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TPS Materials Development Efforts at Sandia National Laboratories

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

National Nuclear Security Administration

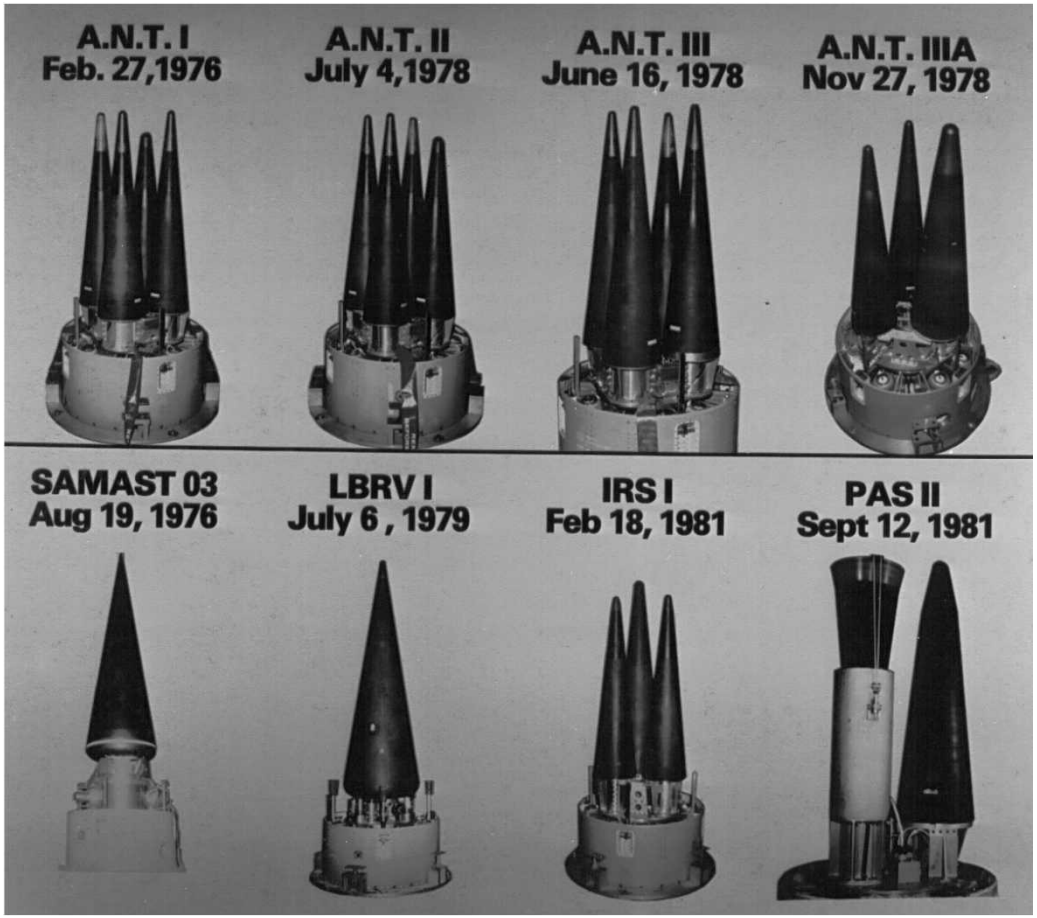
Sandia National Laboratories

Hypersonic Flight Testing at Sandia National Laboratories

U.S. RV Performance
- Ballistic vehicle dynamic behavior
- Component environments and performance

Materials Development
- Heatshields
- All carbon-carbon vehicles
- Antenna windows
- Nosetips

Hypersonic Vehicle Recovery
- Pioneered the soft recovery of hypersonic vehicles for post-flight inspection



Hypersonic Flight Testing at Sandia National Laboratories

Minuteman Launch
from VAFB

- More than 100 Instrumented RV/RB's flown (1968-present)
- 7 Carbon-Carbon vehicles
- 6 RV's soft recovered
- 10 RV's on 9 AO's [USAF;MM III & PK]
- 9 RB's on 4 DASO's [USN]
- Most vehicles, One-of-a-kind, unique R & D tests
- High risk, excellent track record [>96% of flight test objectives satisfied]

SAMAST/MINT
All Carbon-Carbon
Vehicle

GRANITE

MaST Recovery
Vehicle

MaST
Payload

NASA SHARP-B2
Vehicle

NNSA National Nuclear Security Administration

Sandia National Laboratories

TPS Materials Interests at Sandia National Laboratories

- Sandia's flight vehicles have historically used a variety of TPS materials, including:
  - RTV
  - Silica-Phenolic
  - Carbon-Phenolic
  - Carbon-Carbon

- These materials are well suited for ballistic flight, but are insufficient for the new generation of boost-glide hypersonic flight vehicles, which will experience moderate heating rates for relatively long flight times.

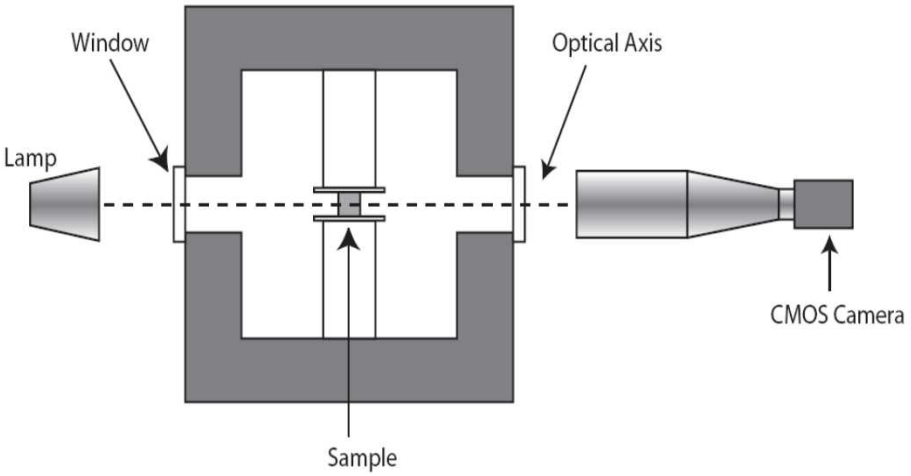
- SNL is currently in the third year of internally funded efforts to develop new TPS materials capable of protecting this new generation of hypersonic flight vehicles.

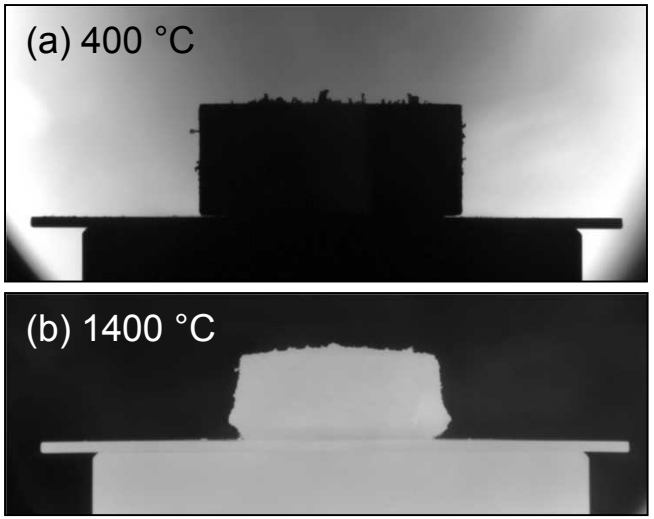
Current Materials Development Efforts Coated Carbon-Carbon Composites

- **Ceramic Matrix Composites**
  - **Pre-treated C-C infiltrated with ceramic matrix slurries:**
    - Interfacial layer:
      - Matrix slurry SiC (crystalline particles of SiC).
    - Top layer:
      - Sputter-coated ZrB_2 ceramic matrix composite.
- **Processing approach:**
  - **Infiltrate C-C with SiC powder-filled precursor.**
  - **Repeat infiltration cycles until uniform coating is observed.**
  - **Apply continuous top coat of UHTC ceramic.**

Materials Screening Capabilities

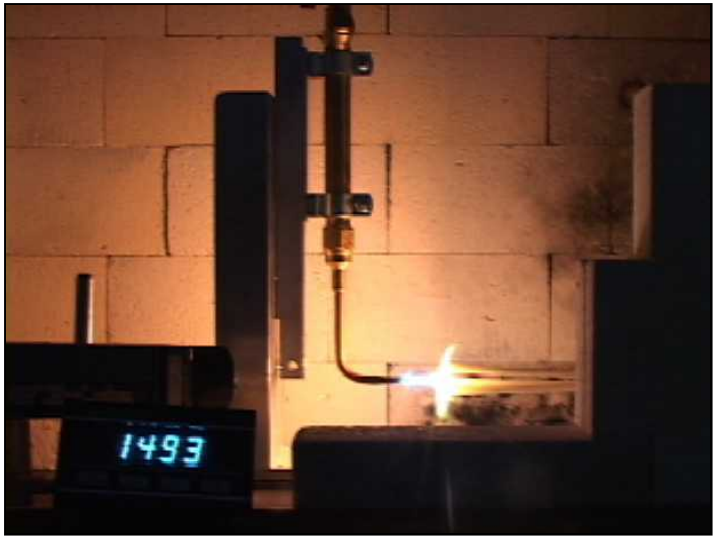
- **TOMMI (Thermal Optical Mechanical Measuring Instrument)**
  - **Combination of a high temperature oven and optical dilatometer.**
  - **Temperatures to 1700°C.**
  - **Useful for determining coating mechanism/failure.**

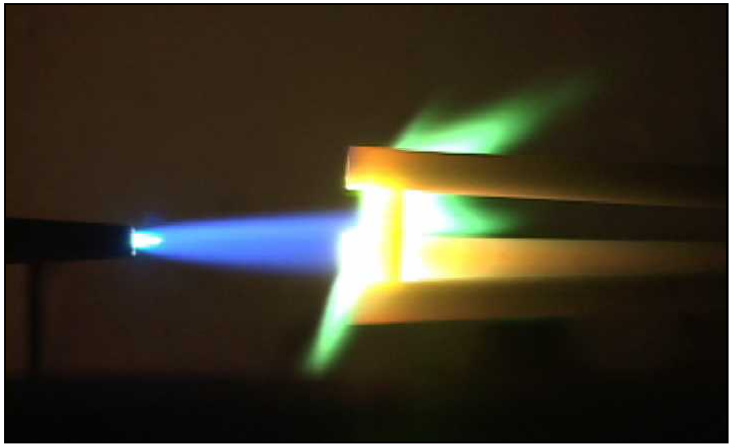




Materials Screening Capabilities (cont.)

- **Oxyacetylene Torch**
  - **Heat Flux – ~835 W/cm^2.**
  - **Multiple screenings with low turnaround time and low cost.**
  - **Recommended for weeding out poor materials.**





Materials Screening Capabilities (cont.)

- **National Solar Thermal Test Facility**
  - **Heat Flux to 200 W/cm^2.**
  - **Test times up to 10 minutes.**
  - **Capable of testing up to 12 samples simultaneously.**

Materials Screening Capabilities (cont.)

- **Solar Furnace**
  - **Heat Flux to 700 W/cm^2.**
  - **Variable heating profiles can be easily implemented.**
  - **Currently open to atmosphere with subsonic shear to remove ablation products.**

Conclusions

- Sandia is currently focusing significant efforts on a new generation of hypersonic boost-glide flight vehicles.
- Current TPS materials are not adequate to protect this new generation of flight vehicles for all necessary flight profiles.
- Efforts are currently underway to develop new TPS materials based on non-ablating carbon-carbon composites.
- A series of material screening capabilities is currently available to aid in the development of these new composites.