

Goddard Space Flight Center

Next Generation X-Ray Optics

Mono-crystalline Silicon Meta-shell X-ray Optics

W.W. Zhang, K.D. Allgood¹, M.P. Biskach¹, J. Bonafede¹, K.W. Chan², M. Hlinka¹, J.D. Kearney¹, L.D. Kolos, J.R. Mazzarella¹, G. Matthews³, R.S. McClelland, H. Mori², A. Numata¹, T. Okajima, L.G. Olsen, R.E. Riveros², T.T. Saha, and P.M. Solly¹

NASA Goddard Space Flight Center, ¹also Stinger Ghaffarian Technologies, Inc., ²also University of Maryland, Baltimore County, ³also ATA Aerospace LLC

Objective

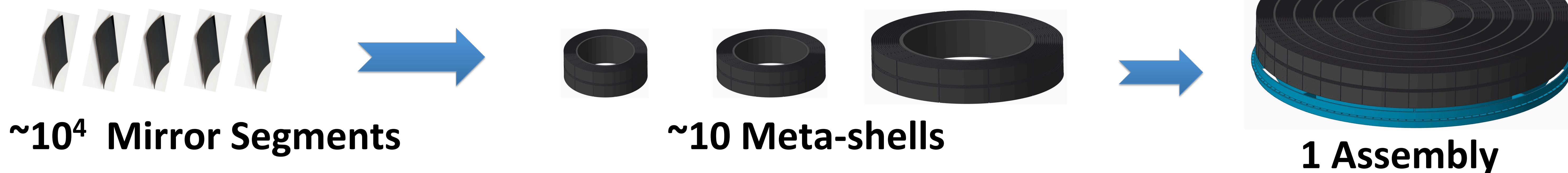
Develop and perfect an X-ray mirror technology that has the following characteristics:

- **Better PSF** than Chandra's, both **on-** and **off-axis**,
- **>10X lighter** than Chandra's per unit effective area, and
- **>10X less expensive** than Chandra's per unit effective area.

Future Missions Enabled

- **Sounding rocket:** **OGRE** (PI: Randy McEntaffer)
- **Explorers:** **STAR-X** (PI: William Zhang), and **FORCE** (PI: Koji Mori)
- **Probes:** **AXIS** (PI: Richard Mushotzky), **HEX-P** (PI: Fiona Harrison), and **TAP** (PI: Jordan Camp)
- **Flagships:** **Lynx** and **Generation-X**

Meta-shell Hierarchical Approach



Four Essential Technical Elements

Mirror Fabrication

- Use of precision **polishing processes** to achieve best possible PSF, all the way to diffraction limits.
- Use of **mono-crystalline silicon** to make thinnest possible mirrors, down to 0.2 mm.
- Use of **mass production** to minimize cost.

Mirror Coating

- Use of **iridium** and other combination of materials to maximize reflectivity.
- Use of a layer of iridium or silicon oxide on backside to **eliminate distortion** caused by coating stress.

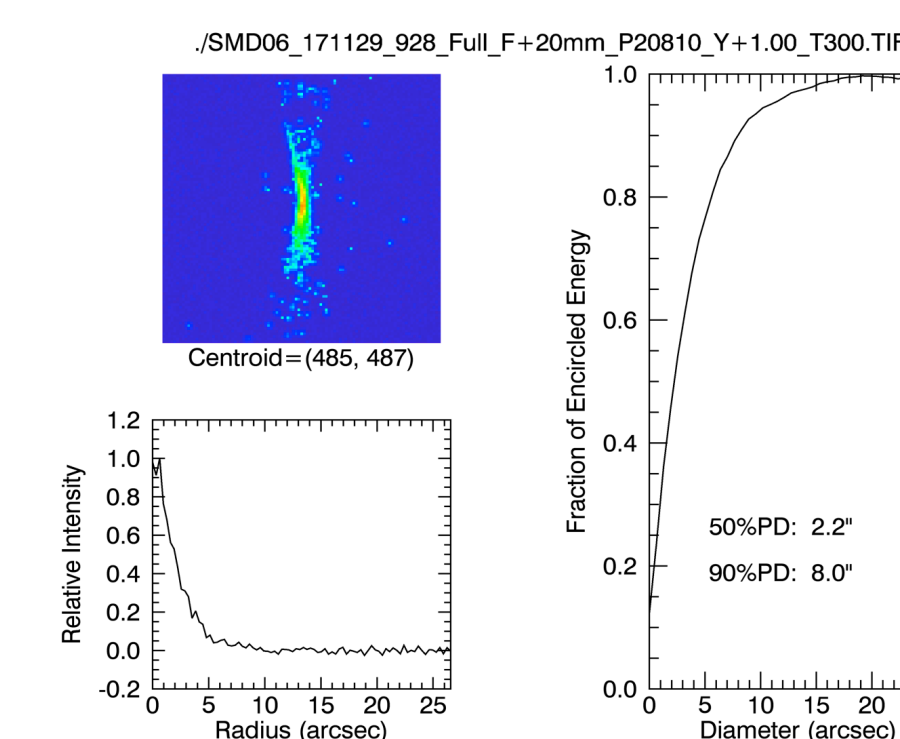
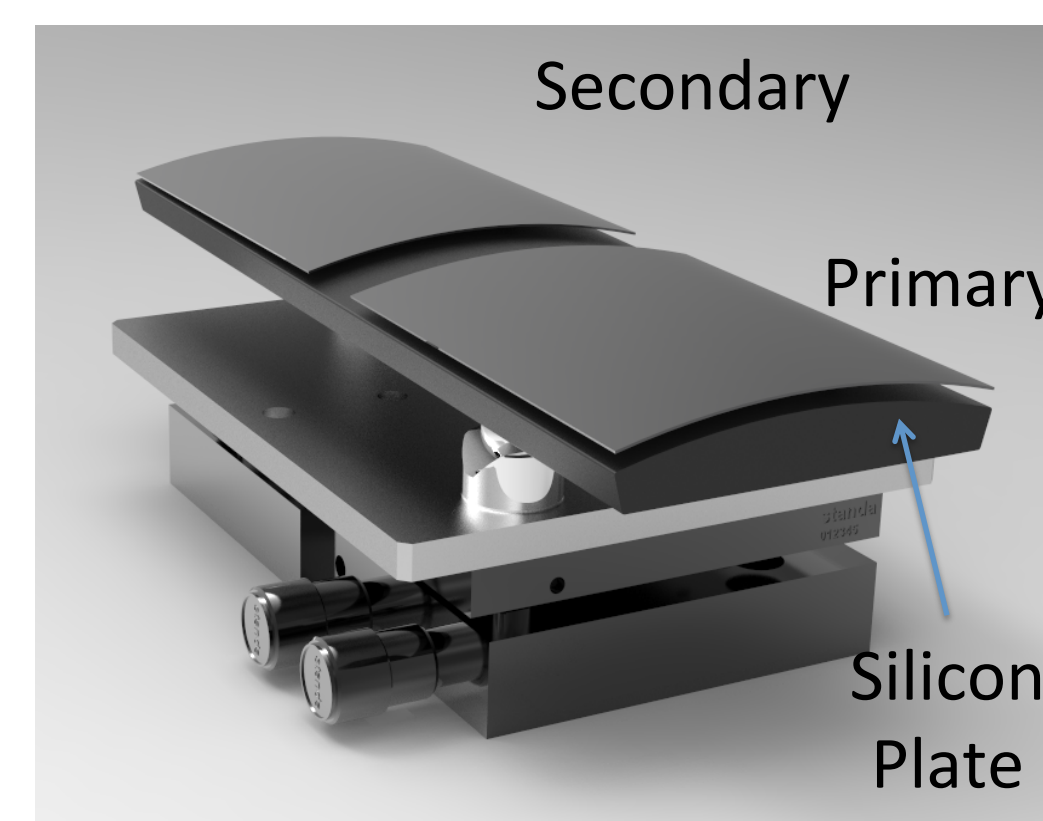
Mirror Alignment

- Use of 4 points at quarter locations to **kinematically support and align** each mirror.
- Use of precision lapping to adjust the **heights of four points** to achieve alignment.

Mirror Bonding

- Use of epoxy to **permanently** fix each mirror.

Validation of Technical Elements: Building and X-ray Testing Mirror Modules



- Full illumination with 4.5 keV X-rays.
- Best X-ray images achieved with lightweight X-ray mirrors.
- Demonstrating the possibility of building lightweight arc-second X-ray telescopes.

Prospects

