



# Flexible Ceramics, Inc.

## 2010

**The Future is here - We are the solution**

# Our Mission Statement

*To deliver solutions that will help our customers exceed their goals, to be environmentally responsible and have a positive impact on the world.*

# Prologue

Dr. Eugene Rochow, Professor of Chemistry, Harvard University predicted in his state of the art 1964 Reinhold publication on Organometallic Chemistry that some day we would be able to solve the following problem that would lead a host of new products. “We want flexible resilient, and elastic materials which will act the same at red heat as the common organic plastics and elastomers act at room temperature. The demand is imposed by the requirements of pollution free and fuel efficient high performance truck and automotive engines, supersonic aircraft, rockets and space vehicles, where developments are held up by lack of suitable materials.

**The Future is here - We are the solution**

# Introduction

We used the term Flexible Ceramic to describe products developed with an inhibited elastic stage and a more fully reactive ceramic stage thus allowing the ceramic materials to remain flexible at temperatures where they perform best. We have created a poly blend. Two separate polymers come together to create a hybrid material with properties that enhance each other's capabilities. Our composite material is non-combustible and can enter and sustain itself in the Red Heat Zone (600 ° - 1000 ° C). Through our proprietary processing methods we can customize our product to meet your most demanding applications.

We use selective heat treating, thermally advancing the resin composition and changing the architecture of ceramic filler and fabric reinforcement, causing the silicone composite to pass through different phases, producing different products. Therefore, products can evolve from liquid to resin to prepeg to elastomeric to flexible ceramic laminates to fully ceramic products. Laser cutting transforms the laminate resin to create ceramically sealed edges and constrained viscoelastic joints with rebound capability that compensates for any gaps or movement in the sealing process. This material is flexible, with considerable strength, and unlike today's ceramics offers excellent resistance to thermal shock, high heat flux, and abrasions.

# Universal Polymer Systems

We have developed a multipurpose universal polymer system with a superior fireproof resistance capability, strength and versatility and is process compatible with current laminate processing equipment. It is environmentally friendly and completely recyclable. A coating has been developed which lowers the heat transfer through Thin Fireproof Laminates. Through our proprietary formulation, we have developed a system that can control the various stages of reaction through variations in the amount of catalyst, inhibitor and thermal cure rate. Controlling these different stages of polymer reactions affords us the ability to work with our customers to meet new challenges and to improve upon existing designs and products in the market today.

## **Our resin can be used as a:**

- Liquid spray insulator/liquid gasket
- Adhesive
- Coating
- Gasket or Seal
- Thin Fireproof Laminate
- Structural Panel
- Fiber and Molding Compound
- Fireproof Honeycomb Panel
- Structural Composite Matrix Resin

# Product Advantages

## **Advantages of our multi-purpose polymer system include:**

- Broad & Economical supplier base
- Redundant certification
- Reduced inventory
- Joining capability
- Processing knowledge base
- Design flexibility

## **Flexible Ceramics' inorganic material offers the following advantages:**

- Fireproof barrier
- Lightweight
- Cost effective processing methods
- Non-Toxic
- Smokeless
- Self extinguishing
- Waterproof
- Self-curing
- Environmentally recyclable
- Sound dampening qualities

# Cost Saving Process Innovations Enabled By Resin Properties

1. Resin mixing and storage at room temperature
2. Resin enables ambient temperature high speed prepreg processing (as high as 400 ft./min) without solvents, odors or toxicity.
3. Sealants, coatings and adhesives all made from same base resin materials with same advantages of thermal protection.
4. A cocure bonds easily eliminating the need for adhesives, primers and tooling costs. It can be bonded as a protective shield for Kapton and polyimides.
5. Our material process is compatible with current laminate processing equipment.

# Cost Saving Process Innovations Enabled By Resin Properties

6. We can provide a thin, fire protective coating that can economically offer fire protection to existing structures now in place.
7. Permanent part identification accomplished through silkscreen process at high speed production rates.
8. Stacking of laminates provides multiple parts in one laser cutting operation.
9. The laser cut edge offers a glass sealed edge for superior fire protection with no additional edge preparation.
10. We offer a fiber-rich gasket material that can be extruded onto any surface configuration eliminating the cost of laminating processing, inventory and assembly.



# Mechanical Properties

## Typical Mechanical Properties of Flexible Ceramic Materials:

- The material pyrolysis yield at 1000°C is greater than 90% by weight and when retested experiences no additional weight loss.
- The densified ceramic material specific gravity is 2.0 gm/cc with typically less than 0.1% porosity
- 100 hours boiling in Texaco Oil D955M resulted in < 1% swelling
- Steam testing of the gasket caused no problem or breakdown such as experienced with RTV rubber
- The dielectric strength of the head gasket is 500 volts/mil at 1mm thickness and with a polyimide wrapped special wire in the core of a 1mm gasket, the gasket can carry 35 kV ignition cold start (-40°F) requirements with a 200% safety margin

# Testing Data

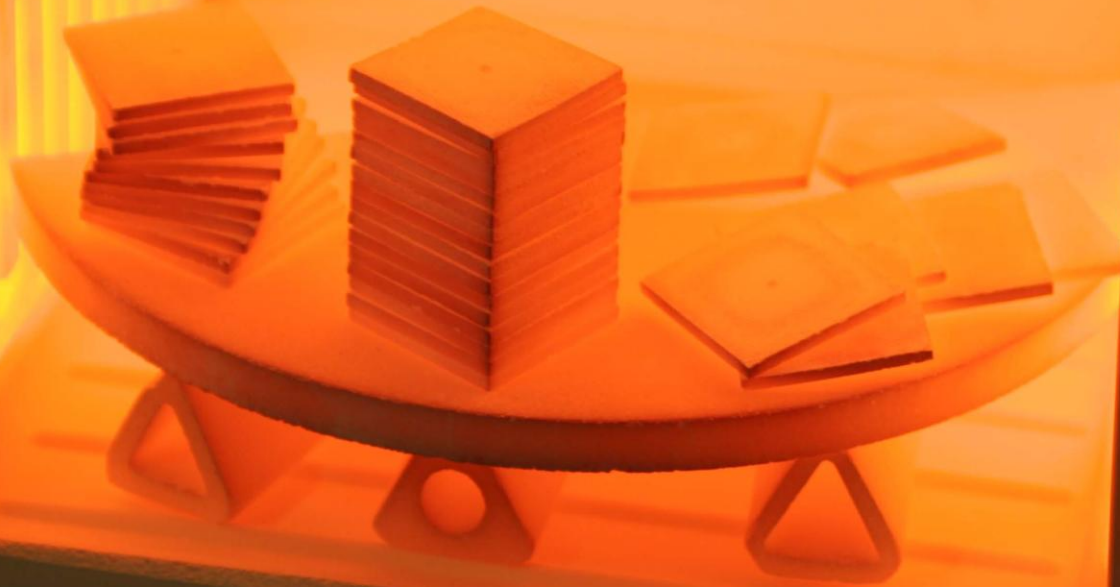
**Our laminates have passed the following tests:**

- 1. FAA standard fireproof test** ( Performed at National Technical Systems- certified FAA test lab)
  - Results: passed @ 1832 °F (1000 ° C) duration 15 minutes full flame penetration
- 2. FAA standard test heat release** – (Performed at Testcorp -certified FAA facility)
  - Results: passed peak heat release rates less than 10kW/m<sup>2</sup>-acceptable range 65kW/m<sup>2</sup>

# Testing Data

3. **FAA Standard Smoke Density Test** – (Performed at Testcorp - FAA certified facility)
  - Results: passed at lowest levels 0.5 ds average allowable 200 ds
  
4. **Toxicity Test**-(Performed at Testcorp - FAA certified facility)
  - Results: passed lowest level to meet Boeing spec requirements BSS D6-51377 rev F.
  
5. **Burn Through Test**-(Performed at The Mexmil Company)
  - Results: passed > 1900 ° F duration of 4 minutes

Flexible Ceramics Inc.  
Kiln Tested at 1000 degrees Celsius  
(For 30 minutes with 98% yield)



# Testing Data

6. **ASTM E136**- Materials Behavior @ 750° C Vertical Tube Furnace Test-  
no smoke/ no flame – Non Combustible (Performed at Govmark - FAA  
certified facility)
  - Preceramic Polysiloxane Material
  - Results: passed vertical tube furnace @750° C duration 30 minutes, 98 %  
retention
  - Department of Defense Required Test
  
7. **ASTME 136 RVNC** -Elastomeric Preceramic Polysiloxane Sheet Material-  
(Performed at Govmark Organization - FAA accepted facility)
  - Results: passed Vertical Tube Furnace testing @ 750° C duration 30 minutes,  
99% retention
  - Department of Defense Required Testing

(Copies of test reports provided upon request)

# High Temperature Circuit/Sensor

Our goal is to create a high temperature flexible composite substrate on which a radiant antenna pattern can be etched to perform as a circuit/ sensor. This composite material is similar to Kapton offering a higher thermal advantage. It can also bond to Kapton offering a protective shield. It must be flexible to accommodate non-flat geometrics such as: a stator wall, pipe interior or turbine engine walls. Operating temperature to be 500° C.

The final thickness of this laminate is approximately 2mm thick. We then use our adhesive to bond a foil material to the laminate. Our adhesive is made of materials found in our base resin. Our adhesive bonds well with most metals especially aluminum. Parts, size and shape can be customized to meet the needs of each application. The material is a laminate and can be molded. Foil can be affixed to both sides of the laminate opening the possibility of communication or relay between circuits.

# High Temperature Circuit/Sensor

**The key features of our high temperature circuit board development are:**

- The high temperature circuit consists of an etched metallic foil that is electrical grade.
- The prepreg resin is formulated to produce a high temperature electrical grade laminate.
- The resin formulation is made from high purity preceramic precursors and fillers.
- The bonding of the foil and prepreg material occurs at the performance temperature.
- The bonded foil laminate can be twisted to form a ½ inch diameter flex cable.

# High Temperature Circuit/Sensor

## **Mechanical characteristics are:**

- Dielectric constant-room temperature 3.75 @700° C, 3.54 inches
- Loss Tangent-room temperature-0.01 inches @ 750° C, 0.006 inches
- Bend Radius- ½ inch for 0.100 inches to 0.120 inches thick based upon E-Glass architecture.

## **Other Possible Applications:**

- Microwave sensor, gas turbine monitors, oil drilling seals, sensors, hydro-turbine shields and sensors, and molded high heat pipes



# Closing Statement

- Our initial testing has verified that we can produce a thin fireproof barrier. As a structural material our non-combustible panels offer passive fire protection and containment. Our barrier is a non-burning laminate that inhibits the formation of smoke and toxins generated by fires.
- Our resin is self-extinguishing and self-curing. Flexible Ceramics materials are made from a blend of pre-ceramic polymers, non-toxic catalysts, ceramic additives and solventless materials. This allows us to offer a resilient inorganic non-metallic material that is completely environmentally safe and recyclable.

# Customized Solutions

- **Adhesive** - it can be pressure sensitive and pressure activated
- **Sealant** - it can be thermally sensitive
- **Liquid Spray** - it can cover or replace asbestos as an environmentally friendly fire retardant material and insulator
- **Liquid** - it can create high temperature adhesives and composites for extreme environmental applications
- **Prepreg** - it is capable of making thermal and electrically insulated products
- **Bullet Proof Material** - it can be flexible and impact absorbing
- **In the Red Heat Zone** - it can operate as combustion and exhaust reliable components, shields or sealants
- **Resin Infusion Products** can operate in high heat areas offering the advantage of weight reduction for better fuel efficiency
- **Elastic Material** - it can operate in the high Red Heat temperature arena, retaining its compression recovery elastic capability and sealing durability for extended periods

# Potential Applications

- Lightweight Flexible Fire Barrier
- Self Extinguishing-Smokeless-Cabin Interior Panels
- Cargo Liners
- Air Ducting-Molded Parts
- Cargo Containment Bins
- Fireproof Components-Aircraft Cabin Interiors
- Insulation Blankets
- Exhaust Nozzles
- Heat Shields-Red Heat Sealants
- Space Station Debris Barrier
- Engine Inlet Ducts
- Coatings

- Re-entry Shields
- Electronic Computer Insulators
- High Temp Seals
- Aerospace Tooling and Structures
- Honeycomb Materials-Aerospace Flooring
- Satellite System Seals and Coatings
- Fire Retardant and Impact Barrier Cabin Door
- Aerospace Structural Adhesives
- Fiber Reinforced Composites –Wings and Flaps
- Polysiloxane Film Adhesives for Metal Bonding

# Contact Information

John Butterly, President

Direct Contact: (760) 799-5574

[johnbutterly@flexibleceramics.net](mailto:johnbutterly@flexibleceramics.net)

Lou Simonelli, Sales Manager

Direct Contact: (626) 840-3522

[lousimonelli@flexibleceramics.net](mailto:lousimonelli@flexibleceramics.net)

William Clarke, Technical Manager

Direct Contact: (805) 403-9474

[bille.clarke@flexibleceramics.net](mailto:bille.clarke@flexibleceramics.net)

Website: [www.flexibleceramics.net](http://www.flexibleceramics.net)

[www.flexibleceramicsinc.com](http://www.flexibleceramicsinc.com)