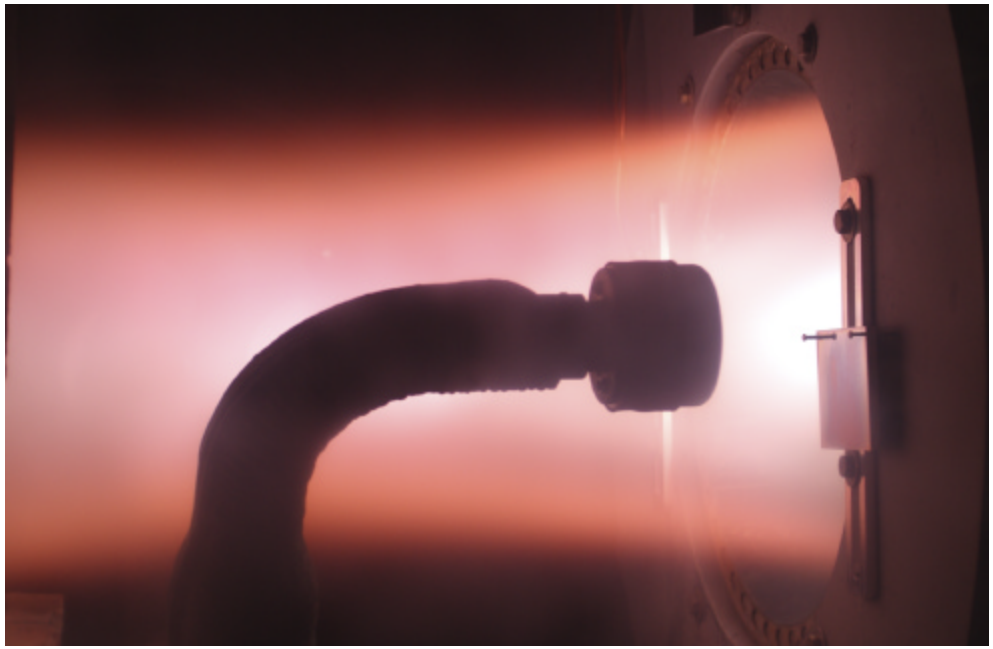
2ND INTERNATIONAL PLANETARY PROBE WORKSHOP

FAMILY SYSTEM OF ADVANCED CHARRING ABLATORS FOR PLANETARY EXPLORATION MISSIONS

ISPT AEROCAPTURE PROJECT – NASA/MSFC



Speaker and PI:

William M. Congdon
Ablatives Laboratory
Applied Research Associates

Co-Investigator:

Donald M. Curry
Thermal Engineering
NASA Johnson space Center

ARA-15763-R-04-16

ADVANCED ABLATORS PROGRAM OBJECTIVES

FLIGHT-READY (TRL-6) ABLATIVE HEAT SHIELDS FOR DEEP-SPACE MISSIONS

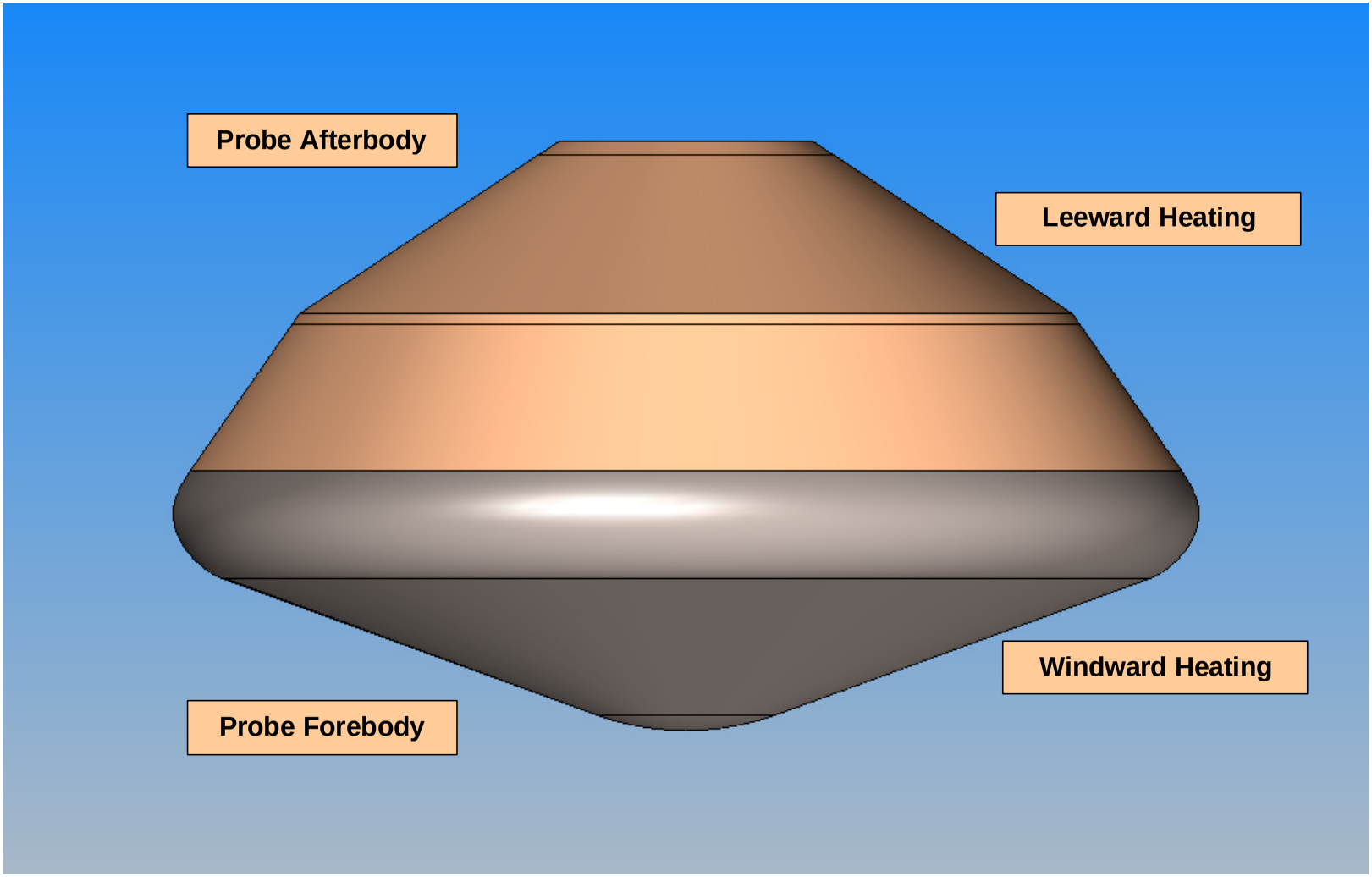
- **DIVERSITY OF SELECTION FROM FAMILY-SYSTEM APPROACH**
- **MINIMUM WEIGHT SYSTEMS WITH HIGH RELIABILITY**
- **OPTIMIZED FORMULATIONS AND PROCESSING**
- **FULLY-CHARACTERIZED PROPERTIES**
- **LOW-COST MANUFACTURING**

DEFINITION AND INTEGRATION OF CANDIDATE LIGHTWEIGHT STRUCTURES

TEST AND ANALYSIS DATABASE TO SUPPORT FLIGHT-VEHICLE ENGINEERING

RESULTS FROM PRODUCTION SCALE-UP STUDIES AND PRODUCTION-COST ANALYSES

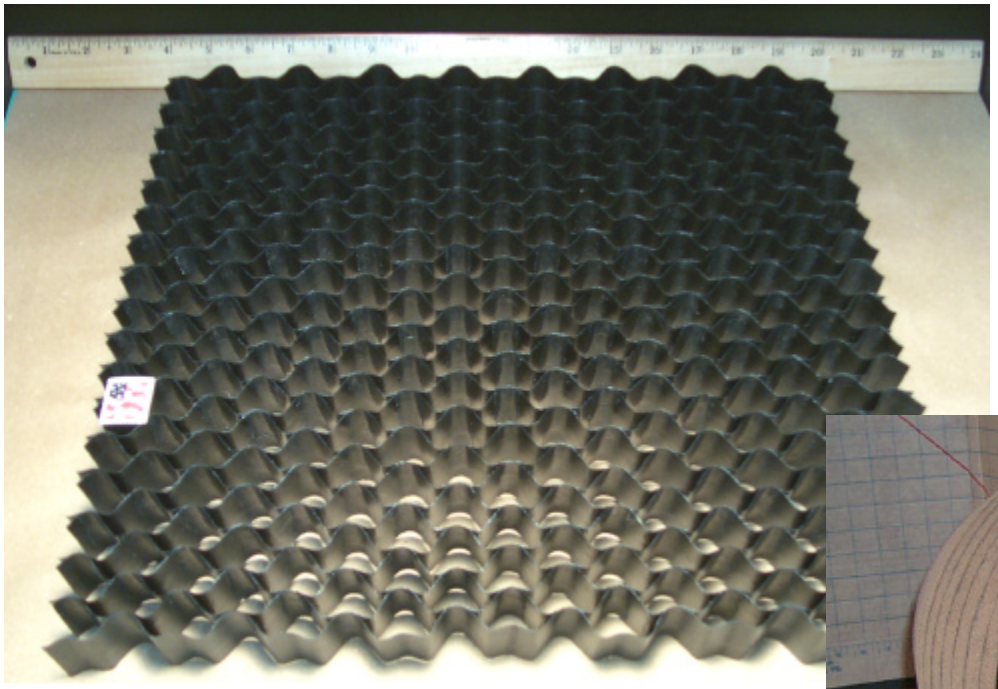
ADVANCED ABLATORS FOR FOREBODY AND BACKSHELL HEATING



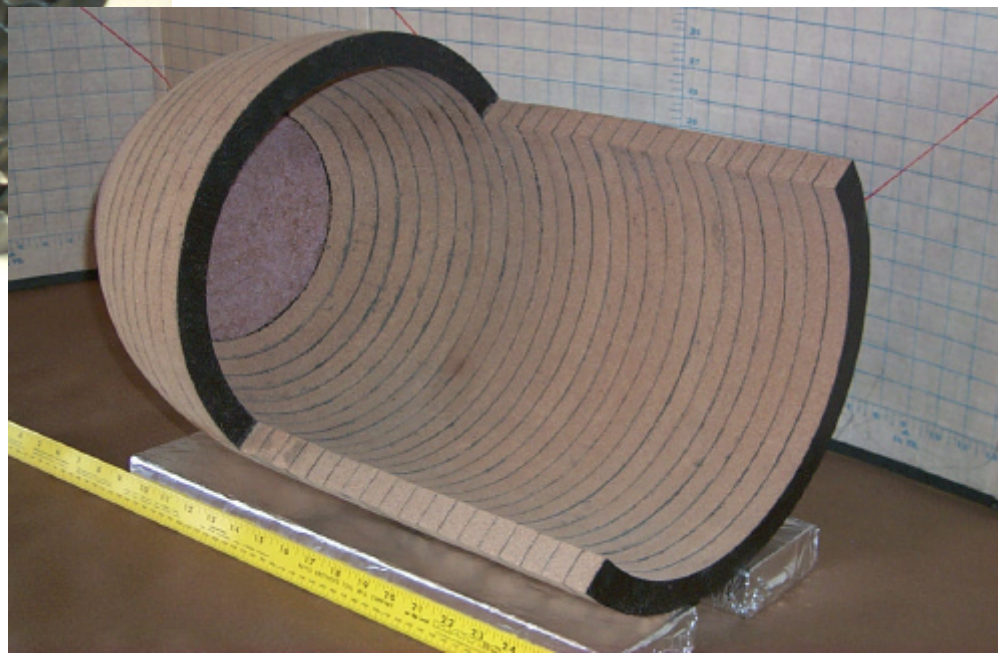
FAMILY SYSTEMS OF ABLATORS – KEY MATERIALS

Ablator	Density	Resin System	Fillers	Heating Range	EDL Location	Abbreviation
SRAM-14	14 lb/ft^3	Silicone	Silica / others	90 to 140 W/cm^2	Forebody	S14
SRAM-17	17 lb/ft^3	Silicone	Silica / others	110 to 120 W/cm^2	Forebody	S17
SRAM-20	20 lb/ft^3	Silicone	Silica / others	140 to 270 W/cm^2	Forebody	S20
SRAM-24	24 lb/ft^3	Silicone	Silica / others	180 to 350 W/cm^2	Forebody	S24
PhenCarb-20	20 lb/ft^3	Phenolic	Carbon / others	200 to 500 W/cm^2-sec	Forebody	P20
PhenCarb-24	24 lb/ft^3	Phenolic	Carbon / others	300 to 700 W/cm^2-sec	Forebody	P24
PhenCarb-28	28 lb/ft^3	Phenolic	Carbon / others	400 to 900 W/cm^2-sec	Forebody	P28
PhenCarb-32	32 lb/ft^3	Phenolic	Carbon / others	500 to 1100 W/cm^2-sec	Forebody	P32
PhenCarb-36	36 lb/ft^3	Phenolic	Carbon / others	600 to 1300 W/cm^2-sec	Forebody	P36
Hyperlite-C	11 lb/ft^3	Silicone	Silica / others	10 to 40 W/cm^2	Afterbody	S11
Hyperlite-B	12 lb/ft^3	Silicone	Silica / others	30 to 70 W/cm^2	Afterbody	S12
Hyperlite-A	13 lb/ft^3	Silicone	Silica / others	40 to 100 W/cm^2	Afterbody	S13

ADVANCED ABLATORS MANUFACTURING METHODS



Honeycomb Packing (1.0-In. Large Cells)

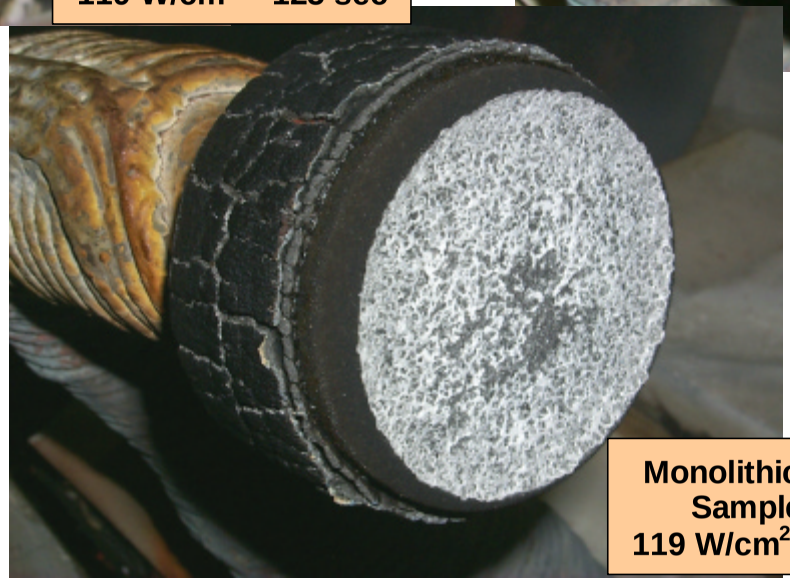


Strip-Collar Bonding Approach (SCBA)

SRAM-17 ARC-JET SAMPLES FROM DIFFERENT PROCESSING

Strip-Collar Bonding
Sample 3085
119 W/cm^2 – 125 sec

Honeycomb Packing
Sample 3119
67 W/cm^2 – 200 sec

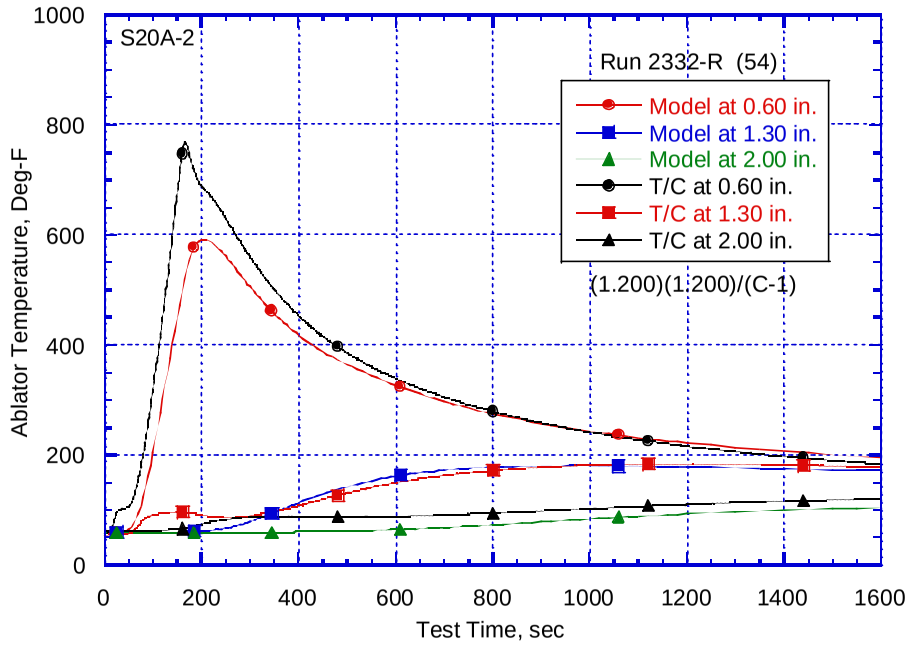


Monolithic Molding
Sample 3105
119 W/cm^2 – 125 sec

SRAM-20 TPS 20 lb/ft^3 Candidate for Titan Mission (140 to 270 W/cm^2)

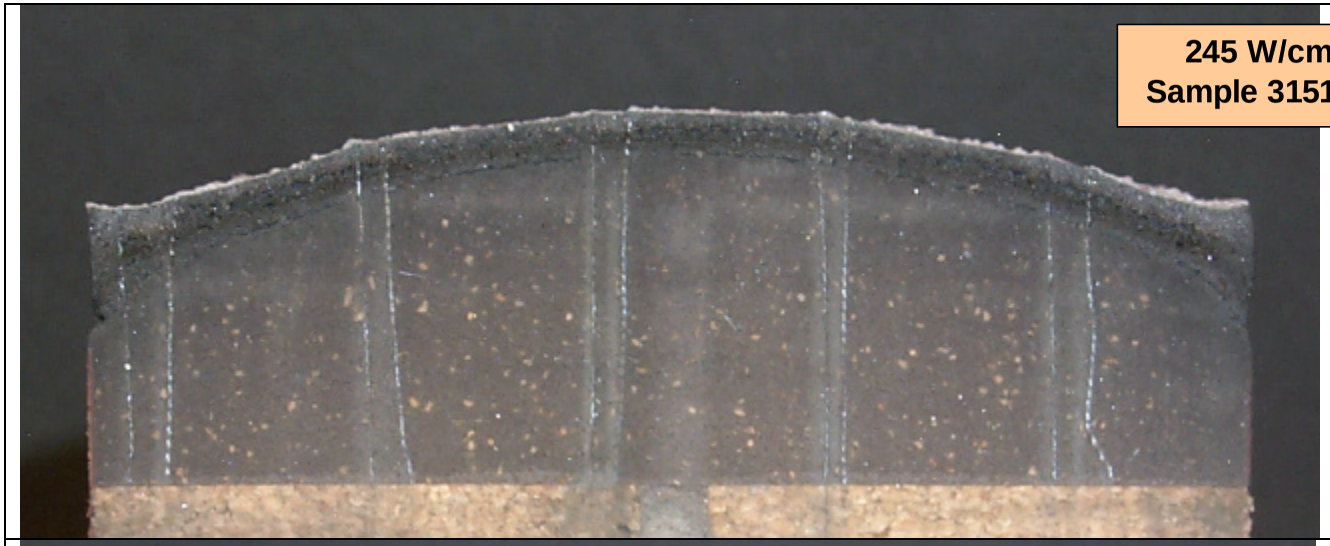
Robust Char Layer - Low Recession and Radiation Opacity from Carbon Loading

114 W/cm^2-sec for 150 sec
Sample 1545 - NASA/JSC Test



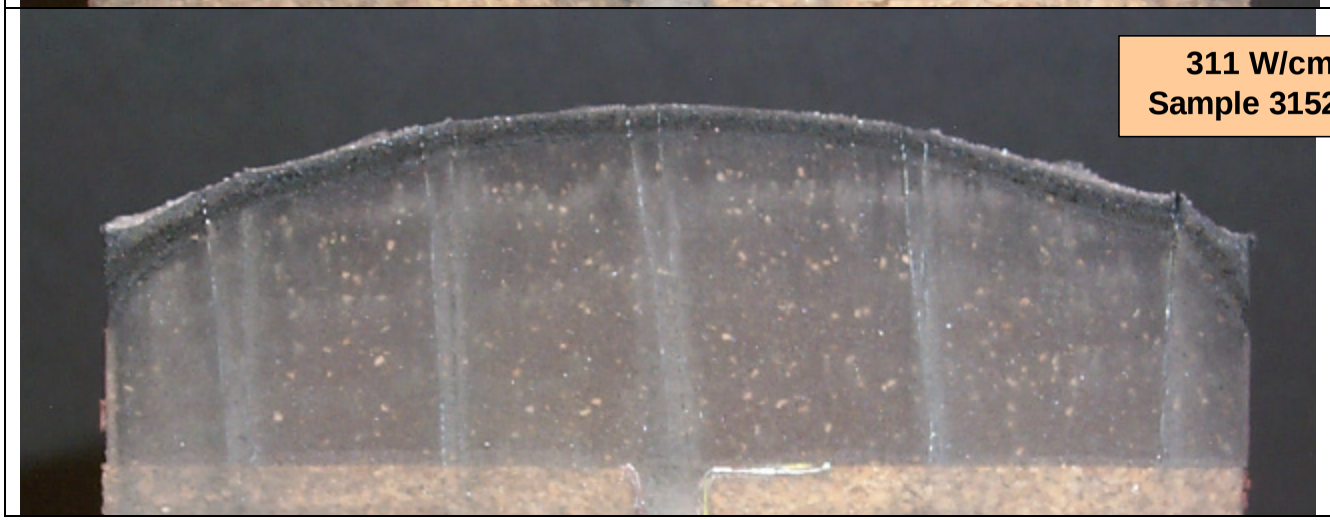
SRAM-20 Thermal Model
Match to Arc-Jet Data

SRAM-20 Test Sample Performance at 245 W/cm^2 and 310 W/cm^2



245 W/cm^2-sec for 40 sec
Sample 3151 - NASA/ARC Test

Recession
0.185 in.

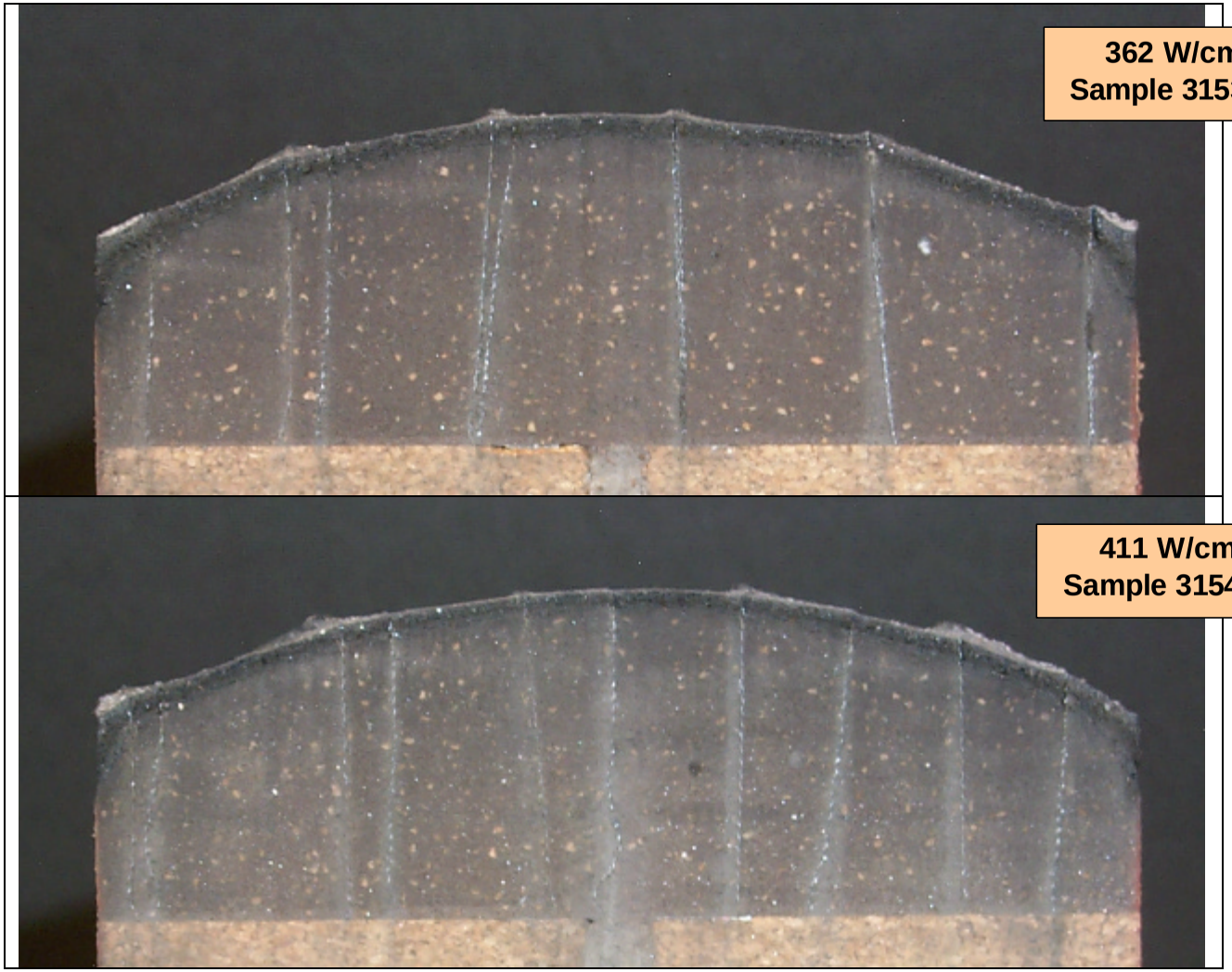


311 W/cm^2-sec for 30 sec
Sample 3152 - NASA/ARC Test

Recession
0.203 in.

Iso-Q Sample Design
1.5-In. Thickness

SRAM-20 Test Sample Performance at 362 W/cm^2 and 411 W/cm^2



362 W/cm^2-sec for 25 sec
Sample 3153 - NASA/ARC Test

Recession
0.233 in.

411 W/cm^2-sec for 20 sec
Sample 3154 - NASA/ARC Test

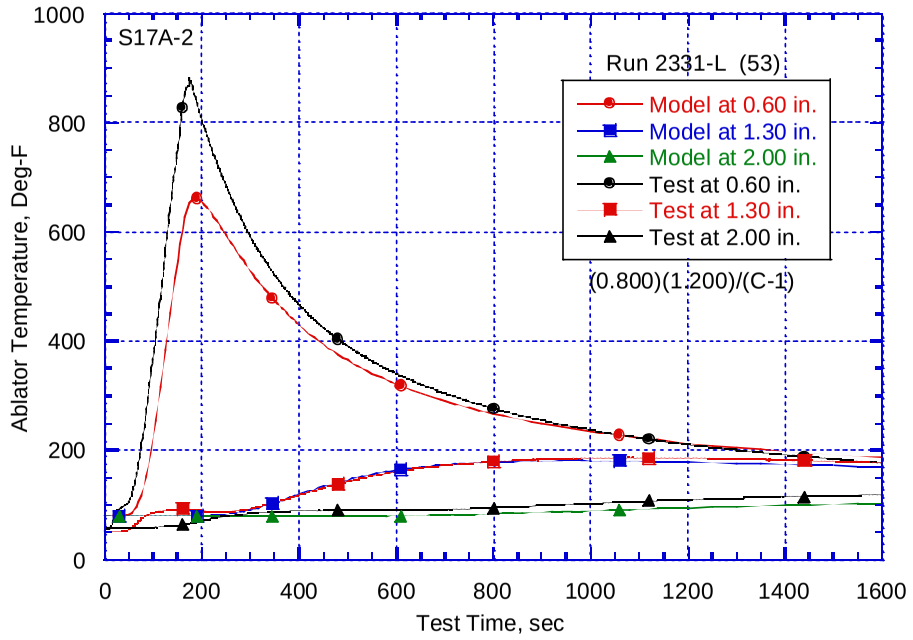
Recession
0.221 in.

Iso-Q Sample Design
1.5-In. Thickness

SRAM-17 Ablator 17 lb/ft^3 Candidate for MSL Mission (110 to 200 W/cm^2)

Durable Char Layer - Low Recession and Radiation Opacity from Carbon Loading

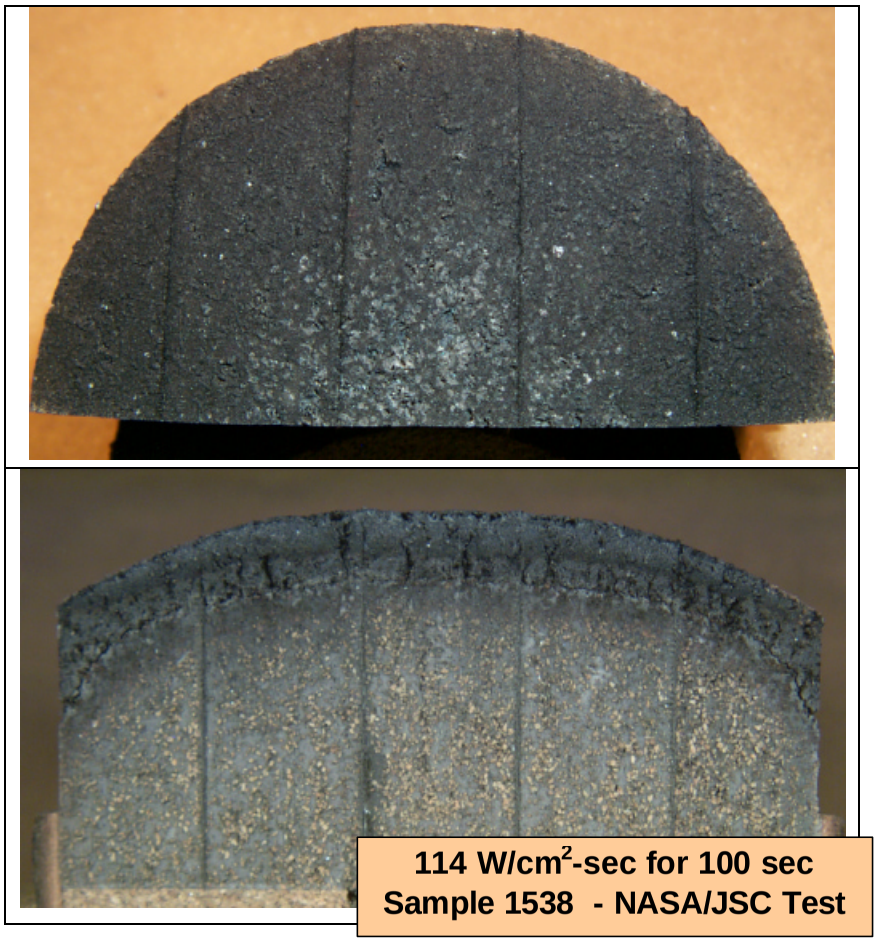
114 W/cm^2-sec for 150 sec
Sample 1541 - NASA/JSC Test



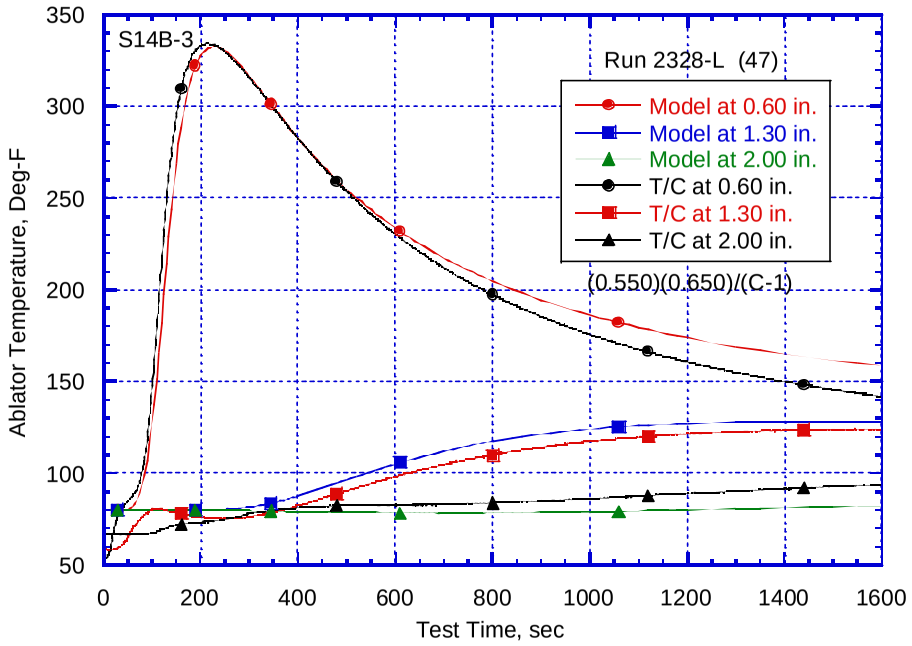
SRAM-17 Thermal Model
Match to Arc-Jet Data

SRAM-14 Ablator 14 lb/ft^3 for MPF-Type Missions (90 to 140 W/cm^2)

Very Lightweight Ablator with Excellent Thermal Insulation



114 W/cm^2-sec for 100 sec
Sample 1538 - NASA/JSC Test

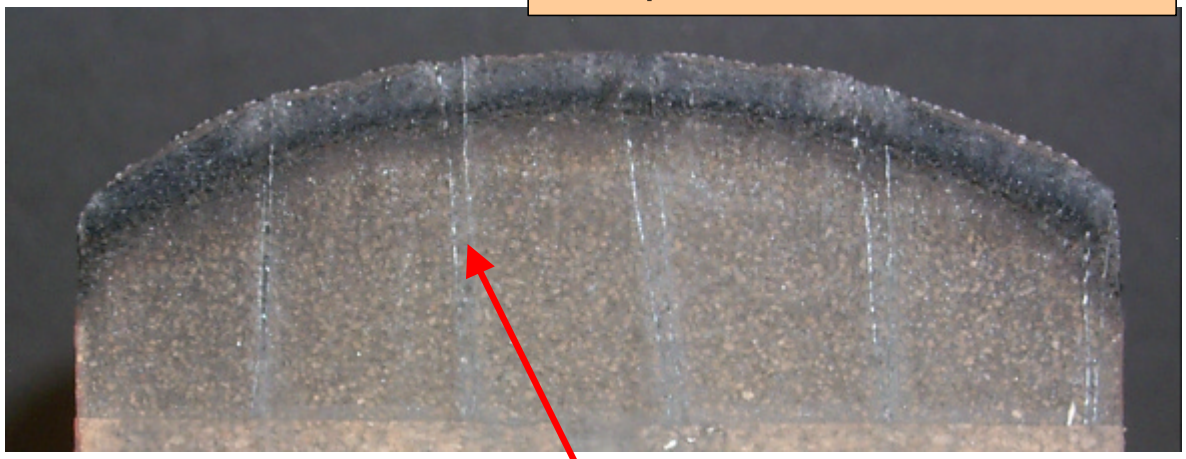


***SRAM-14* Thermal Model Match to Arc-Jet Data**

PhenCarb-28 Ablator in Carbon H/C – IHF Test at 411 W/cm^2

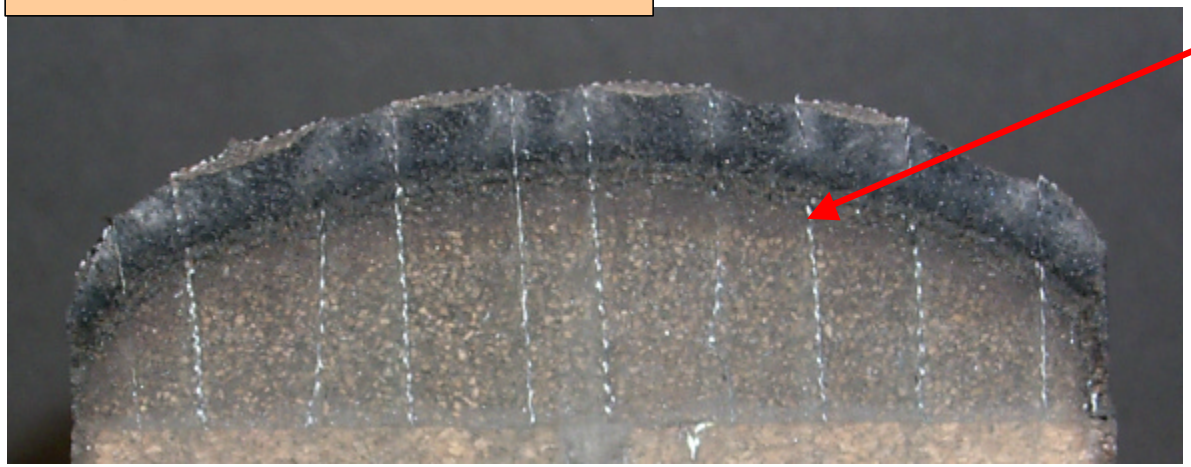
Iso-Q Sample Design
1.5-In. Thickness

Sample 3170 – 411 W/cm^2 for 40 sec



Recession
0.071 in.

Sample 3171 – 411 W/cm^2 for 80 sec

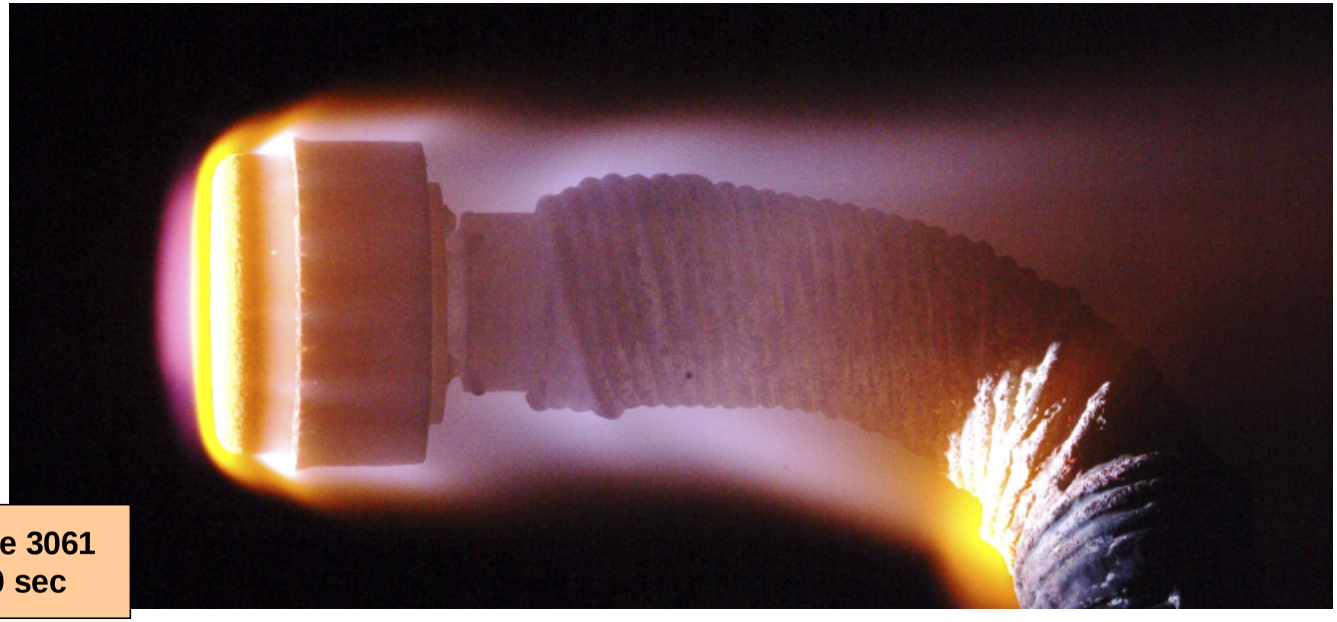


Production Using ARA Lightweight Carbon-Phenolic Honeycomb

Recession
0.178 in.

ADVANCED ABLATORS CURRENT ARC-JET TEST PROGRAM

Series	Date	Heating Range	Samples	Status
IHF-1	Mar 03	Up to 153 W/cm^2	32 Tested	Completed
IHF-2	Sep 03	Up to 182 W/cm^2	32 Tested	Completed
IHF-3	Mar 04	Up to 182 W/cm^2	60 Tested	Completed
IHF-4	Aug 04	Up to 411 W/cm^2	34 Tested	Completed
IHF-5	Sep 04	Up to 1200 W/cm^2	32 Ready	Future
ARMSEF-1	May 05	Up to 720 W/cm^2	70 Ready	Future



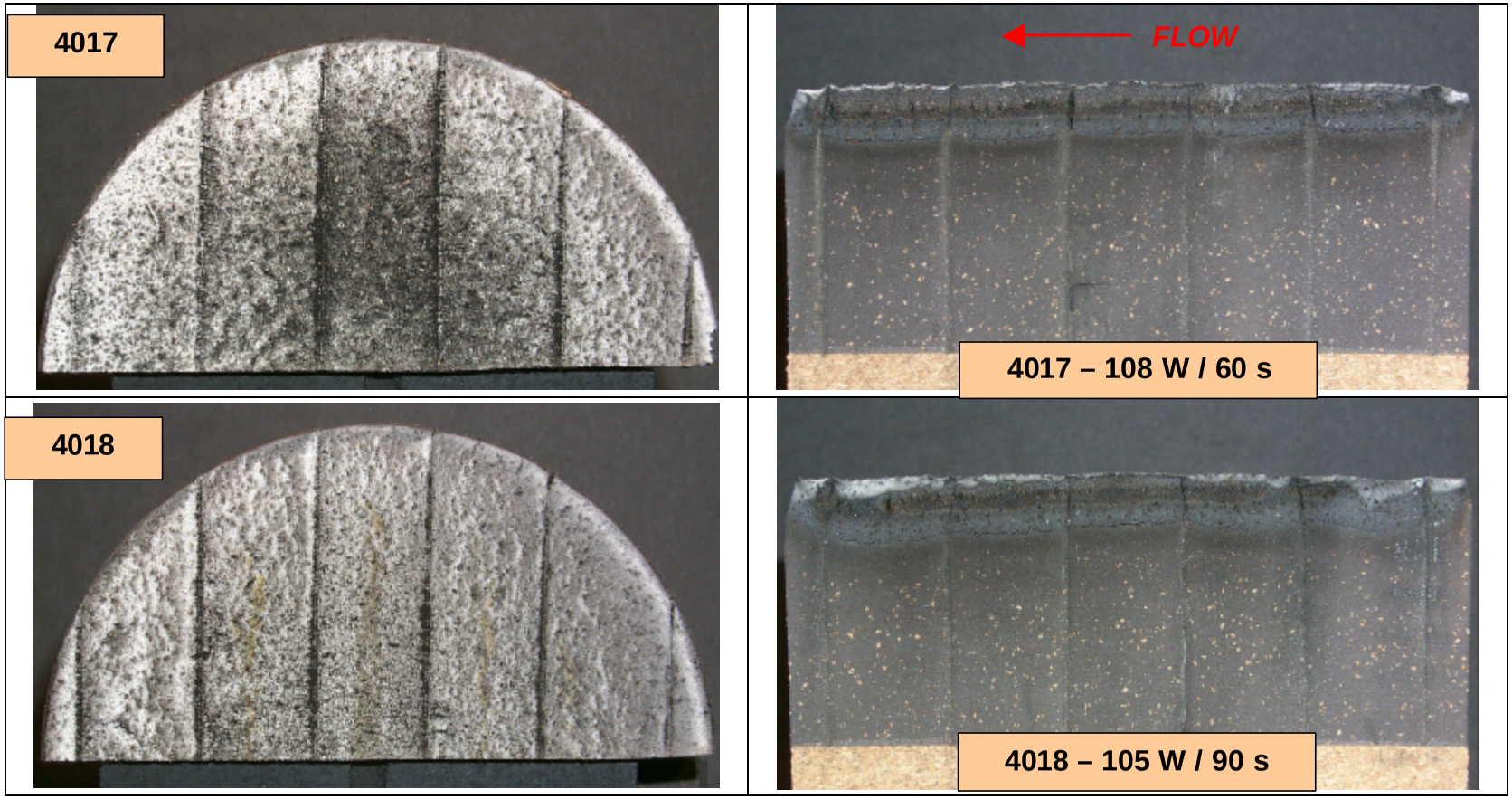
SRAM-14 Sample 3061
67 W/cm^2 - 200 sec

ADVANCED ABLATORS THERMAL RADIATION TEST PROGRAM

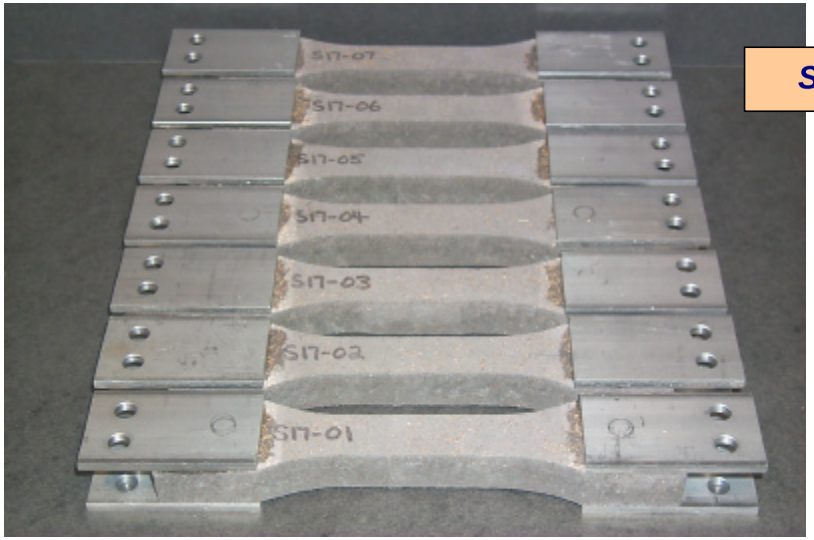
211 individual heliostats occupying 8.0-acre site. Each heliostat contains 25 mirrors of 16 ft^2 each. Can achieve test flux of 300 W/cm^2.

200-ft tower with additional 50 ft below surface. Occupies 1.0-acre site.

RESPONSE OF *SRAM-20* TO THERMAL RADIATION AT ~100 W/cm^2



ADVANCED ABLATORS MECHANICAL PROPERTIES TEST POGRAM



SRAM-17

PhenCarb-20

ARA Lab

OVERVIEW OF ABLATOR TESTING PROGRAMS

ARC-JET TESTING AT NASA/ARC AND NASA/JSC

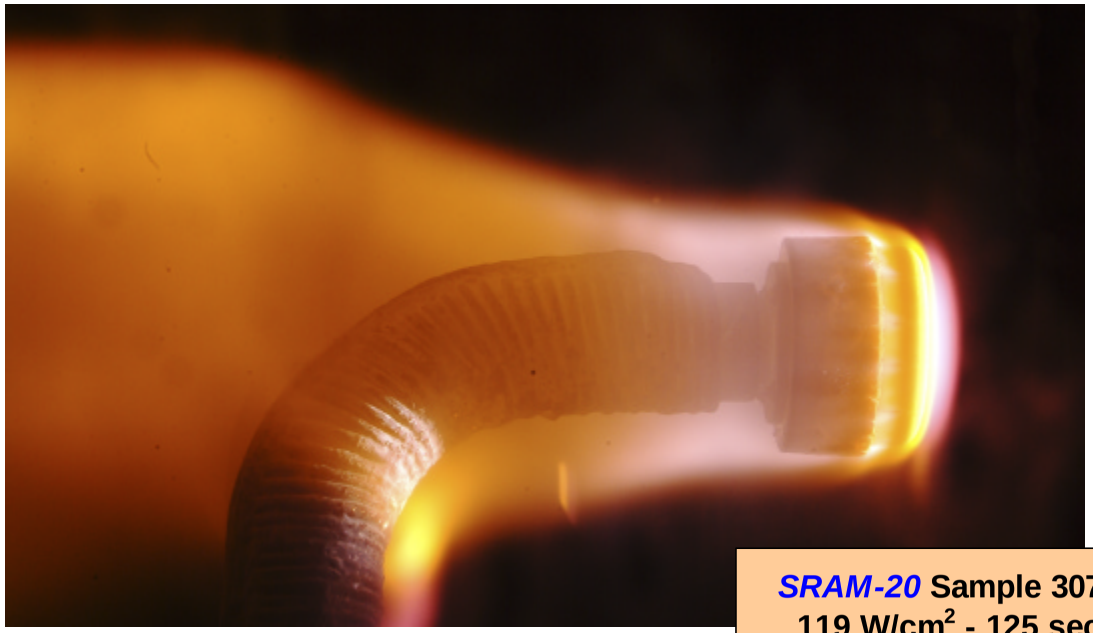
THERMAL RADIATION TESTING AT SOLAR TOWER

MECHANICAL PROPERTIES TESTING

THERMAL PROPERTIES TESTING

NDI AND REPAIR TESTING

ACCOUSTIC TESTING



SRAM-20 **Sample 3070**
119 W/cm^2 - 125 sec

SUMMARY DISCUSSION ADVANCED ABLATORS PROJECT

GOAL IS ADVANCED ABLATORS READY FOR FLIGHT BY 2006

EXTENSIVE ARC-JET TESTING OF MORE THAN 260 SAMPLES

60 THERMAL-RADIATION TESTS IN INTENSE SOLAR SPECTRUM

GENERATING LARGE MATERIAL-PROPERTIES DATABASE

THERMAL-RESPONSE MODELS IN ADVANCED DEVELOPMENT

ABLATORS SHOWING EXCELLENT PERFORMANCE FOR DIVERSE MISSIONS