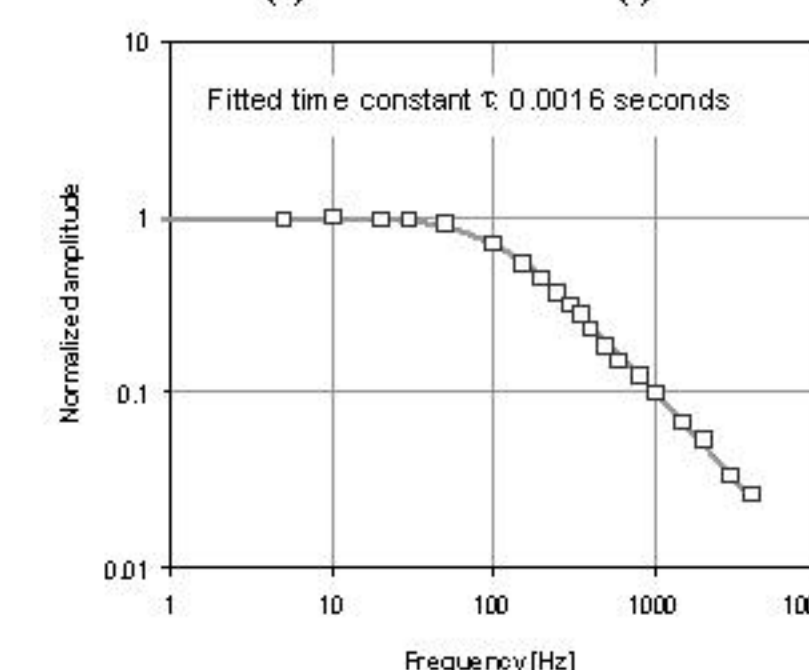


SEM showing detail of electrothermal micromotor actuators and slider

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)



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



Maximum displacement and force vs. yoke width and angle