A Comparison of Thermal Performance: Cu–Clad and Hi–k PCB Processes

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Introduction

- FEA software used to model heat flow on a typical LED-type PCB
- The intent of the model is to show differences in temperature and temperature distribution for popular Cu–Clad boards as compared to the new, printed process
- The substrate for all models is a 2.5” x 4” x 0.063” (63.5 x 101.6 x 1.6mm) 6061 alloy aluminum PCB (k=170)
Materials and Boundaries

- Cu–Clad models use a 4oz. weight Cu foil supported by a 4mil (10um) thick layer of prepreg composite adhesive
  - Thermal conductivity for the prepreg was modeled at 0.2 and 0.4 W/mK
- Hi–k models use a 2mil (50um) layer of Hi–k dielectric ink and a 2mil (50um) layer of Ag conductor
  - Thermal conductivity for the two HiK materials was 2.0 and 10 W/mK
- Boundary conditions remained the same for all models
  - Power in 8 places on the board at 1W
  - Convection heat–transfer coefficients for top and bottom surfaces at 10 W/m2K and edge surfaces at 5 W/m2KA
  - Ambient temperature of 310K (37°C).
Pad Configuration

- For Cu–Clad PCB 4oz. foil covers the entire board surface to enhance spreading.
- Eight 2.7 x 4mm pads are separated from the rest of the Cu foil by a distance of 0.635mm (25mil)
  - The Cu–Clad pad construction is shown in Figure A.
- On the Hi–k board the pad and conductor use the same geometry as the Cu–Clad, but are isolated on the PCB as ‘islands’ while the remainder of the Al substrate is uncoated.
  - The Hi–k dielectric and pad construction is shown in Figure B.
Pad Configuration

Figure A. Cu-Clad Pad

Figure B. Hi-k Pad and Dielectric
## FEA Study Results

### Table 1. Thermal FEA Results Summary

<table>
<thead>
<tr>
<th>Case</th>
<th>Material</th>
<th>PrePreg</th>
<th>k</th>
<th>Tmin (°C)</th>
<th>Tmax (°C)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cu-Clad Lo</td>
<td>100um</td>
<td>0.2 W/mK</td>
<td>96.17</td>
<td>140.30</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>Cu-Clad Hi</td>
<td>100um</td>
<td>0.4 W/mK</td>
<td>96.20</td>
<td>121.01</td>
<td>14%</td>
</tr>
<tr>
<td>3</td>
<td>Hi-k 120A2</td>
<td>50um</td>
<td>2 W/mK</td>
<td>95.06</td>
<td>102.52</td>
<td>27%</td>
</tr>
<tr>
<td>4</td>
<td>Hi-k 120A10</td>
<td>50um</td>
<td>10 W/mK</td>
<td>95.06</td>
<td>100.68</td>
<td>28%</td>
</tr>
</tbody>
</table>

- Table 1 shows the case results and percent improvement over typical low-thermal conductivity Cu–Clad process.
Temperature Distribution

- The following figures show the temperature distribution across the board for all four cases.
- Note that the minimum temperature of the board is not greatly affected, but the temperature at the mounting surface is significantly reduced.
  - Both models show a temperature rise of approximately 60°C above ambient for Tmin.
- Using the printed process, thermal stress is reduced due to lower temperature gradients in the area of the component placement which will improve reliability.
Cu–Clad Temperature Distribution

Case 1. Cu-Clad - 0.2W/mK
Case 2. Cu-Clad - 0.4 W/mK
Hi–k Temperature Distribution

Case 3. Hi-k120A2 – 2 W/mK

Case 4. Hi-k120A10 – 10 W/mK
Benefits of Hi-\(k\) PCB

- Improved thermal performance
  - Reductions in thermal resistance from component to the spreader can be 10X or higher
  - Cooler \(T_j\)
  - Higher power density
- Lower Cost
  - Selective printing reduces material use per area
    - Build up only where necessary
- Lower Temperature Reflow Profiles
  - Low-temperature solder processes and materials are proven and in mass manufacturing
  - Decreases stress
  - Increases reliability
- Simpler, greener processing
  - Selective application saves money in materials, processing and waste stream
  - Less waste, faster process, no etching or hazardous chemical processes
  - Lower temperature reflow means less energy usage
Conclusion

- This new technology is the natural evolution of materials applied to the growing field of solid-state lighting and photo-voltaic applications.
- Lower manufacturing temperatures, less waste and clean processes enable longer life for these applications, addressing the need for greener products from manufacture to end-of-life.

For complete details and specifications, contact Package Science.