Investigation on Smart Parts with Embedded Piezoelectric Sensors via Additive Manufacturing


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Introduction

Objective

• To design, fabricate, and test “smart parts” with embedded sensors.

Methodology & Materials

EBM Manufacturing Process

Piezo Sensing Mechanism

Smart Part fabrication

Fabrication and Characterization

Step 1: Fabricate the bottom and “smart” part

Step 2: Assemble sensor, bonding and “smart” part

Step 3: 3D printer print the bond pocket

Figure 10: Cylindrical EBM’s size for material characterization.

Simulation

Simulation results: Stress and Strain

High-Temperature Wiring

Table 1: The chosen wiring elements, Platinum and Titanium properties, are compared to Copper.

<table>
<thead>
<tr>
<th>Wiring Material</th>
<th>Melting Point</th>
<th>Electrical Conductivity at 20°C</th>
<th>Expansion at 1000°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platinum</td>
<td>1769.5°C</td>
<td>105 mΩ·cm</td>
<td>5.4%</td>
</tr>
<tr>
<td>Titanium</td>
<td>1668°C</td>
<td>420 mΩ·cm</td>
<td>6.4%</td>
</tr>
<tr>
<td>Copper</td>
<td>1084.6°C</td>
<td>16.78 mΩ·cm</td>
<td>17%</td>
</tr>
</tbody>
</table>

Future Work

• Perform mechanical testing.
• Evaluate the bonding strength of alumina paste as bonding agent.
• Assessment of sensing parameters before and after fabrication.

Objective 1

Task 1: Characterization
Task 2: “Smart Parts” Fabrication

Objective 2

Task 3: Mechanical Evaluation
Task 4: Sensing Demonstration

Objective 3

Task 5: “Smart Tube” Testing
Task 6: “Smart Premier” Testing
Task 7: Modification to Fabrication

Acknowledgements

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Students Involved

Mechanical Testing

Figure 16: Example of a mechanical testing setup.

Figure 10: Fabricated/smart parts.

Figure 9: Fabricated “Smart Parts”.

Figure 8: Additive manufacturing enabled process.

Figure 7: Additive manufacturing enabled parts.

Figure 6: Additive manufacturing enabled parts.

Figure 5: Additive manufacturing enabled process.

Figure 4: Additive manufacturing enabled parts.

High-Temperature Testing

Figure 3: Additive manufacturing enabled process.

Figure 2: Additive manufacturing enabled parts.

Figure 1: Additive manufacturing enabled process.