Development of Fabrication Process for Critical-Angle X-ray Transmission Gratings

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Objectives and Key Challenges:
• Develop key technology to enable a Critical-Angle X-ray Transmission Grating Spectrometer (CATGS), advancing to TRL-6 in preparation for proposed missions or Explorers over the next two decades
• Develop improved grating fabrication processes and procure advanced etching tool and other infrastructure in order to accelerate technology development

Significance of Work:
• Development of nanofabrication technology for the silicon nanomirror grating elements
• Development of microfabrication processes for the integrated grating support mesh

Approach:
• Integrated wafer front/back-side fabrication process using silicon-on-insulator (SOI) wafers
• Wafer front side: CAT grating structure + Level 1 support
• Wafer back side: Level 2 support hex-mesh structure
• CAT grating fabricated by deep reactive ion-etching (DRIE) followed by KOH polishing
• Bonded to expansion-matched metal support frame (Level 3 support)
• X-ray testing of prototypes at synchrotrons and MSFC facility

Key Collaborators:
• William Zhang (GSFC)
• Steve O’Dell (MSFC)

Current Funded Period of Performance:
• FY12-FY14

Recent Accomplishments and Next Milestones:
• Developed improved DRIE process with significantly reduced line bowing. Developed improved backside etch process.
• Demonstrated KOH polish to full 4.0 μm depth following DRIE.
• Demonstrated fully-integrated 31x31 mm² grating with KOH polish.
• Developed novel process to produce stress-controlled SOI wafers.
• Acquired and installed new DRIE tool (SPTS Pegasus) in SNL.
• Transferred process to new tool and demonstrated excellent etch profile control.
• Fabricated CAT gratings with record soft x-ray diffraction efficiency.

Application:
• Flagship, Probe and Explorer class x-ray astronomy missions requiring high resolution spectroscopy
• Laboratory x-ray analysis (materials science, energy research)

**TRLin** = 3  **TRLcurrent** = 3  **TRLtarget** = 6