HIGH PERFORMANCE DIELECTRIC MATERIALS DEVELOPMENT

by

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FOSTER-MILLER, INC.

• 37 year old independent technology development company
• Located in the Boston area
• About 270 employees
• Primary areas of business
  - Advanced polymers  - Robotics
  - Composites        - Special machinery
POLYMER COMPOSITES
MATERIALS TECHNOLOGY

• Mission
  - Develop materials and processing technology to meet DoD and commercial needs
• Specific Areas of Research
  - High temperature dielectric materials
  - High performance dielectrics for capacitors
  - Electronics packaging
  - High performance structural materials
  - Micro-composite blends
  - NLO materials, devices
  - Smart processing

HIGH PERFORMANCE
CAPACITORS

• 300°C Filter capacitor for aircraft power conditioning
  - Funded by the U.S. Air Force
• 8 kJ/kg Repetition rated energy storage capacitor - SDIO
• High energy density dielectric film - U.S. Army
• Interpenetrated polymer network capacitor - SDIO (Scheduled to start September, 1991)
HIGH TEMPERATURE AEROSPACE INSULATION

- Identify and develop new insulation materials that can operate reliably at 250°C+
- Phase I SBIR program started in July, 1991
- Funded by the U.S. Air Force
- Monitored by Mr. George Slenski, and Mr. Eddie White

TARGET FOR NEW INSULATION
WHY FOSTER-MILLER?

• Extensive experience in the development of advanced materials for specific DoD applications
  - Thermotropic LCPs, Xydar, Vectra for PWBs
  - Lyotropic LCPs, e.g. PBZT, PBO for capacitors, light weight structures
  - High performance polyimides - electronic packaging
  - Blends of Vectra and LARC TPI
  - Blends of Matramid and PES
  - Interpenetrating networks of PBO, PBZT and polyimide resins, epoxies

• Foster-Miller is not a material vendor
• Design and synthesize novel materials
• Develop techniques to process difficult materials into films for major material producers

• Close working relationship with
  - Resin vendors
  - Cable and wire vendors
  - System houses
  - Airframe companies
  - and leading experts

• Related experience in
  - High temperature dielectrics for capacitors
  - Insulation for electromagnetic launchers
APPROACH

• Phase I
- Identify key performance parameters and requirements for high temperature insulation materials
- Prepare an evaluation matrix consisting of appropriate weighted coefficients for each performance parameter
- Characterize each candidate material with a composite relative merit index (performance index) using the evaluation matrix
- Select a small number of candidates that meet or exceed all requirements for further investigation

• Phase II
- Thoroughly characterize selected materials
- Develop methods to fabricate round and flat wire constructions
- Evaluate materials in finished wire constructions
- Pick one for incorporation into an airframe
PHASE I PROGRAM PLAN

REQUIREMENTS/EVALUATION PARAMETERS

- 250°C+ temperature rating
  - Thermal Index
- Dry arc resistance
- Voltage withstand, insulation resistance, flammability
- Toxicity, smoke quantity, ...
- Retention of properties
  - Abrasion, flex life ...
## MATERIALS UNDER CONSIDERATION

<table>
<thead>
<tr>
<th>Material</th>
<th>Source</th>
<th>Advantages and Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorinated PBO-PI</td>
<td>Hoechst Celanese</td>
<td>Combines processibility of polyimides with high temperature properties of LCPs</td>
</tr>
<tr>
<td>Thermoplastic PBO with hexafluorinated moieties</td>
<td>Material Lab, WRDC</td>
<td>Thermally processible, high temperature stability, Tg&gt;380°C</td>
</tr>
<tr>
<td>Difluoro-PBZT, tetrafluoro-PBZT</td>
<td>Foster-Miller</td>
<td>High temperature stability, low dielectric constant</td>
</tr>
<tr>
<td>PQ-100 polyquinolines</td>
<td>Maxdem</td>
<td>Thermally processible, available in a number of configurations, high purity</td>
</tr>
<tr>
<td>PBO-fluorinated IPN</td>
<td>Foster-Miller</td>
<td>High temperature stability combined with resistance to flashover</td>
</tr>
<tr>
<td>PBO</td>
<td>Foster-Miller, Dow</td>
<td>Ultra high thermal stability 300 - 350°C significantly exceeds the performance of Kapton and Tefzel</td>
</tr>
<tr>
<td>FPE proprietary aromatic polyester</td>
<td>3M</td>
<td>Readily available high quality aromatic films useful up to 250°C</td>
</tr>
<tr>
<td>Fluorinated polyimides</td>
<td>Hoechst-Celanese Ube/ICI DuPont</td>
<td>Readily available, from Ube/ICI, DuPont thermal stability exceeds Kapton and Tefzel</td>
</tr>
<tr>
<td>Polysiloxanemides</td>
<td>McGrath, VPI</td>
<td>Resistant to ionizing radiation, high thermal stability</td>
</tr>
<tr>
<td>Fluorocarbon-hydrocarbon polymers</td>
<td>Tefzel, DuPont</td>
<td>Readily available, high quality films, moderate thermal stability</td>
</tr>
<tr>
<td>Organo-ceramic hybrid nano composites</td>
<td>Garth Wilkes, VPI</td>
<td>Resistant to ionizing radiation, high thermal stability, greater than 200°C</td>
</tr>
<tr>
<td>Polysilsequioxane</td>
<td>David Sarnoff Labs</td>
<td>Good electrical properties up to 250°C superior to Kapton and Tefzel, can dip or spray coat</td>
</tr>
</tbody>
</table>
ADVANCED INSULATION MUST MEET MINIMUM PERFORMANCE INCREASES OVER CURRENT MATERIALS AND BE AMENABLE TO LARGE-SCALE PROCESSING AT ACCEPTABLE COSTS.
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First NASA Workshop on Wiring for Space Applications

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Space power; Wiring; Insulation; Dielectrics; Arc tracking

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