Manufacturing & Prototyping

Fabrication Method for LOBSTER-Eye Optics in <110> Silicon

The major advantages are the potential for higher x-ray throughout and lower cost over the slumped micropore glass plates.

Goddard Space Flight Center, Greenbelt, Maryland

Soft x-ray optics can use narrow slots to direct x-rays into a desirable pattern on a focal plane. While square-pack, square-pore, slumped optics exist for this purpose, they are costly. Silicon (Si) is being examined as a possible low-cost replacement. A fabrication method was developed for narrow slots in <110> Si demonstrating the feasibility of stacked slot optics to replace micropores.

Current micropore optics exist that have 20-micron-square pores on 26-micron pitch in glass with a depth of 1 mm and an extent of several square centimeters. Among several proposals to emulate the square pore optics are stacked slot chips with etched vertical slots. When the slots in the stack are positioned orthogonally to each other, the component will approach the soft x-ray focusing observed in the micropore optics. A specific improvement Si provides is that it can have narrower sidewalls between slots to permit greater throughput of x-rays through the optics. In general, Si can have more variation in slot geometry (width, length). Further, the sidewalls can be coated with high-Z materials to enhance reflection and potentially reduce the surface roughness of the reflecting surface.

Narrow, close-packed deep slots in <110> Si have been produced using potassium hydroxide (KOH) etching and a patterned silicon nitride (SiN) mask. The achieved slot geometries have sufficient wall smoothness, as observed through scanning electron microscope (SEM) imaging, to enable evaluation of these slot plates as an optical element for soft x-rays. Etches of different angles to the crystal plane of Si were evaluated to identify a specific range of etch angles that will enable low undercut slots in the Si <110> material. These slots with the narrow sidewalls are demonstrated to several hundred microns in depth, and a technical path to 500-micron deep slots in a precision geometry of narrow, close-packed slots is feasible. Although intrinsic stress in ultrathin wall Si is observed, slots with walls approaching 1.5 microns can be achieved (a significant improvement over the 6-micron walls in micropore optics).

The major advantages of this technique are the potential for higher x-ray throughout (due to narrow slot walls) and lower cost over the existing slumped micropore glass plates. KOH etching of smooth sidewalls has been demonstrated for many applications, suggesting its feasibility for implementation in x-ray optics. Si cannot be slumped like the micropore optics, so the focusing will be achieved with millimeter-scale slot plates that populate a spherical dome. The possibility for large-scale production exists for Si parts that is more difficult to achieve in micropore parts.

This work was done by James Chervenak and Michael Collier of Goddard Space Flight Center, and Jennette Mateo of SB Microsystems. Further information is contained in a TSP (see page 1). GSC-16717-1

Compact Focal Plane Assembly for Planetary Science

New fabrication methods were incorporated to produce an ultra-lightweight and compact radiometer.

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A compact radiometric focal plane assembly (FPA) has been designed in which the filters are individually co-registered over compact thermopile pixels. This allows for construction of an ultra-lightweight and compact radiometric instrument. The FPA also incorporates micromachined baffles in order to mitigate crosstalk and low-pass filter windows in order to eliminate high-frequency radiation.

Compact metal mesh bandpass filters were fabricated for the far infrared (FIR) spectral range (17 to 100 microns), a game-changing technology for future planetary FIR instruments. This fabrication approach allows the dimensions of individual metal mesh filters to be tailored with better than 10-micron precision. In contrast, conventional compact filters employed in recent missions and in near-term instruments consist of large filter sheets manually cut into much smaller pieces, which is a much less precise and much more labor-intensive, expensive, and difficult process.

Filter performance was validated by integrating them with thermopile arrays. Demonstration of the FPA will require the integration of two technologies. The first technology is compact, lightweight, robust against cryogenic thermal cycling, and radiation-hard micromachined bandpass filters. They consist of a copper mesh supported on a deep reactive ion-etched silicon frame. This design architecture is advantageous when constructing a lightweight and compact instrument because (1) the frame acts like a jig and facilitates filter integration with the FPA, (2) the frame can be designed so as to maximize the FPA field of view, (3) the frame can be simultaneously used as a baffle for mitigating crosstalk, and (4) micron-scale alignment features can be patterned so as to permit high-precision filter stacking and, consequently, increase the filter bandwidth and sharpen the out-of-band rolloff.