SiC Lightweight Optics with Hybrid Skins for Large Cryo Telescopes

Mirror Technology Workshop

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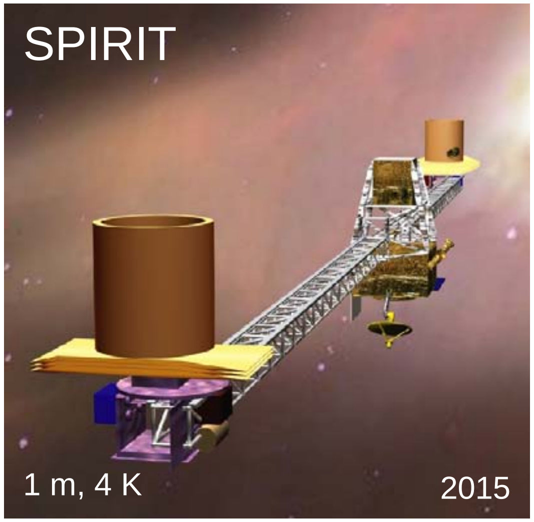
Agenda

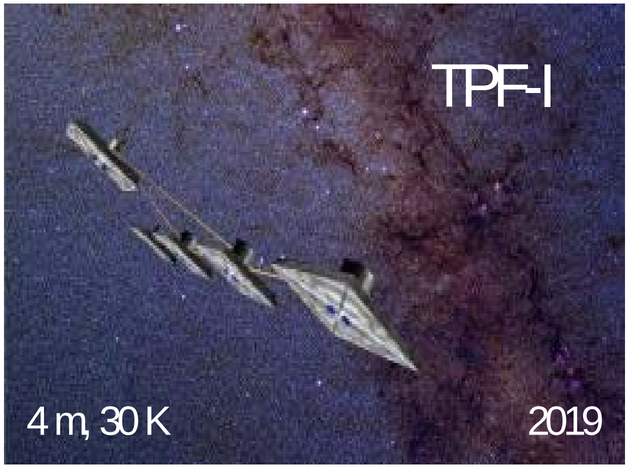
- **Phase I SBIR Purpose**
- **NASA Cryogenic Missions**
- **Hybrid Skins for SiC FOCAL Mirrors**
- **Demonstration Mirror Specs**
- **Schedule**
- **Summary**

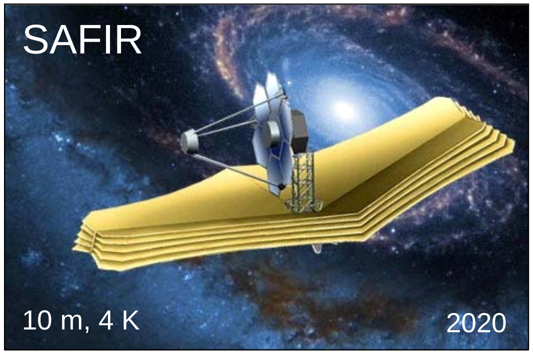
Phase I SBIR Purpose

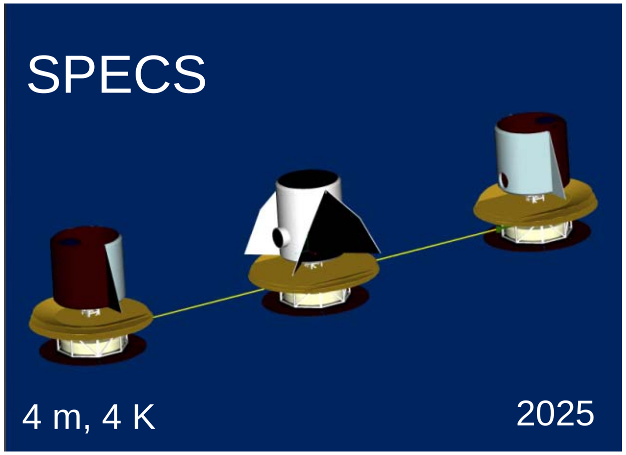
- Future NASA space missions will require 2 to 3 meter class cryogenic mirrors for infrared telescopes
- Silicon carbide (SiC) foam-based optics that are composite, athermal and lightweight (FOCAL) enable internal cooling with cryogenic fluid
- Open-cell foam core mirror technology has evolved over the past ten years and has produced 0.5 m diameter, lightweight, rapidly and uniformly cryo-cooled, and dimensionally stable mirrors configured with .040"-.050" thick monolithic chemical vapor deposited skins.
- Significant problems have arisen as the size has increased that prevent their use on large aperture telescopes which include :
  - Inherent stress in the monolithic skins results in cracking during manufacturing and finishing
  - Non-uniformity of monolithic skins require significant material removal to provide an optical surface
  - Long manufacturing schedule caused by "thick" monolithic skins
  - Large $2M/m2 cost to produce large cryogenic SiC FOCAL mirrors
- SBIR innovation is that the monolithic SiC skins are replaced with hybrid SiC fiber reinforced/SiC CVD skins which consist of a .020"-.030" thick SiC fiber reinforced layer ground to a smooth finish and near net shape and a .005"-.010" thick, 100% dense CVD SiC polishing layer
- Optical finishing cost and schedule is reduced since the hybrid mirror substrates are provided near net shape

Future NASA Missions Requiring Actively Cooled Cryogenic Optic



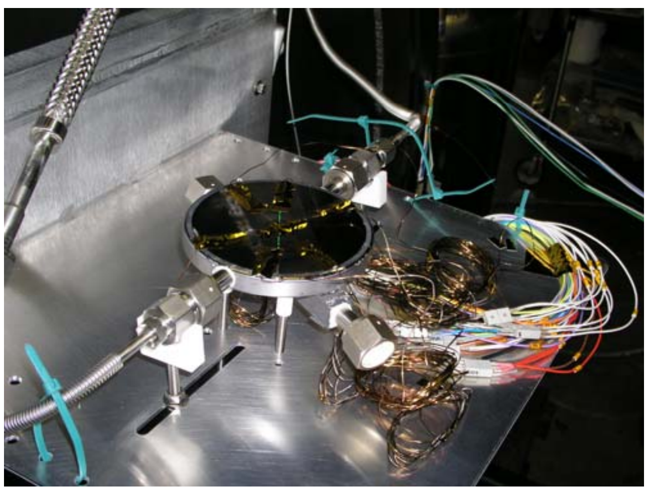


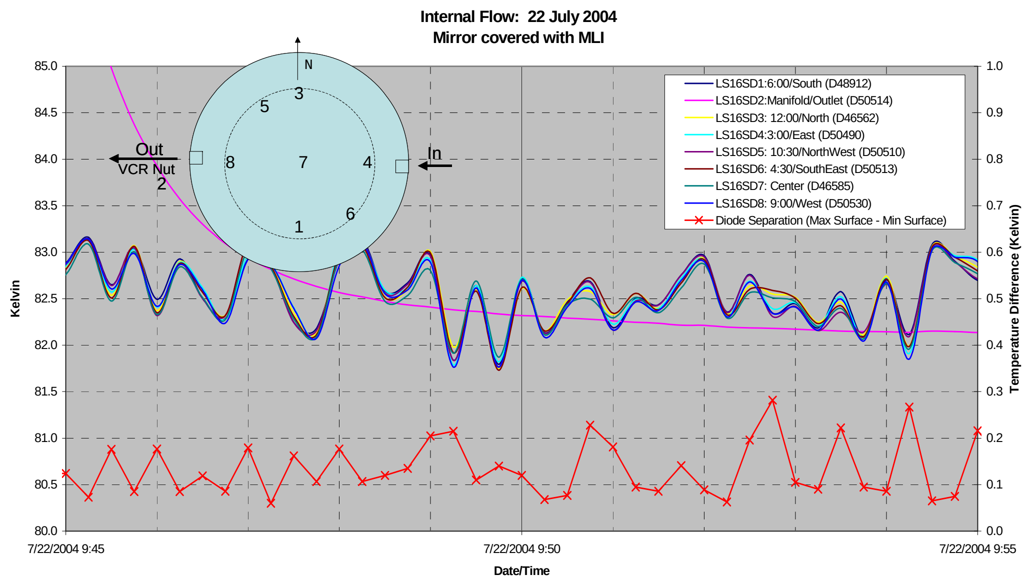




Internally Cryogenic Cooled Foam Optic

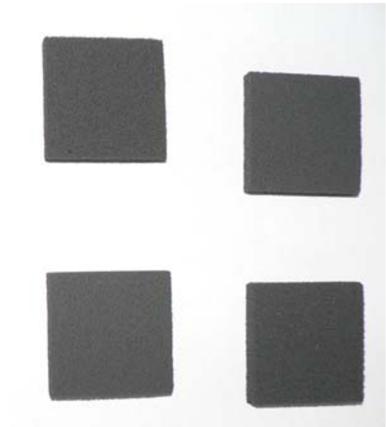
- **Experiment done at NASA/MSFC with LN_2**
- **The test mirror quickly and uniformly reached steady state @ $82.75 \pm 0.075\ ^{o}K$**

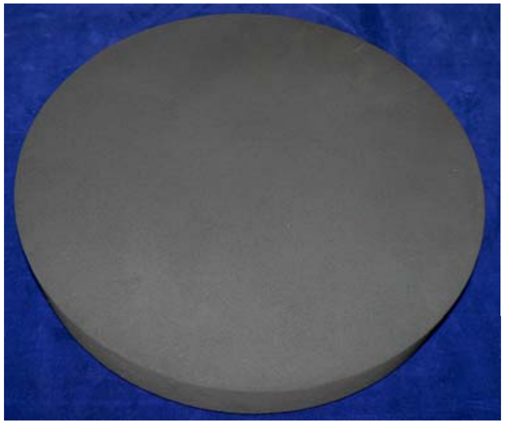


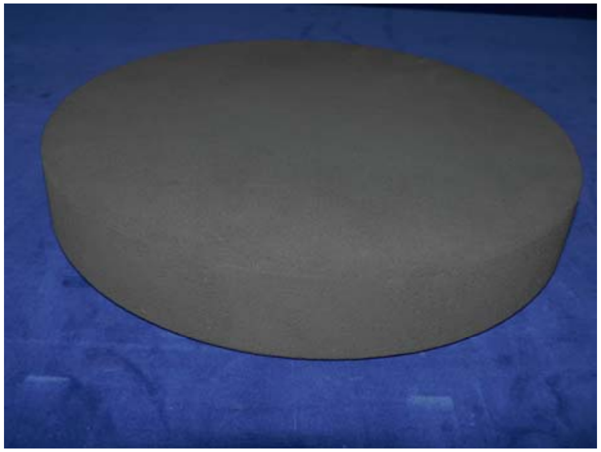


SiC Foam Cores for Hybrid Skin Development

- **All cores are ~14% relative density & 80/100 pores per inch**
- **1.5” x 0.25” square cores manufactured**
  - **SiC fiber reinforced layer optimization in process**
- **4.0” x 1.0” subscale flat cores manufactured**
  - **Optimized configuration will be applied to subscale flat**
- **12.0” x 2.0” full scale powered core manufactured**
  - **Thickness is nominally the same as a meter-class core**





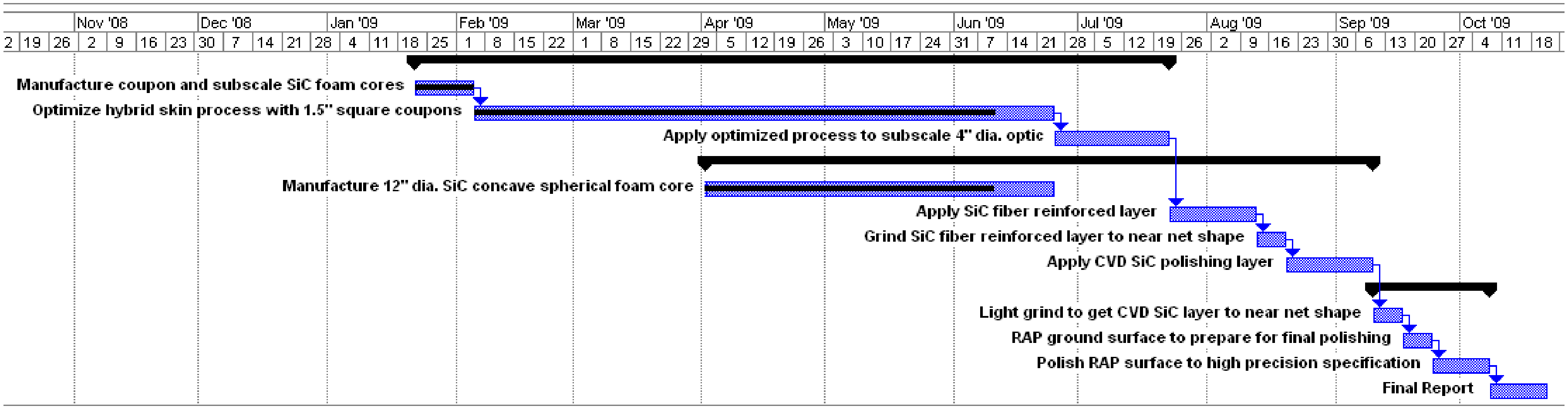


Hybrid Skin Demo Mirror Specs

Mirror shape	F/2 concave sphere
Mirror clear aperture	90%
Mirror thickness	5.0 cm
Mirror diameter	30.0 cm
Surface finish (scratch/dig)	60/40
Surface figure	<λ/10 RMS HeNe
Surface Roughness	<10 Å RMS

Schedule

- **Nine month schedule is shown below**
  - **Black bars indicate task progress**



Summary

- **SiC fiber reinforced layer being optimized on 1.5” coupons**
- **Next step is to apply initial optimized hybrid skin process to 4” x 1” subscale SiC foam core**
- **Final step is to apply final optimized hybrid skin process to 12” x 2” SiC foam core and polish it to a finished mirror**