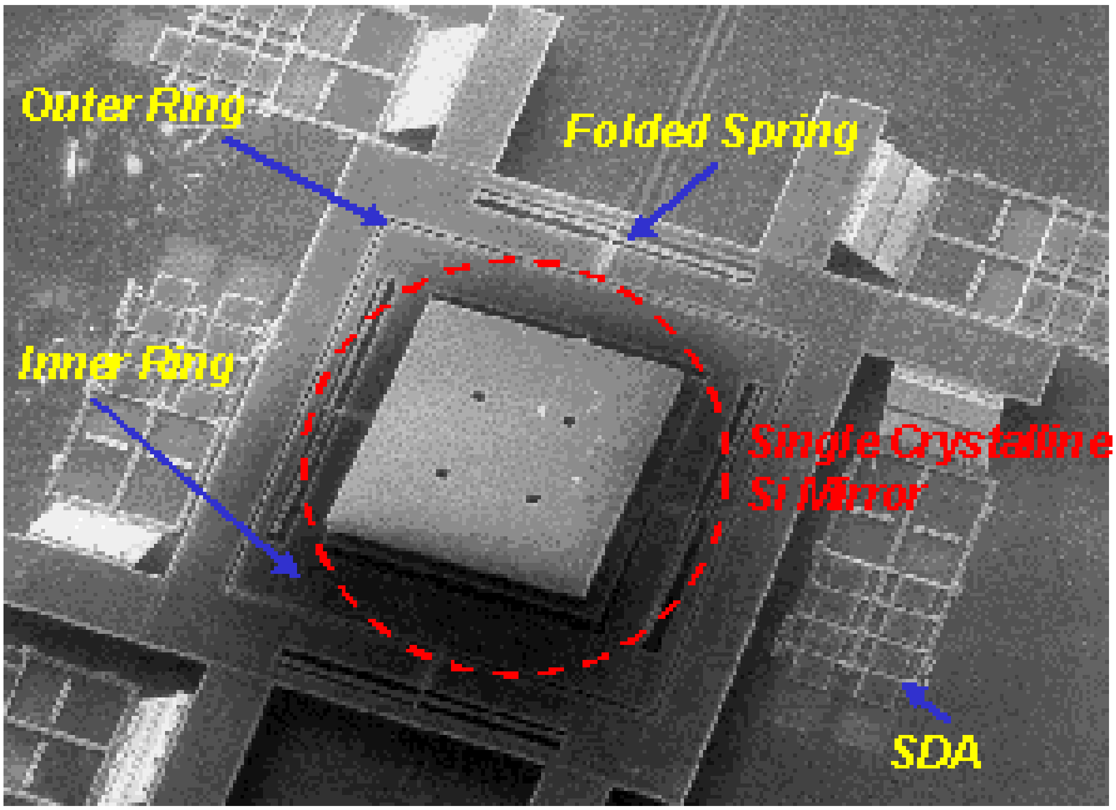
2-D MEMS scanner features single-crystalline silicon micromirrors

Surface micromachining techniques create 450 µm x 450 µm, nearly flat mirror capable of scanning through 7.5°.



By fabricating single crystal silicon mirrors on surface-micromachined polysilicon actuators, researchers at the University of California, Los Angeles (UCLA) have produced optical scanners 450 µm x 450 µm micromirrors with radii of curvature greater than 265 cm (see Figure 1).[1] The wafer scale process combines bulk- and surface-micromachining technology, and generates optical surfaces with roughness of less than 10 nm.

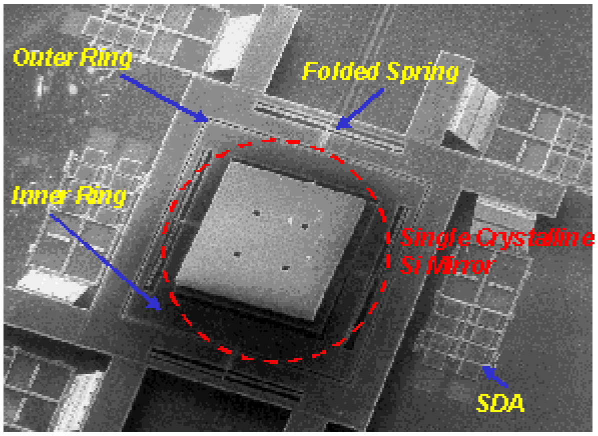


Figure 1. Single crystal micromirror yields flat, smooth optical surface. (Courtesy of UCLA

Micro-electro-mechanical systems (MEMS) technology is all the rage right now in optical switching circles (see MEMS technology grabs the telecom spotlight). Key components of these devices are thin film micromirrors, typically fabricated using polysilicon surface micromachining techniques. Unfortunately, residual thin film stresses distort the mirror surface, imposing radii of curvature on the order of a centimeter or two.

Meanwhile, optical applications require micromirrors with a surface roughness of better than l/10 and a radius of curvature of great than 30 cm. The single-crystalline mirrors developed by the UCLA group offer a fabrication method for routinely producing flat components for a variety of applications.

Manufacturing process

In the scanner, folded springs attach a micromirror to a nested ring. To fabricate the single-crystalline mirror, the group first selectively bonded a thinned silicon-on-insulator (SOI) wafer to the polysilicon actuators using hard-baked photoresist (AZ 4620). A deep reactive ion etch (DRIE) removes the SOI wafer substrate, then the buried oxide layer is etched away by HF. The single crystalline silicon mirror is patterned and aligned to the polysilicon actuators using photolithographic techniques and

DRIE. After releasing in HF solution, the MEMS 2D scanner is assembled by the on-chip actuators.

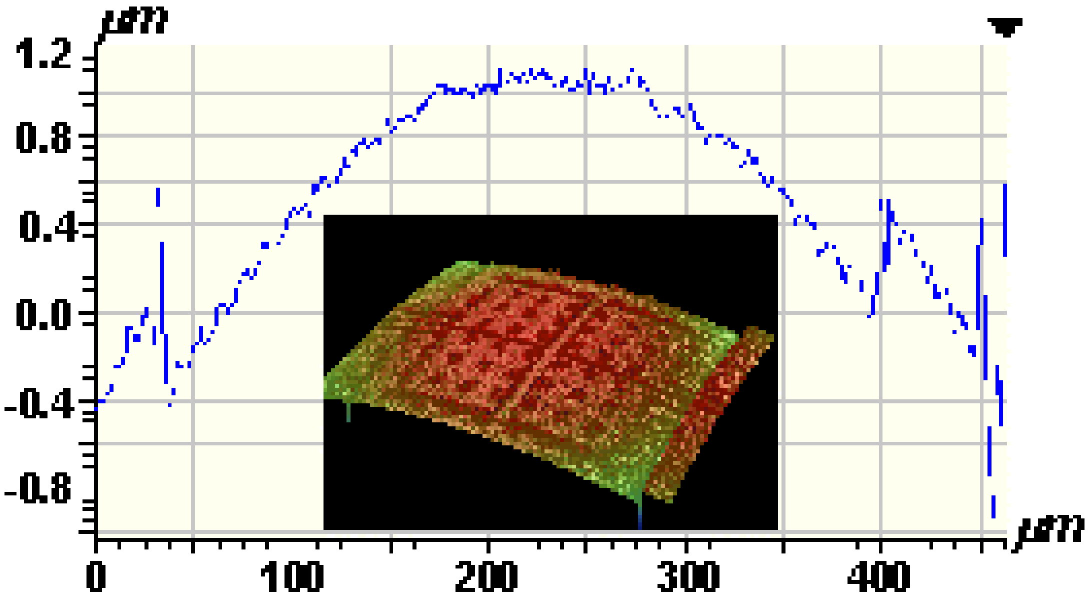
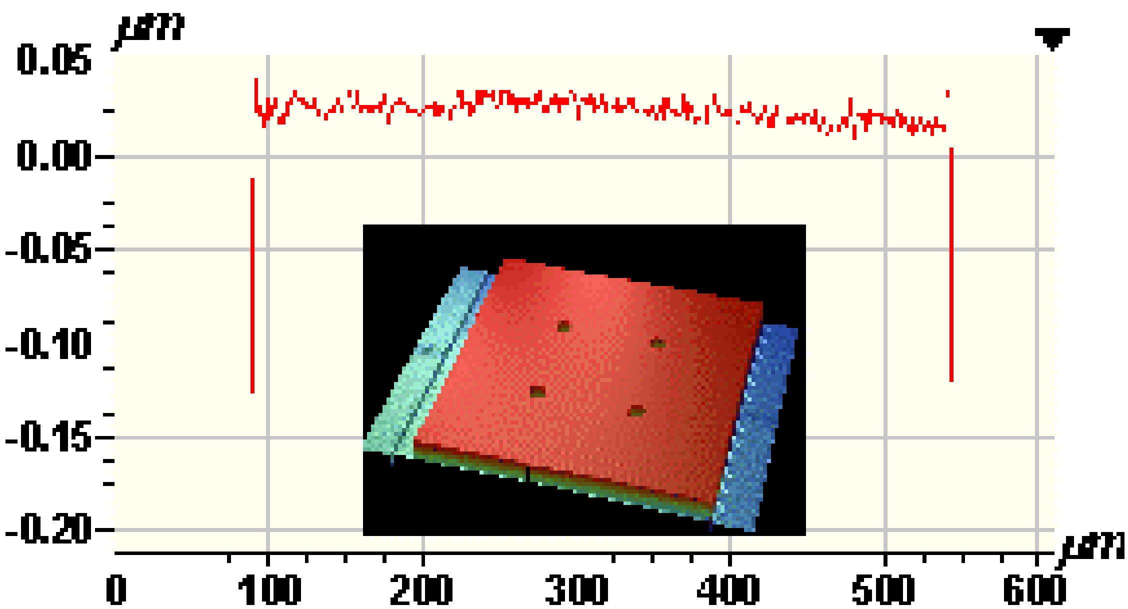


Figure 2. Cross section profile and 3D plot of polysilicon mirror (top) and single crystalline (bottom) show 1.8 cm curvature (1.15µ deformation) for polysilicon element compared to 265 cm curvature (10 nm deformation) for single crystalline components. Courtesy UCLA



After the release and assembly steps, the group measured the mirror surfaces using an interferometric surface profiler, and comparing the results to those from a conventional thin-film polysilicon mirror manufactured by Cronos (Research Triangle Park, NC). According to estimates based on the surface deformation, the polysilicon mirror exhibited a radius of curvature of 1.8 cm, compared to the 265 cm radius of curvature displayed by the single-crystalline silicon mirror (see Figure 2).

The scanner assembly can scan the mirrors through 7.5°. According to UCLA researcher John Su, the 3-dB frequencies of the single crystalline and the polysilicon micromirrors are 230 Hz and 280 Hz, respectively. In both cases, performance is limited by squeeze film damping of the air.

References

1. G.J. Su, H. Nguyen, et. al, "Surface-micromachined 2D optical scanners with high-performance single-crystalline silicon micromirrors," CLEO 2000 postdeadline paper #CPD21, San Francisco (2000).