DEVELOPMENT AND EVALUATION OF HIGH TEMPERATURE GASKETS FOR HYPERSONIC AND REENTRY APPLICATIONS

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Outline

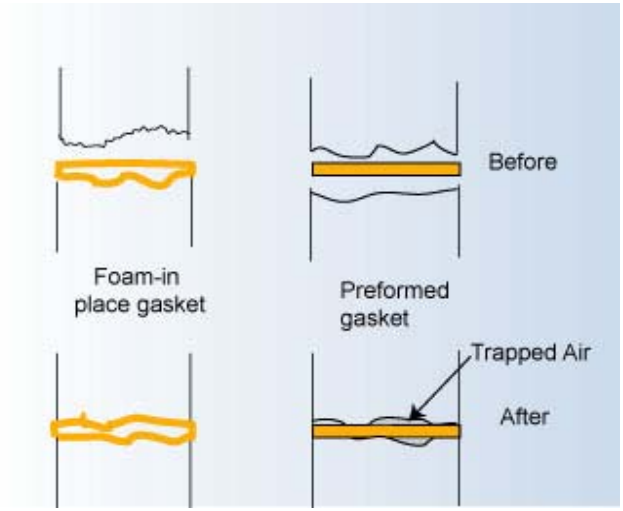
- **Background and Introduction**
  - *Need and Requirements*
  - *Sealants and Gasket Development and Testing in Space Shuttle RTF*
- **Experimental Procedures**
  - *Fabrication of Gaskets*
  - *Substrate Material*
  - *Testing Conditions*
- **Results and Discussion**
  - *Thermal Analysis*
  - *Load Bearing Characteristics and Thermal Stability (under loads)*
  - *Post Test Microstructural Characterization*
- **Summary and Conclusions**
- **Future Work**

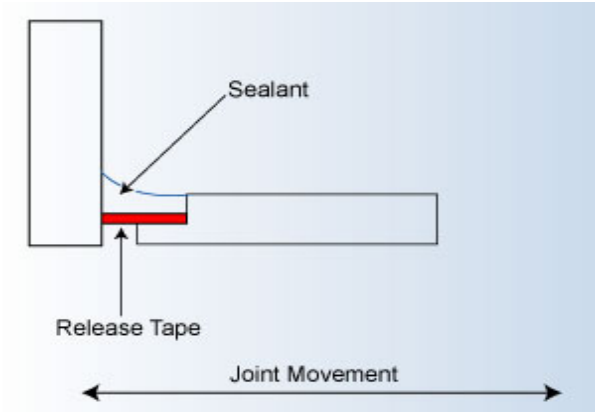
Typical Performance Requirements for Gaskets

General Requirements:

- Good dimensional tolerance
- Zero leakage through/over the gaskets
- Heat and thermochemical resistance
- Affordable and environmentally safe
- Ease of alignment/assembly
- Reusability and serviceability

- **Form-in-place gaskets:**
  - *Anaerobics (acrylate monomer, resins)*
  - *Silicones (RTVs)*
  - *Others (Polyurethanes, hot melts, Rubber modified polyesters, etc.)*
- **Preformed gaskets:**
  - Metallics, rubber, cork, flurocarbon, composites
  - Elastomers





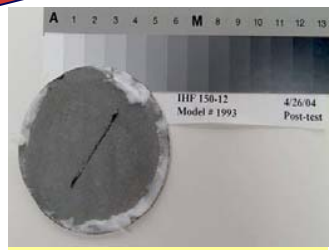
RTV based Gaskets can be applied in both configurations

From Adhesives and Sealants (2005)

Glenn Refractory Adhesive for Bonding and Exterior Repair *(GRABER)*

Arc Jet Testing Front View

Arc Jet Testing Side View



Post Test- Front Side

Post Test- Back Side

Multiuse Capability/Versatility of GRABER

- Repair of cracks, gouges, small holes, and missing surface coatings
- Edge sealant/adhesive for Plug concept
- Gap filler for T-seals and other areas
- Sealing the edges, gaps, attachment areas for flexible ceramic/metallic wrap concepts for large area damage repair
- Prepregs made with various ceramic fabrics are useful for various high temperature applications in aerospace and ground based systems.

- **Analogue RCC Plug Sealed with GRABER 5A Crack Sealant**
- **Survived the ArcJet Testing at JSC**

- **2005 R&D 100 Award**
- **Northern Ohio Live Magazine- Awards of Achievement, S&T Category- Runner Up**

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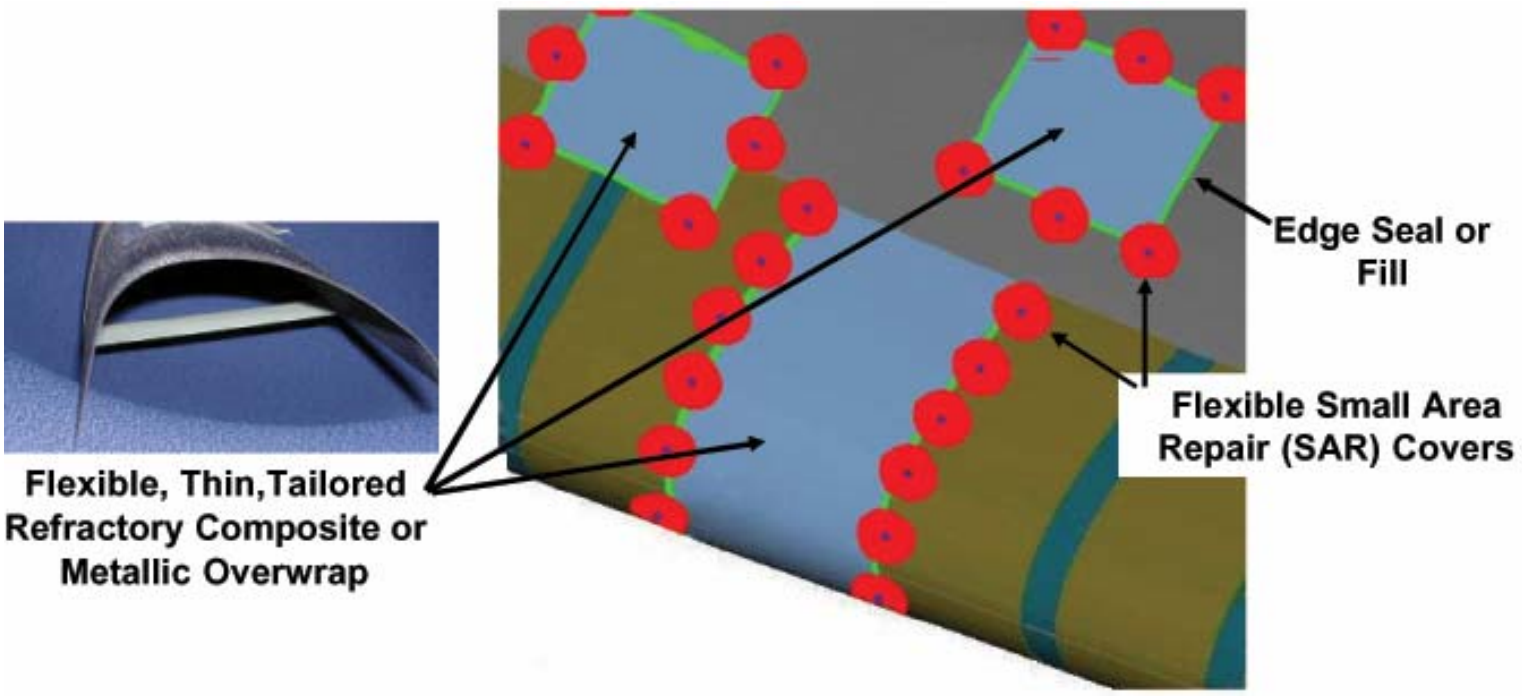
Large Area RCC Leading Edge and Tile Repair



Drill/Tap Tools

Fasteners

Gaskets

SAR Patch

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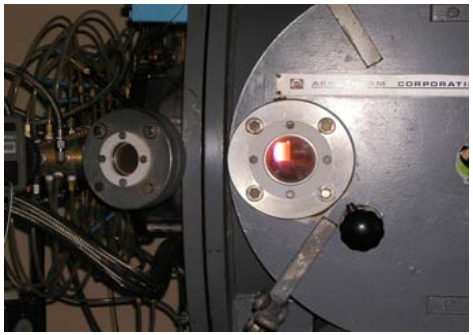
Integrated System for Leading Edge and Tile Repair (InSTALER)

Flexible Ceramic Overwrap

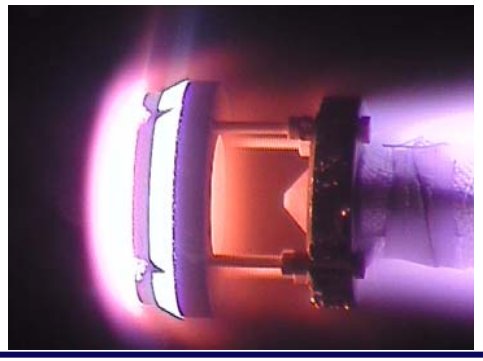
DEVELOPMENT

TESTING

QARE Rig Testing (GRC)



HYMETS (LaRC)



ArcJet Testing at JSC, ARC, and LCAT

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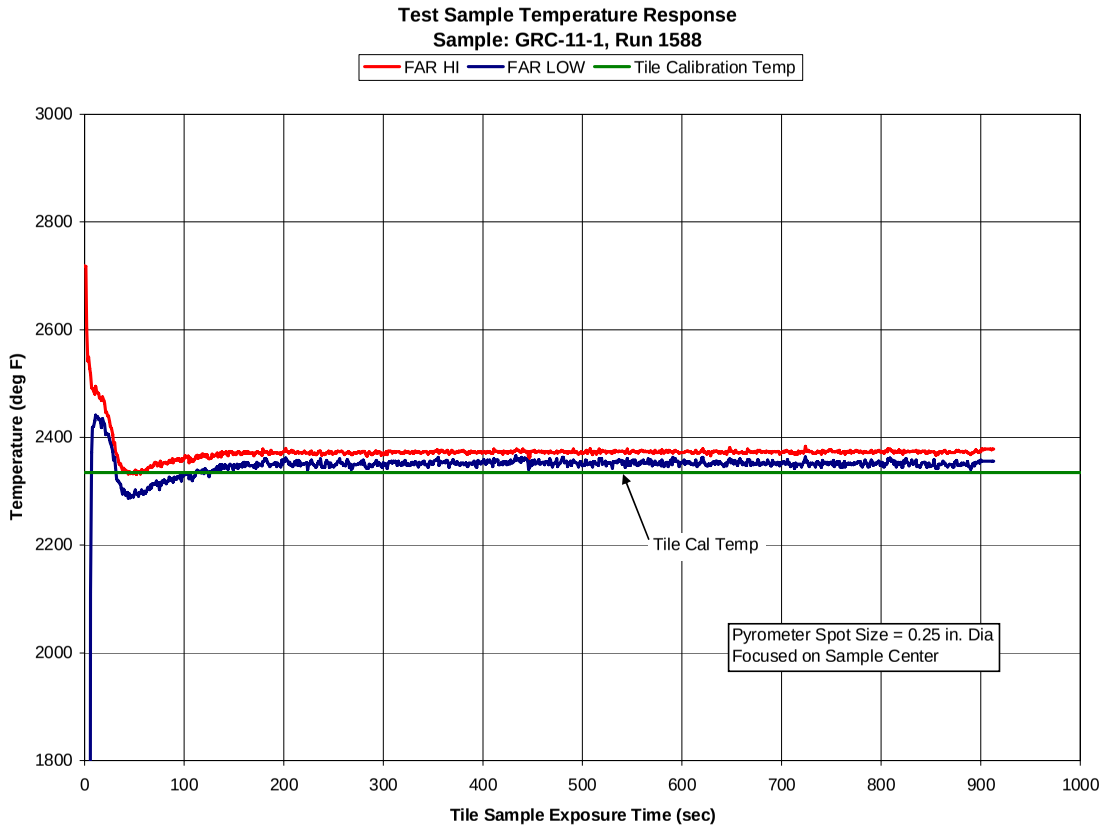
Integrated System for Leading Edge and Tile Repair (InSTALER)

Flexible Ceramic Overwrap

Pre-Test

Post Test



Excellent Plasma Performance in ArcJet Tests

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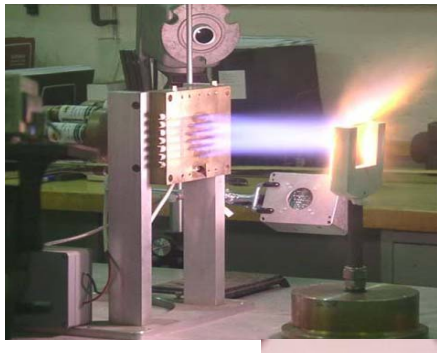
Flexible Gaskets for Reentry Applications

GRC 11 Gaskets made from RTV foam

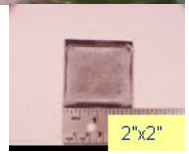
GRC 16 Gaskets made from Ablative polymer

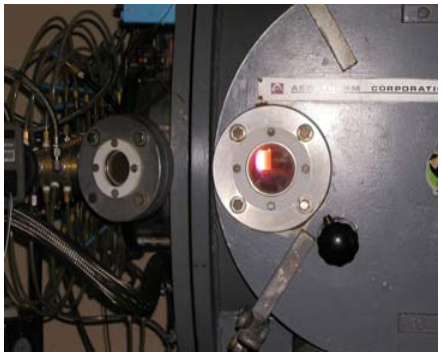
GRC 17 Gaskets made from silicone based RTV polymer

These gaskets have shown excellent plasma performance in various facilities under re-entry and hypersonic conditions.



QARE Testing at GRC





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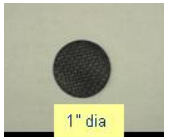
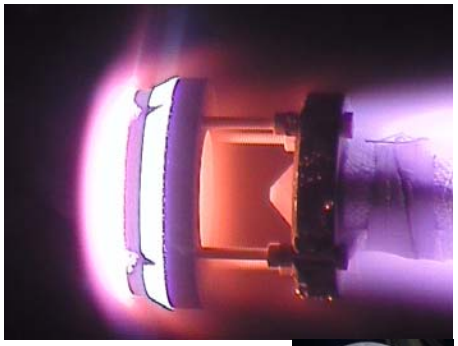
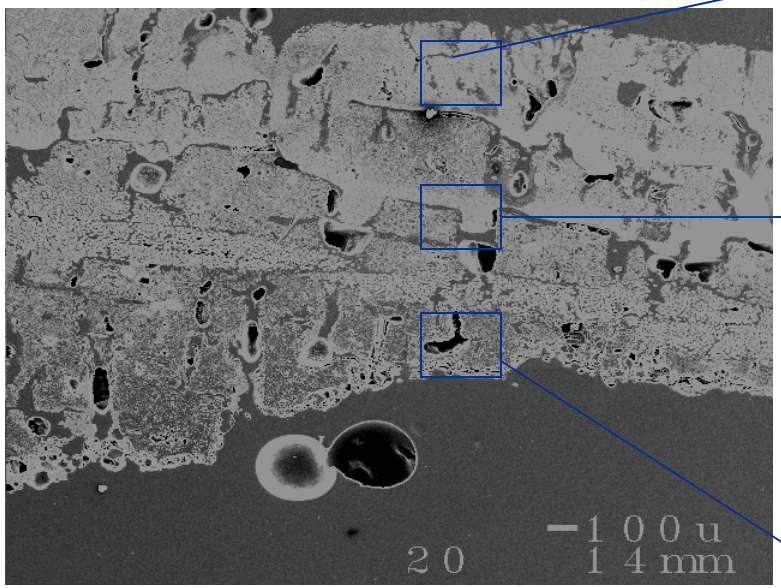




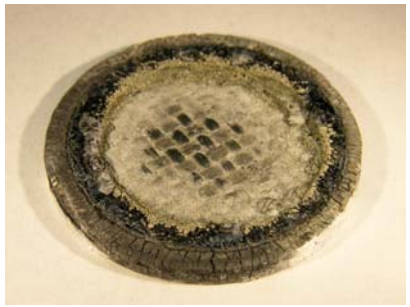
ArcJet Testing at ARC and LCAT

Microstructural Analysis of HYMETS Tested Gasket Samples

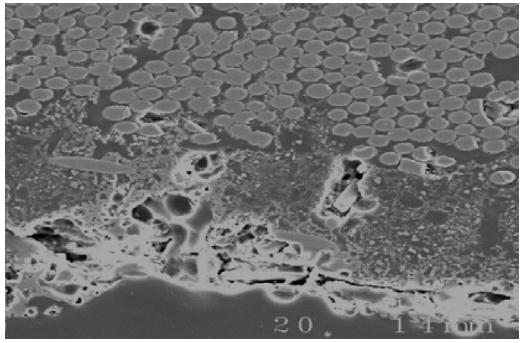


HYMETS Sample #1

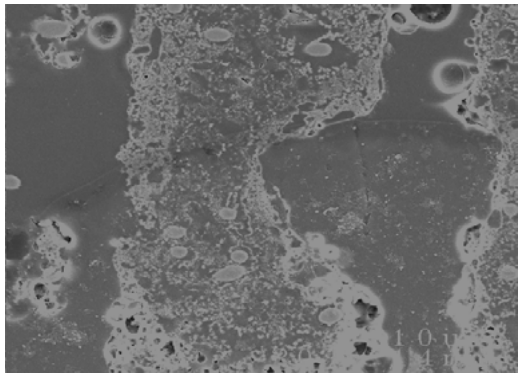
(RCC test profile, 9 minutes)



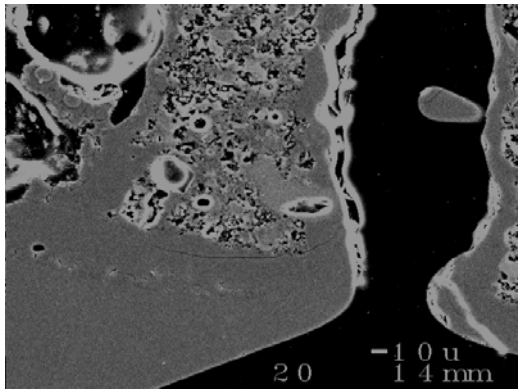
Back



Middle



Front



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Development and Fabrication of Gasket Materials

- Two part RTV system provides control of amount of pores (final gasket density) by controlling the amount of gas generating component as well as fillers.
- GEN-1 flexible gaskets were made from RTV and a number of fillers (glasses with varying melting temperatures and refractory ceramics) along with chopped Tyranno-SA SiC fibers.
- Thin sheets of three thickness were prepared and used for rapid furnace heating, compressibility testing, and thermal properties characterization.

Nomenclature and Specimen Identification

- Baseline RTV
- GRC 2 (RTV, Chopped Fibers, LT Fritz, and a Refractory Powder)
- GRC 9 (RTV, Chopped Fibers, HT Fritz, and a Refractory Powder)
- GRC 13 (RTV, some chopped fibers, LT Fritz, and two Refractory Powders)

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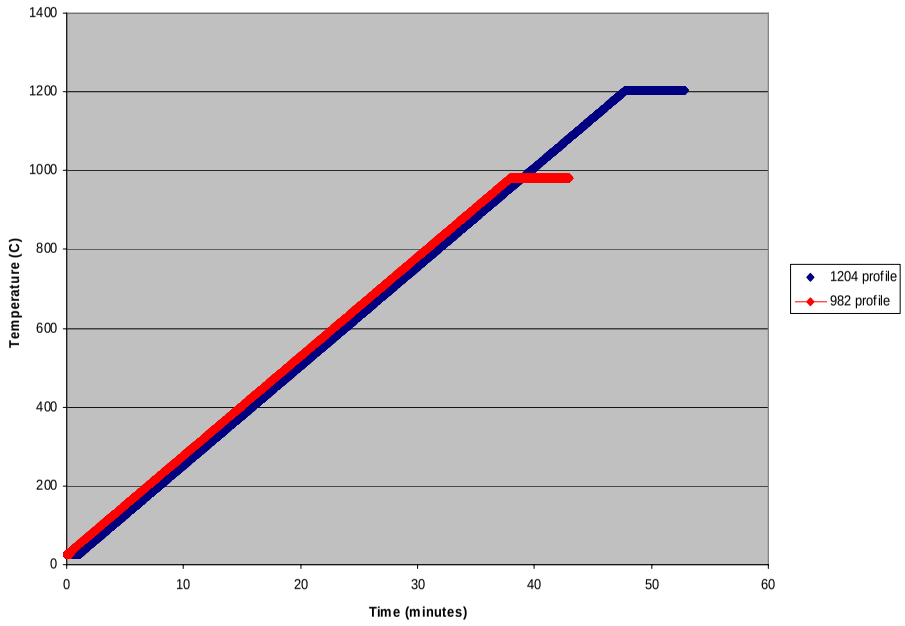
Composite Substrates and Testing Conditions

- **ACC-4 (T-300 Carbon Fibers and SiC coating) from C-CAT Composites was used as substrate material during compressibility and thermal stability tests.**
- **GRABER was used to seal the edges of 1”x1” ACC-4 specimens to prevent edge oxidation.**

Test Conditions:

- **Temperatures: *982°C (1800 F)* and 1204°C (2200 F)**
- **Pressure/ Load on Gaskets: *60 psi* and 100 psi**
- **Five minute hold**
- **Test was carried out in a Instron load frame with a high temperature furnace, in air**



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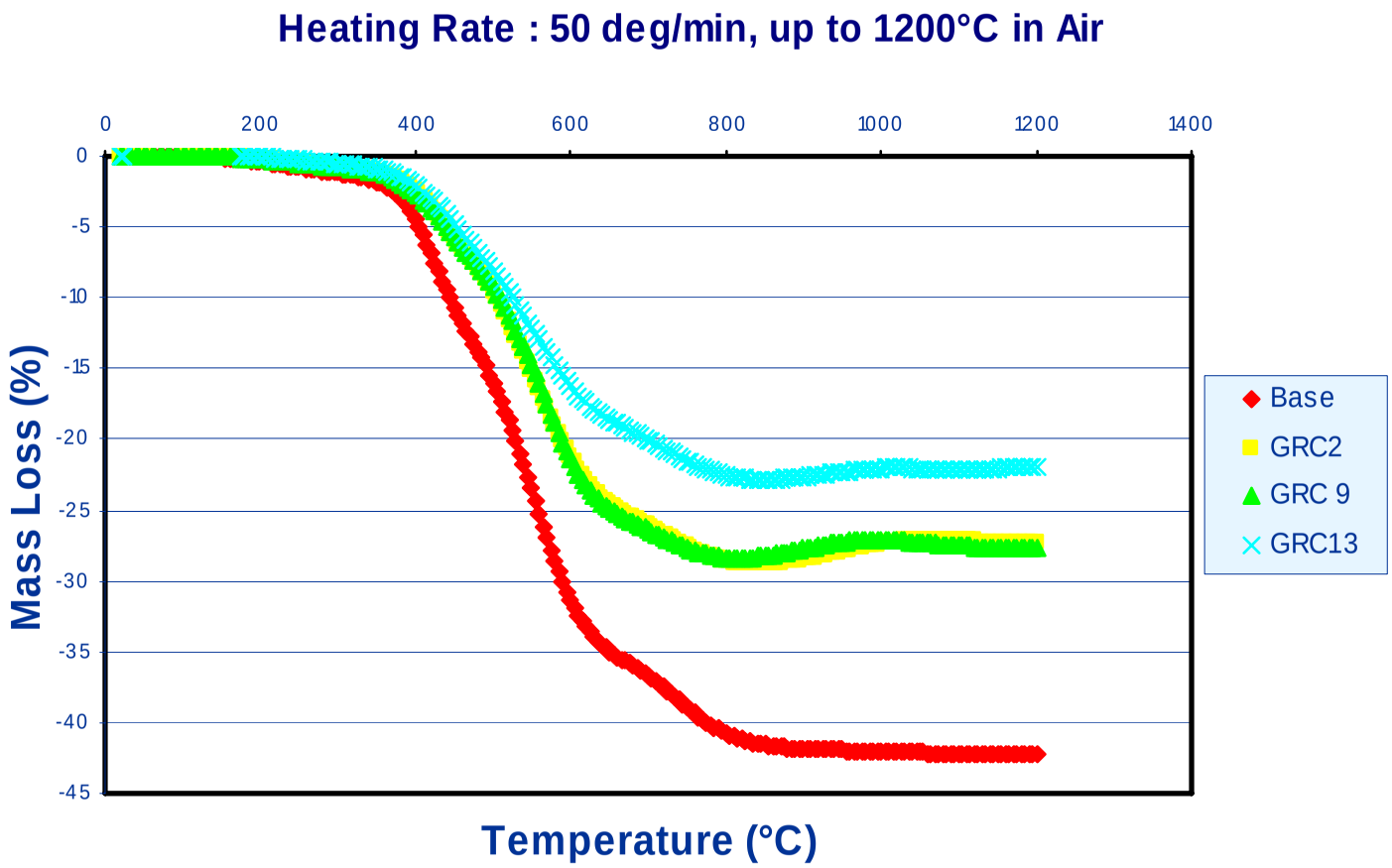
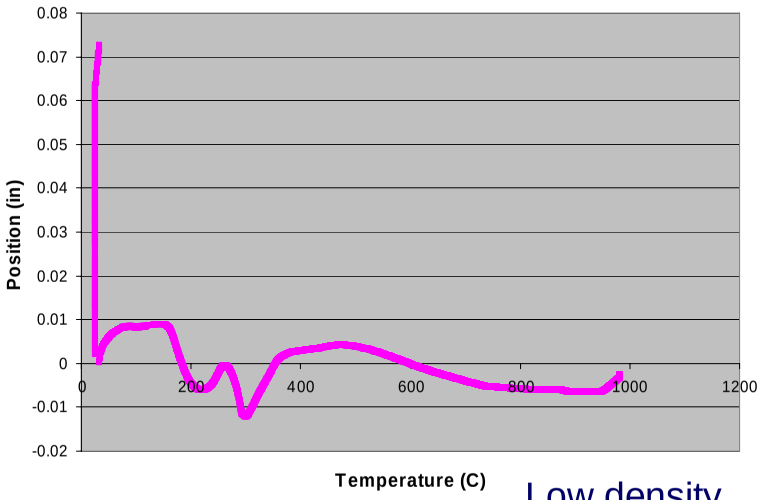
Thermogravimetric Analysis of Gasket Materials



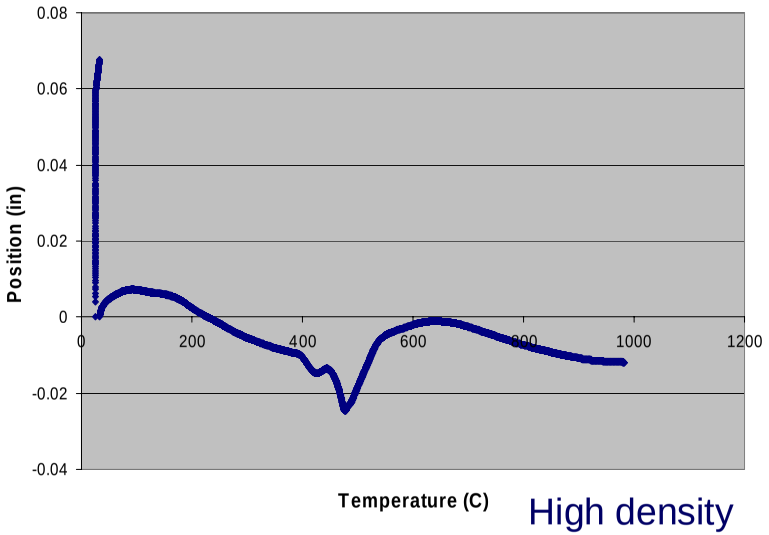
Compression Testing of Base Gasket Material at 60 psi and 982°C (5 min hold)

- Base gasket material fell apart after testing. There are no optical or SEM images available.
- Without composition modifications, it will not meet gasket performance requirements.
- Modified compositions GRC-2, GRC-9, and GRC-13 were used for further testing.

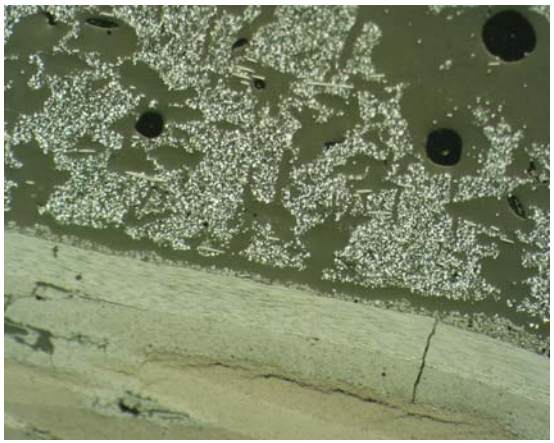
Compression Testing of GRC-2 Gasket Material at 60 psi and 982°C (5 min hold)



Low density (1.1 gm/cc)

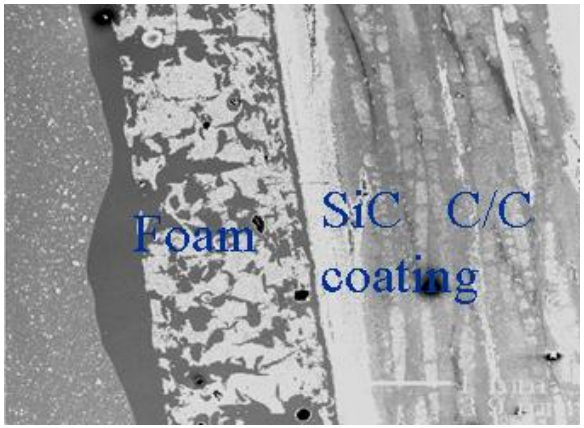


High density (1.26 gm/cc)

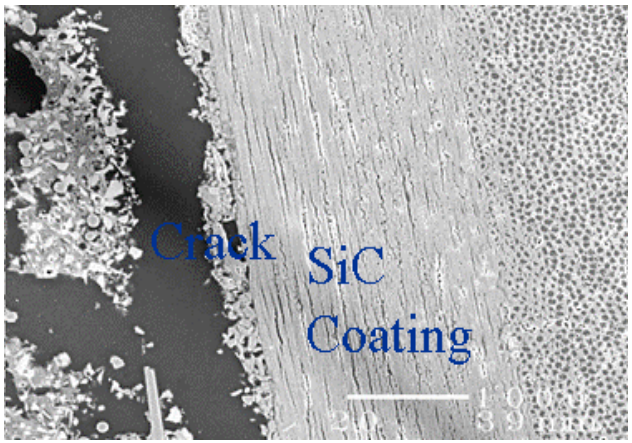


Optical images of GRC 2 at 50 X. The picture (right) shows the interaction of GRABER and the SiC coating. To the left is an image of the gasket material after heating.

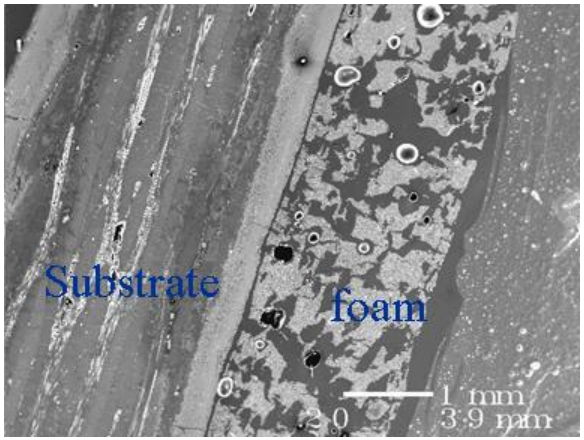
Micrographs of GRC-2 Gasket Material at 60 psi and 982°C (5 min hold)



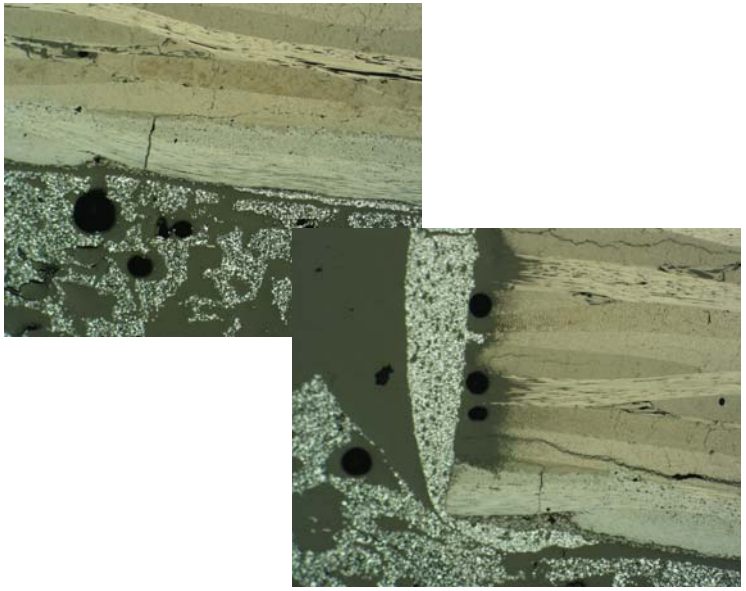
Lower Density



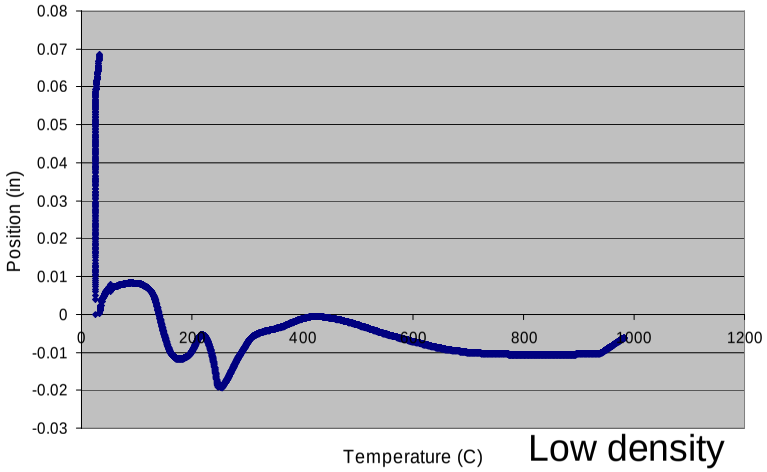
T_i: 4 mm; T_f: 2.2 mm



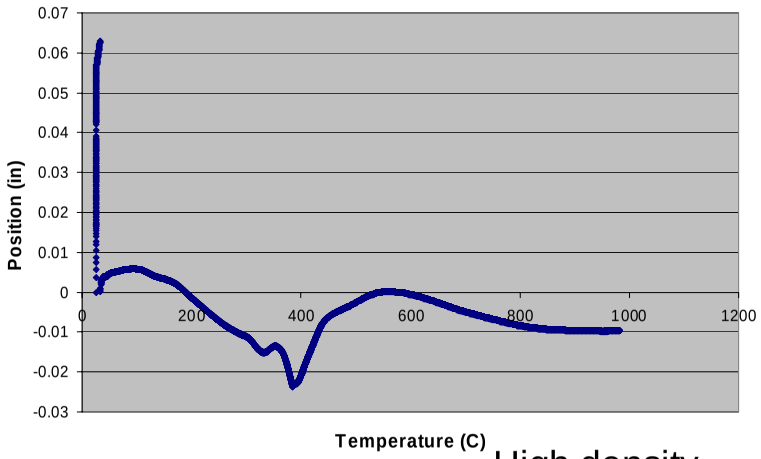
Higher Density



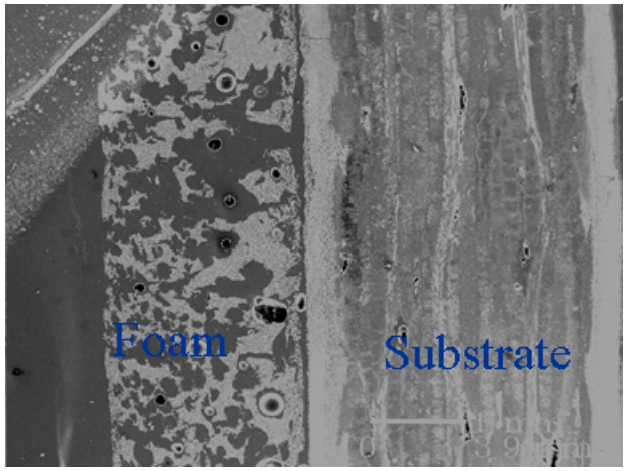
GRC 9 Gasket Material at 60 psi at 982°C (5 min. cycle)

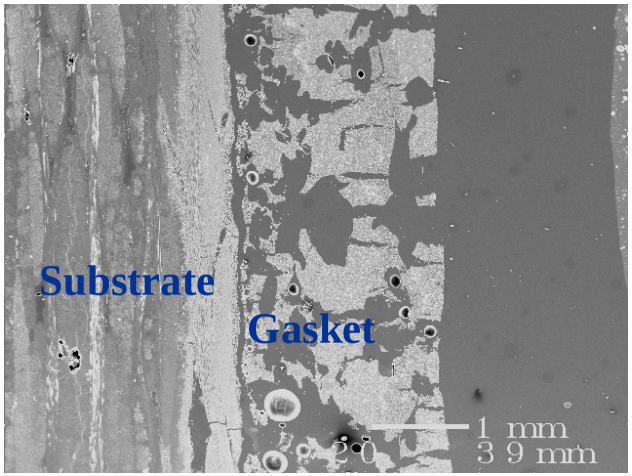


Low density
(1.15 gm/cc)

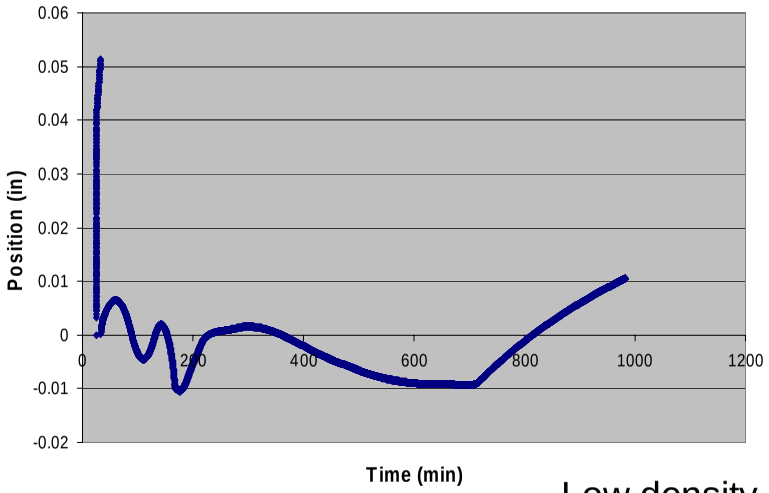


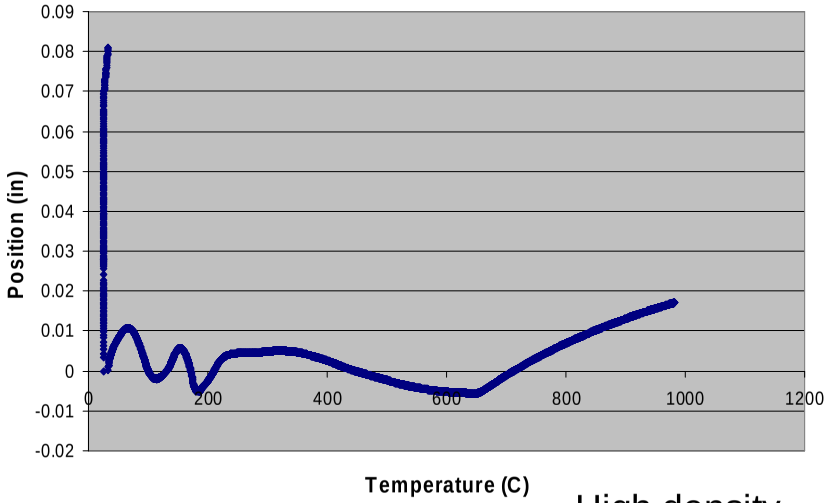
High density
(1.32 gm/cc)





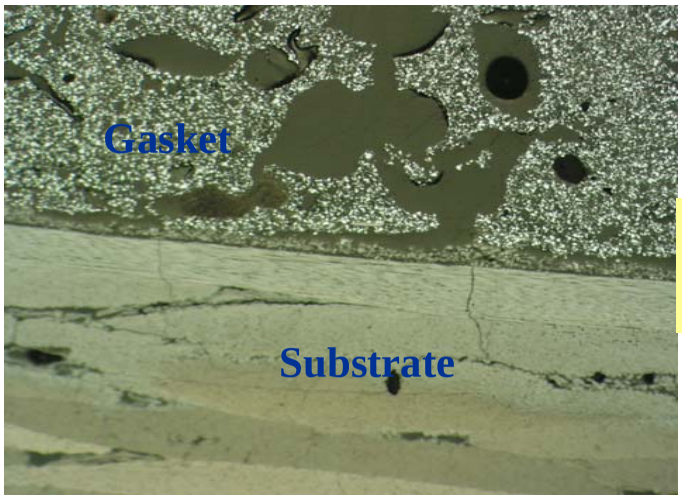
GRC 13 Gasket Material at 60 psi and 982°C (5 min. hold)



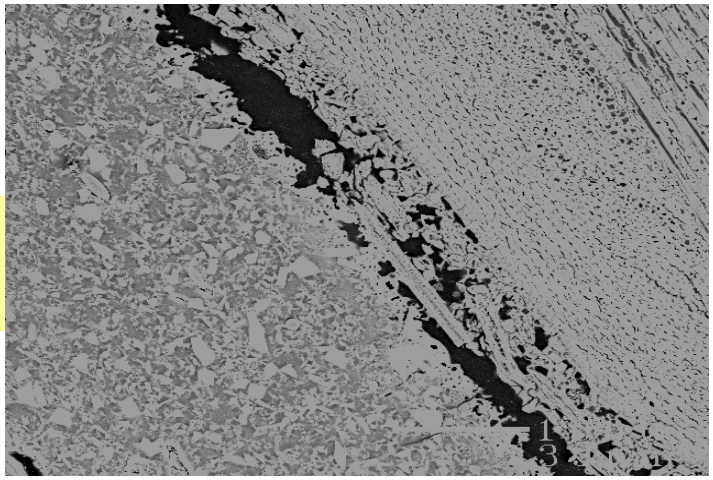


Low density (1.06 gm/cc)

High density (1.18 gm/cc)



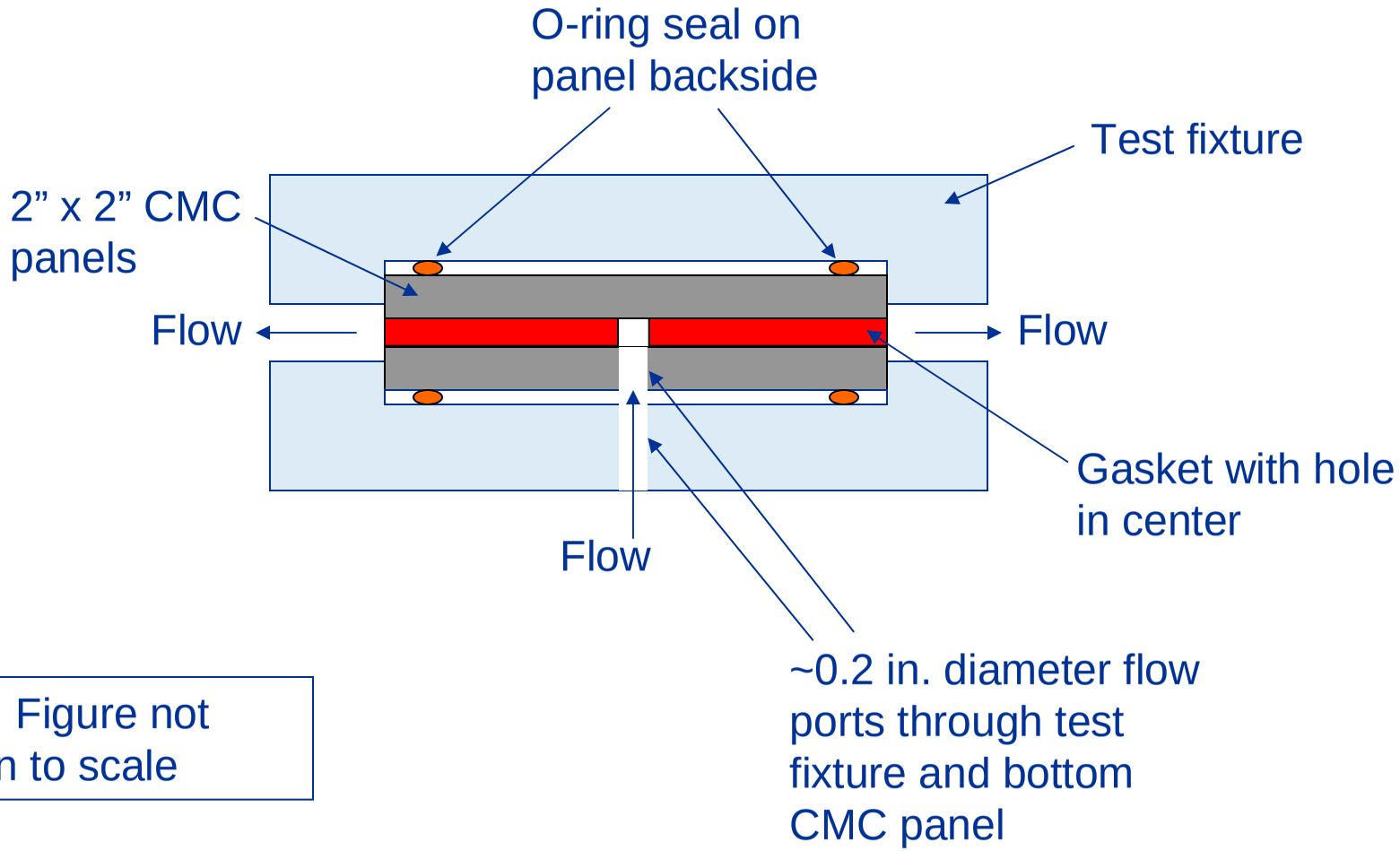
Microstructural Details of Gaskets



Summary and Conclusions

- A wide variety of flexible gasket compositions were developed and tested at high temperatures. The gasket material system has high temperature capability.
- GRABER sealants were very effective in sealing machined ACC-4 composite surfaces.
- The gasket composition do not bond strongly with the ACC-4 substrate materials.
- The density of gasket materials can be tailored to show appropriate compressibility.

Schematic for Potential Test Setup of GRC Gasket Materials



Note: Figure not drawn to scale

Pat Dunlap, NASA GRC

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- Ron Phillips, ASRC Aerospace for Mechanical Testing
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