Nano-Accurate Assembly Technology for X-ray Foil Optics

Personnel

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Future X-ray astronomy missions will require orders of magnitude improvement in collecting area and resolution. Foils optics are attractive candidates for X-ray telescopes because of the tremendous weight and cost savings which can be achieved compared to traditional monolithic optics. However, substantial improvements in our ability to assemble foils to high accuracy are required. In this research program we are developing microstructures to assemble foil optics, including both reflective and diffractive components.

Plasma micromachining is used to lithographically fabricate silicon microstructures designed to guide and register silicon and glass foils into precise three-dimensional shapes with sub-micron accuracy. Thousands of 200-400 μm-thick foils are typically required in an X-ray telescope, each shaped and assembled to form the precise flats or curves that focus X-rays by grazing-incidence reflection. Figure 14 shows SEM images of two types of microcombs under development.

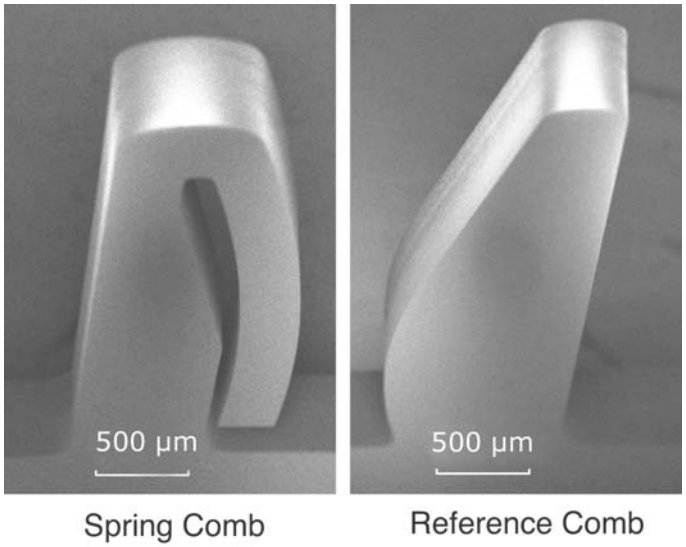

Figure 14: Electron micrographs of silicon microcombs. Teeth are ~500 μm wide. a) Spring comb. b) Reference comb.

A prototype flight mirror structure based on these principles has been built and tested. Test results show that glass sheets are assembled to an accuracy of ~1 micron, corresponding to an angle error of ~1 arc-second. This accuracy exceeds previous foil assembly methods by a factor of ~100. Our microstructure technology is being supported by NASA as the baseline technology for assembling the optics in the *Constellation X* telescope.

Recent effort seeks to improve the accuracy of the microcombs from the current level of ~200 nm to under 20 nm. At the improved level it may be possible to achieve diffraction-limited X-ray imaging, which can potentially improve the accuracy of telescopes by over 1000X.