Microsheet X-ray Optics Shaping Technology

Personnel

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Sponsorship

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Future X-ray astronomy missions will require orders of magnitude improvement in collecting area and resolution. Foil "microsheet" 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 shape foils to high accuracy are required. In this research program we are developing technology for high-volume shaping of glass and silicon microsheet optics, including both reflective and diffractive components.

Over the last several years we have developed methods for thermally shaping glass microsheets. This process involves heating the glass sheet in a furnace until it begins to slump, conforming to quartz or silicon mandrels that have been lithographically patterned with thousands of pins. The pins reduce the surface area of the mandrel to minimize sticking and mitigate the effects of dust particles. We are also developing an alternative slumping method based on air bearings.

We are also developed a complementary shaping process called block lapping. This novel process involves the bonding of microsheets to rigid polishing blocks, while in their relaxed state, using special UV-cure epoxies and thermoplastics. The bonded sheets are then mechanically polished into the desired shape.

A third method involved a process called Magneto-Rheologic Finishing (MRF) to deterministically shape the surface of the substrate. A magnetic polishing compound is entrained onto a spinning sphere that is scanned over the substrate. A magnetic field rigidizes the fluid in a confined area generating high shear polishing forces. This method requires an accurate surface error map as input to the MRF shaping machine.

A critical component of this research is accurate surface metrology of thin sheets. We are developing a variety of Hartmann and Shack-Hartmann surface metrology tools for this purpose, and special fixturing that holds the sheets during metrology while minimizing holding torques and gravity distortions.

Our short-term goal is to develop microsheet shaping technology with 500 nm accuracy. This will enable a number of important NASA missions such as Constellation X. Our long term goal is to realize sub-20 nm shaping accuracy, which will enable diffraction-limited X-ray imaging with potential resolution improved 1000X over today's telescopes.