STABLCOR® Technology for "Printed Circuit Board and Substrate"
Outline

- Electronics Challenges
- Today’s Material and it’s limitations
- Need for High Performance Material and Test data
- How to use STABLCOR® in a PCB
- Benefits of STABLCOR® in a PCB
- Supply Chain
- Case Study
- Design Guidelines
- Conclusion
Challenges of the Electronics

The electronics Industry today is facing challenges such as

- HOT SPOT
- CTE mismatch,
- solder joint stress,
- thermal fatigue failure
- shock and vibration issues,
- “SMALLER, FASTER, STRONGER”

www.stablcor.com
# PCB material & Its limitations (Dielectric)

<table>
<thead>
<tr>
<th>DIELECTRIC MATERIAL</th>
<th>Thermal Conductivity (W/m.K)</th>
<th>IN-PLANE CTE (ppm/C)</th>
<th>Tensile Modulus (Msi)</th>
<th>Density (g/cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR-4/E-glass</td>
<td>0.3 to 0.4</td>
<td>16 to 20</td>
<td>3.5 to 4.5</td>
<td>1.6-1.8</td>
</tr>
<tr>
<td>Polyimide/E-glass</td>
<td>0.2 to 0.4</td>
<td>15 to 19</td>
<td>3.5 to 4.5</td>
<td>1.5-1.7</td>
</tr>
<tr>
<td>Aramid/Epoxy</td>
<td>0.2 to 0.3</td>
<td>9 to 12</td>
<td>2 to 2.1</td>
<td>1.25-1.3</td>
</tr>
<tr>
<td>PTFE Ceramic (RO3000)</td>
<td>0.5 to 0.66</td>
<td>17</td>
<td>0.30</td>
<td>2.1-3.0</td>
</tr>
<tr>
<td>Non-PTFE Ceramic (R4000)</td>
<td>0.6 to 0.65</td>
<td>12 to 16</td>
<td>1.6 to 3.9</td>
<td>1.8-1.86</td>
</tr>
</tbody>
</table>
Current Material & It’s limitations

- ELECTRICAL Property - Very Good
- THERMAL Property – Poor
- MECHANICAL Property – Poor
  - Rigidity
  - Co-efficient of Thermal Expansion (CTE)
STABLCOR® Material is used today in Printed Circuit Boards and Substrate to address THERMAL & MECHANICAL issues
What is STABLCOR® Material?

- It is a Carbon Composite Laminate
- A thermally & Electrically Conductive Composite Material
  - It has very good In-plane Thermal Conductivity
  - It has low In-plane CTE (3-6 ppm/C)
  - It can be used as a plane layer, Preferably GND plane

Copper

Carbon Composite core

Copper
### STABLCOR® material part number system

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Core Thickness</th>
<th>Copper Thickness (oz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST10-EP387</td>
<td>0.0045”(114um), 0.006”(152um), 0.009”(229um), 0.018”(457um)</td>
<td>H/H, 1/1</td>
</tr>
<tr>
<td>ST10-LC909</td>
<td>0.009” (229um)</td>
<td>H/H, 1/1</td>
</tr>
<tr>
<td>ST325-EP387*</td>
<td>0.008”(203um)</td>
<td>H/H, 1/1</td>
</tr>
</tbody>
</table>

**Part Number System:** **ST325-EP387-0.008 H/H**

- **STABLCOR type**
- **Resin type**
- **Core thickness**
- **Copper thickness**

- EP387 = EPOXY Grade STABLCOR
- LC909 = POLYIMIDE Grade STABLCOR

*ST325 Material subject to have MICROCRACKS*
## STABLCOR Material - Part Number List

<table>
<thead>
<tr>
<th>Products</th>
<th>Part Number</th>
<th>Copper Weight</th>
<th>Overall Thickness Inch (mm)</th>
<th>Tg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Epoxy STABLCOR® Products</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST10</td>
<td>ST10-EP387-0.0045H/H</td>
<td>1/2 oz over 1/2 oz</td>
<td>0.0059&quot; (0.150)</td>
<td>170° C</td>
</tr>
<tr>
<td></td>
<td>ST10-EP387-0.0045 1/1</td>
<td>1oz over 1oz</td>
<td>0.0073&quot; (0.185)</td>
<td>170° C</td>
</tr>
<tr>
<td></td>
<td>ST10-EP387-0.006H/H</td>
<td>1/2 oz over 1/2 oz</td>
<td>0.0074&quot; (0.188)</td>
<td>170° C</td>
</tr>
<tr>
<td></td>
<td>ST10-EP387-0.006 1/1</td>
<td>1oz over 1oz</td>
<td>0.0088&quot; (0.224)</td>
<td>170° C</td>
</tr>
<tr>
<td></td>
<td>ST10-EP387-0.009H/H</td>
<td>1/2 oz over 1/2 oz</td>
<td>0.0104&quot; (0.264)</td>
<td>170° C</td>
</tr>
<tr>
<td></td>
<td>ST10-EP387-0.009 1/1</td>
<td>1oz over 1oz</td>
<td>0.0118&quot; (0.300)</td>
<td>170° C</td>
</tr>
<tr>
<td></td>
<td>ST10-EP387-0.018H/H</td>
<td>1/2 oz over 1/2 oz</td>
<td>0.0194&quot; (0.493)</td>
<td>170° C</td>
</tr>
<tr>
<td>ST325*</td>
<td>ST325-EP387-0.008H/H</td>
<td>1/2 oz over 1/2 oz</td>
<td>0.0094&quot; (0.239)</td>
<td>170° C</td>
</tr>
<tr>
<td></td>
<td>ST325-EP387-0.008 1/1</td>
<td>1oz over 1oz</td>
<td>0.0108&quot; (0.274)</td>
<td>170° C</td>
</tr>
<tr>
<td><strong>Polyimide STABLCOR® Products</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST10</td>
<td>ST10-LC909-0.009H/H</td>
<td>1/2 oz over 1/2 oz</td>
<td>0.0104&quot; (0.264)</td>
<td>240° C</td>
</tr>
<tr>
<td></td>
<td>ST10-LC909-0.009 1/1</td>
<td>1oz over 1oz</td>
<td>0.0118&quot; (0.300)</td>
<td>240° C</td>
</tr>
</tbody>
</table>

*ST325 Material subject to have MICROCRACKS

www.stablcor.com

Technology Presentation-0309
### COPPER CLAD CARBON COMPOSITE (STABLCOR®)

**Thermal, Low CTE, Stiff and Light Weight Material**

<table>
<thead>
<tr>
<th>E.CONDUCTIVE MATERIAL</th>
<th>Thermal Conductivity (W/m.K)</th>
<th>CTE (ppm/C)</th>
<th>Tensile Modulus (Msi)</th>
<th>Density (g/cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR-4/E-glass</td>
<td>0.3 to 0.4</td>
<td>16 to 20</td>
<td>3.5 to 4.5</td>
<td>1.6-1.8</td>
</tr>
<tr>
<td>Polyimide/E-glass</td>
<td>0.2 to 0.4</td>
<td>15 to 19</td>
<td>3.5 to 4.5</td>
<td>1.5-1.7</td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td>385</td>
<td>17 to 20</td>
<td>8.92</td>
</tr>
<tr>
<td>CIC (Copper-Invar-Copper)</td>
<td>108</td>
<td>5 to 6</td>
<td>19</td>
<td>9.90</td>
</tr>
<tr>
<td><strong>Stablcor Laminate-Unclad (X &amp; Y)</strong></td>
<td>ST10~ 2*</td>
<td>ST10~4.5to6</td>
<td>ST10~ 9</td>
<td>ST325~24</td>
</tr>
<tr>
<td></td>
<td>ST325~82*</td>
<td>ST325~1to3</td>
<td>ST325~ 24</td>
<td></td>
</tr>
<tr>
<td><strong>STABLCOR® Laminate-with 1oz Cu clad (X &amp; Y)</strong></td>
<td>ST10~ 75*</td>
<td>ST10~5to7</td>
<td>ST10~ 10</td>
<td>ST325~ 25</td>
</tr>
<tr>
<td></td>
<td>ST325~175*</td>
<td>ST325~2to4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Theoretical calculated In-Plane values based on volume & Thermal conductivity of the composite materials*
CTE – STABLCOR® Material

In-Plane CTE

CTE vs Temperature
Material: ST325-EP450 Unclad

Composite CTE (0-3 ppm) over Temp. range of -50C to +130C

DIELECTRIC MATERIAL | In Plane CTE (ppm/C)
--- | ---
FR-4 / E-glass | 16 to 20
Polyimide/E-glass | 15 to 19
Non Woven Aramid/Epoxy | 9 to 12
PTFE Ceramic (RO3000) | 17.00
Non-PTFE Ceramic (RO4000) | 12 to 16
CTE – STABLCOR® Material

Through Plane CTE

Sample: Tg and CTE test for CCL
Size: 0.7159 mm
Method: Ramp

File: C:\TA\Data\TMA\Stablcor substrate.008
Operator: BP
Run Date: 12-Sep-2005 17:38
Instrument: TMA Q400 V7.1 Build 89

<table>
<thead>
<tr>
<th>Run number</th>
<th>Z-CTE before Tg (ppm/°C)</th>
<th>Tg (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42.1</td>
<td>209.57</td>
</tr>
<tr>
<td>2</td>
<td>34.8</td>
<td>201.87</td>
</tr>
</tbody>
</table>

DIELECTRIC MATERIAL

<table>
<thead>
<tr>
<th>Material</th>
<th>Through Plane CTE (ppm/°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR-4/E-glass</td>
<td>55 to 60</td>
</tr>
<tr>
<td>Polyimide/E-glass</td>
<td>50 to 60</td>
</tr>
<tr>
<td>Non Woven Aramid/Epoxy</td>
<td>110 to 120</td>
</tr>
<tr>
<td>PTFE Ceramic (RO3000)</td>
<td>25 to 40</td>
</tr>
<tr>
<td>Non-PTFE Ceramic (RO4000)</td>
<td>50 to 55</td>
</tr>
</tbody>
</table>

Z-axis CTE measurement by TMA method

www.stablcor.com
How is STABLCOR® used in a PCB?

(<0.035”) PCB/Substrate

1-CORE

Prepreg
FR-4
Prepreg
FR-4
Prepreg
FR-4
Prepreg
FR-4
Prepreg

(<0.093”) PCB

2-CORE

Prepreg
FR-4
Prepreg
STABLCOR®
Prepreg
FR-4
Prepreg
FR-4
Prepreg
STABLCOR®
Prepreg

(>0.093”) PCB

3-CORE

Prepreg
FR-4
Prepreg
STABLCOR®
Prepreg
FR-4
Prepreg
STABLCOR®
Prepreg
FR-4

www.stablcor.com
CROSS SECTIONS

3-layer PCB

6-layer PCB

12-layer PCB

1-CORE

2-CORE

4-CORE

www.stablcor.com

Technology Presentation-0309
The Benefits Of STABLCOR® in a PCB / Substrate

- Thermal
- CTE (Co-efficient of Thermal Expansion)
- Rigidity / Stiffness
- Density / Weight

www.stablcor.com
CARBON IN A PCB

Thermal / HEAT
VME - Wedge Lock

MILLING STEP

Wedge Lock

Ground Via

Thermal Via

Isolated via on Ground layer

Wedge Lock

Cu Edge Plating

Ground Pin

Heat source

STABLCOR®

HIGH LAYER VME CARD

www.stablcor.com
PCB acts as HEAT SPREADER

www.stablcor.com
THERMAL – PRODUCT LEVEL

* >124.9°F

* <68.0°F

FR4 PCB – 1G module

STABLCOR® PCB – 1G module

NATURAL CONVECTION
40Watt

STABLCOR® ST325+FR4

FR4 PCB

www.stablcor.com

Technology Presentation-0309
THERMAL SIMULATION SOFTWARE

STABLCOR® material is listed in these software library

1. Ansys Inc. (TAS PCB Software)
   David Rosato
   Ph: (978) 772-3800
   David.rosato@ansys.com
   Canonsburg, PA 15317

2. Fluent Inc. (Icepak Software)
   Dan Scharpf
   Ph: (603) 643-2600 x 617
   dfs@fluent.com
   New Hampshire 03766

3. Flomerics (Flotherm Software)
   Sherman Ikemoto
   Ph: (512) 420-9273 x 203
   Sherman.Ikemoto@flowmerics.com
   Vista, California 92083

www.stablcor.com
CARBON IN A PCB

Co-efficient of Thermal Expansion
IC PACKAGE TYPE

- Organic Packages (CTE: 16-19ppm/C)
- Ceramic Packages (CTE: 6-8ppm/C)
- Flip Chip, DDA, WLP (2-4ppm/C)
<table>
<thead>
<tr>
<th>Sample</th>
<th>CTE, $\alpha_x$ (x $10^{-6}$ 1/°C)</th>
<th>CTE, $\alpha_y$ (x $10^{-6}$ 1/°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST10-EP387-0.006 0/0</td>
<td>4.88</td>
<td>6.28</td>
</tr>
<tr>
<td>ST10-EP387-0.009 0/0</td>
<td>5.85</td>
<td>6.48</td>
</tr>
<tr>
<td>ST325-EP387-0.008 0/0</td>
<td>0.25</td>
<td>1.8</td>
</tr>
<tr>
<td>ST325-EP387-0.010 0/0</td>
<td>0.91</td>
<td>1.6</td>
</tr>
</tbody>
</table>
CTE – STABLCOR PCB

14-Layer, 80mil Thick, FR4+Stablcor PCB

Temperature Dependent Coefficient of Thermal Expansion

Board: (STABLCOR+ FR4)

\[
\alpha_{X1} = 10.96498 + 0.00834 T - 0.0000346 T^2 \\
\alpha_{X2} = 12.47485 + 0.01158 T - 0.0000548 T^2
\]

10.9 to 12.4ppm/C
CARBON IN A PCB

RIGIDITY / STIFFNESS
Rigidity / Stiffness

Rigidity of STABLCOR® PCB v/s FR4 PCB at Room Temp

**Printed Wiring Board Bend Data**

- **Sample 1 (FR4)**
- **Sample 2 (FR4)**
- **Sample 3 (FR4 + STABLCOR)**
- **Sample 4 (FR4 + STABLCOR)**
- **Sample 5 (FR4 + STABLCOR)**
- **Sample 6 (FR4 + STABLCOR)**
- **Sample 7 (FR4 + STABLCOR)**

**Maximum Force at 15mm Deflection**

This result shows the STABLCOR® samples to be ~66.6% stiffer than the FR4 test samples.
Rigidity / Stiffness

Bend Test Over Temperature Range (40°C to 250°C)

Length of vertical lines represent the amount of Deflection

www.stablcor.com

Technology Presentation-0309
Rigidity / Stiffness

Rigidity of thick STABLCOR® PCB (0.093” – 0.125”)

ST10 - STABLCOR® samples are ~ 275% stiffer than the Polyimide test samples

ST325- STABLCOR® samples are ~ 450% stiffer than the Polyimide test samples

www.stablcor.com

Technology Presentation-0309
## WEIGHT

<table>
<thead>
<tr>
<th>Material (Laminate)</th>
<th>Density gm/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR4</td>
<td>1.80</td>
</tr>
<tr>
<td>Polyimide</td>
<td>1.70</td>
</tr>
<tr>
<td>STABLCOR® (w/o Cu)</td>
<td>1.65</td>
</tr>
<tr>
<td>Aluminum</td>
<td>2.7</td>
</tr>
<tr>
<td>Copper</td>
<td>8.92</td>
</tr>
<tr>
<td>Copper Invar Copper</td>
<td>9.9</td>
</tr>
</tbody>
</table>
Current Supply Chain

Factory: Millbury, Massachusetts, USA

Lewcott / Carbon Core Laminates (STABLCOR material manufacturer / Distributor)

** Qualified PCB Manufacturer **
- Dynamic Details Inc
- Hunter Technologies
- North Texas Circuit Board
- Murrietta Circuits
- Winonics
- Cosmotronic
- Cirtech
- Unicircuit
- Harbor Electronics / ECT
- TTM Technologies – Stafford & Chippewa Falls Plants

End User / CUSTOMER

54,000 sq.ft facility

www.stablcor.com
Customer Quote:

ST10 represented a 12% to 15% temperature reduction compared to FR4.

dT between ST325 and ST10 PCBs are very close to each other.

CASE STUDY – Thermal at 40W, ST10

40Watt, Natural Convection, STABLCOR® PCB running 11.2°C Cooler

NATURAL CONVECTION
40Watt

FR4 PCB

STABLCOR®
ST10+FR4

Courtesy: CONTINENTAL Automotive France SAS, Mr. Loic Bertrand

www.stablcor.com
CASE STUDY – Thermal at 40W, ST325

Customer Quote:

With the STABLCOR we can say that hot spots are practically eliminated. ST325 represented a 15% to 20% temperature reduction compared to FR4.
CASE STUDY – Thermal at 40W

6-Layer PCB, 0.062” thick, ~6.0” x 6.0”, ST325 at L2 & L5

<table>
<thead>
<tr>
<th>Thermal Resistance (at 40Watt), Natural Convection</th>
<th>Without plate</th>
<th>With plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR4 PCB</td>
<td>6.7°C/W</td>
<td>4.7°C/W</td>
</tr>
<tr>
<td>Stablcor PCB (ST325)</td>
<td>4.5°C/W</td>
<td>2.5°C/W</td>
</tr>
<tr>
<td>Stablcor PCB (ST10)</td>
<td>4.8°C/W</td>
<td>Not Tested</td>
</tr>
</tbody>
</table>

**ST325:** With the STABLCOR solution **thermal resistance** decreased by ~30% compared to the FR4 solution

**ST10:** With the STABLCOR solution **thermal resistance** decreased by ~28% compared to the FR4 solution

Courtesy: CONTINENTAL Automotive France SAS, Mr. Loic Bertrand

www.stablcor.com
CASE STUDY – SBC (Single Board Computer)

PPC Single Board Computer

Prototype Engineering Module
Commercial Parts

Super Computer for Space
CASE STUDY – SBC, Thermal & CTE

SCS750 Ideal Application for Stablcor®

Thermal Management
- Conduction cooled
- Dissipates 38W on 6U cPCI board
- Max temp rise (die) ≈ 15°C

Mechanical
- Less mass than copper core board
  – Budget < 1.5Kg
- Improved shock and random vibration performance
  – Higher frequency
- Lower CTE improves CCGA reliability
  – Required for large – high pin count components
The superior thermal conductivity is evident from the reduced temperature at the resistor. The power resistor was set up to heat up to about 100°C (ambient was about 24°C during the test), which required slightly over 6W into the resistor. Keeping the resistor power constant, the STABLCOR® material lowered the resistor temperature by 12.8°C. The thermal resistivity of the resistor to ambient was 12.6°C/W with the FR-4 and 10.6°C/W with the STABLCOR® indicating a 2.0W or 19% improvement in power handling capability with this configuration.
CASE STUDY – Solar Panel, low CTE & Rigidity

- **MATCHED CTE**
  Eliminates thermal induced stress on the triple junction solar cells. Initial thermal cycle testing has shown no damage to solar cells due to matching thermal expansion.

- **AUTOMATED PRODUCTION**
  Reduces cost in large volume production compared with traditional attachment methods.

- **RUGGED**
  The rigidity of the CCL substrates reduces costs by eliminating need for additional supports to meet shock and vibration requirements.

www.stablcor.com
With no underfill, the characteristic (63.2%) life of the FR-4/NELCO is about 20 cycles. The STABLCOR® board is about 173 cycles.

For no underfill test, the chips on STABLCOR® substrate remain attached at 353 cycles. Most of the chips detached from the other test boards at 353 cycles.
CASE STUDY – Ceramic BGA Reliability

The characteristic life of the CBGA on the STABLCOR PWB is roughly 2X better than on the regular PWB.

www.stablcor.com

Technology Presentation-0309
Case Study – Thermount vs. Stablcor PCB CTE

85NT THERMOUNT PCB Layer Stack-up

- 0.008" H/H Poly. Thermount85NT
- 1ply. 0.0018"
- 1ply. 0.0031"
- 0.0039" 1/1 Poly. Thermount85NT
- 2ply x 0.0018"
- 0.0039" H/H Poly. Thermount85NT
- 2ply x 0.0018"
- 0.0039" H/H Poly. Thermount85NT
- 2ply x 0.0018"
- 0.0039" H/H Poly. Thermount85NT
- 2ply x 0.0018"
- 0.0039" H/H Poly. Thermount85NT
- 2ply x 0.0018"
- 0.0039" 1/1 Poly. Thermount85NT
- 1ply. 0.0031"
- 1ply. 0.0018"
- 0.008" 0/H Poly. Thermount85NT

L1 - Signal-0.5oz
No Copper
L2 Ground
L3 Ground
L4 Signal
L5 Signal
L6 GND
L7 Signal
L8 Signal
L9 GND
L10 Signal
L11 Signal
L12 Ground
L13 Ground
No Copper
L14 - Signal-0.5oz

2ply 106 prepreg

---

14-Layer, 80mil Thick, 85NT Thermount PCB

14-Layer, 80mil Thick, FR4+Stablcor PCB

www.stablcor.com
# Case Study – Thermount vs. Stablcor PCB CTE

## 14-Layer, 80mil Thick, 85NT Thermount PCB

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>CTE (ppm / °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60</td>
<td>0</td>
</tr>
<tr>
<td>-40</td>
<td>2</td>
</tr>
<tr>
<td>-20</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>60</td>
<td>12</td>
</tr>
<tr>
<td>80</td>
<td>14</td>
</tr>
<tr>
<td>100</td>
<td>16</td>
</tr>
<tr>
<td>120</td>
<td>18</td>
</tr>
<tr>
<td>140</td>
<td>20</td>
</tr>
<tr>
<td>160</td>
<td>22</td>
</tr>
</tbody>
</table>

- **X1 direction**
  - \( \alpha_{X1} = 12.0942 + 0.015026 \, T - 0.000118 \, T^2 \)
- **X2 direction**
  - \( \alpha_{X2} = 10.33096 + 0.00757 \, T - 0.0000488 \, T^2 \)

### Board: EP3900B-C1 (Thermount)

- **Temperature Dependent Coefficient of Thermal Expansion**

![Graph of Thermount CTE](image)

- **CTE Values:** 10.3 to 12.1ppm/C

---

## 14-Layer, 80mil Thick, FR4+Stablcor PCB

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>CTE (ppm / °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60</td>
<td>0</td>
</tr>
<tr>
<td>-40</td>
<td>2</td>
</tr>
<tr>
<td>-20</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>60</td>
<td>12</td>
</tr>
<tr>
<td>80</td>
<td>14</td>
</tr>
<tr>
<td>100</td>
<td>16</td>
</tr>
<tr>
<td>120</td>
<td>18</td>
</tr>
<tr>
<td>140</td>
<td>20</td>
</tr>
<tr>
<td>160</td>
<td>22</td>
</tr>
</tbody>
</table>

- **X1 direction**
  - \( \alpha_{X1} = 10.96498 + 0.00834 \, T - 0.0000346 \, T^2 \)
- **X2 direction**
  - \( \alpha_{X2} = 12.47485 + 0.01158 \, T - 0.0000548 \, T^2 \)

### Board: EP3900B-A1 (STABLCOR+ FR4)

- **Temperature Dependent Coefficient of Thermal Expansion**

![Graph of Stablcor CTE](image)

- **CTE Values:** 10.9 to 12.4ppm/C

---

www.stablcor.com
CASE STUDY

Multi-Functional Spacecraft Structures Using Advanced Printed Wiring Board Materials

Principal Investigator: Donald Schatzel, Section 374
Kevin Watson, Section 345, Carissa Tudryn, 374, Donald Hunter, 374

Benefits to NASA and JPL:
- Significant mass and volume reduction is attained by incorporating electrical signal paths into the mechanical structure.
- Reduced risk due to more efficient integrated thermal paths.
- Favorable material properties that exhibit low thermal coefficient of expansion that will increase mission life in extreme environments.
- Major reduction in cable and connector mass.
- Enhanced material properties for existing flight circuit board applications.

JPL Study for Multifunctional Spacecraft Structure

Project Objectives:
- Develop and demonstrate a low mass electromechanical integrated spacecraft sub-system that incorporates functions electronics within the sub-system structural elements.
- Leverage advanced printed circuit board laminate technology into the design and fabrication of structural geometries.
- Design, fabricate and assemble simple structural elements & incorporate electronicidiocy (traces, vias) with pcg geometries to allow placement of discrete devices, micro Ball Grid Arrays and Chip-On-Board devices.
- Leverage the inherent material strength properties of a carbon core laminate (CCL) composite.
- Compare the strength and stiffness of test articles with CCL to metallic structures.
- Demonstrate electrical functionality of test articles with CCL under load.

FUTURE APPLICATIONS:
- Rover Camera
- Multifunctional Spacecraft Structure Rover Camera
- Micro-Satellite
- Payload Instruments

FYOC Results:
- The optimum strength to weight and stiffness is obtained using 2-layers of CCL.
- Two layers of CCL has the lowest weight compared to 0d and 3-layer beams with the same thickness (0.0625 to 0.0685). The practical limit for PCB layer thickness (0.0625 to 0.125) is 4-layers of CCL for maximum strength and minimum weight.
- Greater than 4-layers of CCL would result in an undesirable weight penalty.
- For beams with CCL, the force of fracture through the electronic traces and board structure increased as the number of layers of CCL increased.
- For aluminum beams, yielding or the onset of plastic deformation occurs prior to failure.
- The graphs on the left depict the maximum force and deflection prior to failure. The Aluminum yielding is defined at 2% offset value (determined by the beam cross-section ASME F 1595-22).
- Results from the 3-point bend tests demonstrated the 4-layers of CCL exhibited a 4% higher strength than the Aluminum beam test article.
- Results from the cantilever bend tests demonstrated the Aluminum beam had the highest strength overall by a minimum of 17%.
STABLCOR® Laminate

......is an......

*Electrically Conductive Material*
Thus, ............

It is used as a PLANE layer, preferably GROUND plane layer within a multilayer PCB
BEST WAY TO USE STABLCOR?

- USE AS A **GROUND** PLANE
- USE ALL STABLCOR LAYERS AS SAME **GROUND**
- DO NOT USE AS **SPLIT GROUND** PLANE
- DO NOT USE AS A **POWER** PLANE
- DO NOT USE AS A **MIX PLANE** LAYER
OPTIMIZE CLEARANCE PAD SIZES ON GND Plane

Plated Through Hole (PTH) pattern

Rule to optimize anti-pad size:
- PTH size + 20mil (minimum)
- PTH size + 28mil (maximum)
** stay towards minimum side

DESIGNER MUST OPTIMIZE ANTI-PAD SIZES ON A STABLCOR GROUND PLANE DATA
STABLCOR LAYERS MUST BE PLACED SYMMETRICALLY ALONG THE THICKNESS OF A PCB

1-CORE

2-CORE

3-CORE

STABLCOR must be symmetrical in a stack-up
Proposed stack-up to Optimize RIGIDITY Benefit

**Non-Optimized Stack-up for Rigidity**

- Preparation
- FR-4
- FR-4
- FR-4
- FR-4

**Optimized Stack-up for Rigidity**

- Principle: Use STABLCOR® layers away from Neutral Axis
- Two thin STABLCOR® layers as arranged below would give higher stiffness than single thick core in a center

**Non-Optimized Stack-up for Rigidity**

- Preparation
- FR-4
- FR-4
- FR-4
- FR-4

**Optimized Stack-up for Rigidity**

- Preparation
- FR-4
- FR-4
- FR-4

**Non-Optimized Stack-up for Rigidity**

- Preparation
- FR-4
- FR-4
- FR-4
- FR-4

**Optimized Stack-up for Rigidity**

- Preparation
- FR-4
- FR-4
- FR-4

**Non-Optimized Stack-up for Rigidity**

- Preparation
- FR-4
- FR-4
- FR-4
- FR-4

**Optimized Stack-up for Rigidity**

- Preparation
- FR-4
- FR-4
- FR-4

**Non-Optimized Stack-up for Rigidity**

- Preparation
- FR-4
- FR-4
- FR-4
- FR-4

**Optimized Stack-up for Rigidity**

- Preparation
- FR-4
- FR-4
- FR-4

www.stablcor.com
Do’s and Don’ts
Do’s & Don’t

Don’t

<table>
<thead>
<tr>
<th>Prepreg</th>
<th>Thick Dielectric Core</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4 GND</th>
<th>L5 GND</th>
<th>L6</th>
<th>L7</th>
<th>L8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepreg</td>
<td>STABLCOR®</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepreg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepreg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepreg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do’s

<table>
<thead>
<tr>
<th>Prepreg</th>
<th>Thick Dielectric Core</th>
<th>L1</th>
<th>L2 GND</th>
<th>L3</th>
<th>L4</th>
<th>L5 GND</th>
<th>L6</th>
<th>L7 GND</th>
<th>L8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepreg</td>
<td>STABLCOR®</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepreg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepreg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepreg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Distribute the STABLCOR material across the thickness of a PCB

www.stablcor.com
Do’s & Don’t

Don’t

- Use thick core instead of using two thin core next to each other

Do’s

- Use 3ply 106 Prepreg min.
- Use 16mil STABLCOR®
- Use Dielectric Core
- Use Prepreg

L1
L2 GND
L3 GND
L4
L5
L6
L7
L8 GND
L9 GND
L10

www.stablcor.com
Do’s & Don’t

**Don’ts**

- **SINGLE CORE, SINGLE PLY STACK-UP**
  
  - Top
  - Prepreg
  - NF, STABLCOR (CTE control layer)
  
  - Bottom
  - Prepreg
  - SINGLE PLY, UNCLAD, STABLCOR LAMINATE

- **SINGLE CORE, DOUBLE PLY STACK-UP**
  
  - Top
  - Prepreg
  - NF, STABLCOR (CTE control layer)
  
  - Bottom
  - Prepreg
  - DOUBLE PLY, UNCLAD, STABLCOR LAMINATE

**Do’s**

- **SINGLE CORE, DOUBLE PLY STACK-UP**
  
  - Top
  - Prepreg
  - NF, STABLCOR (CTE control layer)
  
  - Bottom
  - Prepreg
  - DOUBLE PLY, Copper CLAD, STABLCOR LAMINATE

- “Single ply” Stablcor in a “Single Core, Thin PCB” stack-up will cause “warpage”. That is why it is recommended to use “Double ply” Stablcor in a “Single Core, thin PCB”

DO NOT USE “SINGLE PLY” STABLCOR IF THERE IS ONLY ONE CORE STACK-UP
LIMITATIONS

- IT IS NOT A DIELECTRIC MATERIAL
- IN SOME CASES IT CAN INCREASE FINISH PCB THICKNESS
- STABLCOR “CORE” WILL BE EXPOSED AROUND THE PERIMETER OF THE FINISHED PCB
- AVAILABLE FROM AUTHORIZED MANUFACTURERS ONLY
- IT IS NOT RECOMMENDED TO USE HOT AIR SOLDER LEVEL (HASL) SURFACE FINISH FOR ST325 PRODUCTS
CONCLUSION

Operates Cooler
- Reduces Hot Spot
- PCB acts as a Heat Sink
- Reduces Thermal Stress on Components

Matches CTE
- Attach Ceramic packages more reliably
- Attach Flip Chip more reliably

Stiffness
- Prevents Warpage
- Increased Yields for Component Placement

All above benefits at almost no weight premium

Benefits for lead free PCBA processing
lower reflow oven temperatures

www.stablcor.com
For more info
www.stablcor.com