HUNTER TECHNOLOGY CORP

STABLCOR

KEY BENEFITS OF THE CARBON FIBER COMPOSITE IN A PRINTED CIRCUIT BOARD AND A SUBSTRATE

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ON BEHAF OF HUNTER TECHNOLOGY

Outline

- Electronics Challenges
- What is Carbon Fiber Composite Material
- Test data of the Carbon Fiber Composite
- How to use Carbon Fiber Composite in PCBs
- Benefits of the Carbon Fiber Composite in PCBs
- Conclusion

Challenges of the Electronics

The electronics Industry is facing challenges such as

HOT SPOT

CTE mismatch,

solder joint stress,

thermal fatigue failure

shock and vibration issues,

“SMALLER, FASTER, LIGHTER”

Thermal & Thermo-mechanical material

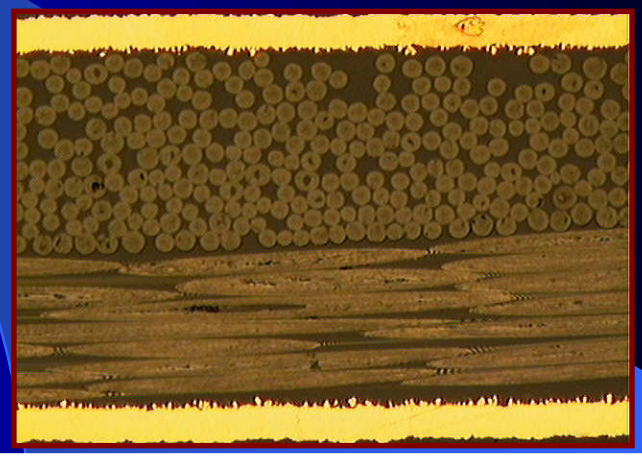
Carbon Fiber Composite is used today in Printed Circuit Boards and Substrate to address these issues.

Carbon Fiber Composite is also known as

STABLCOR® Laminates

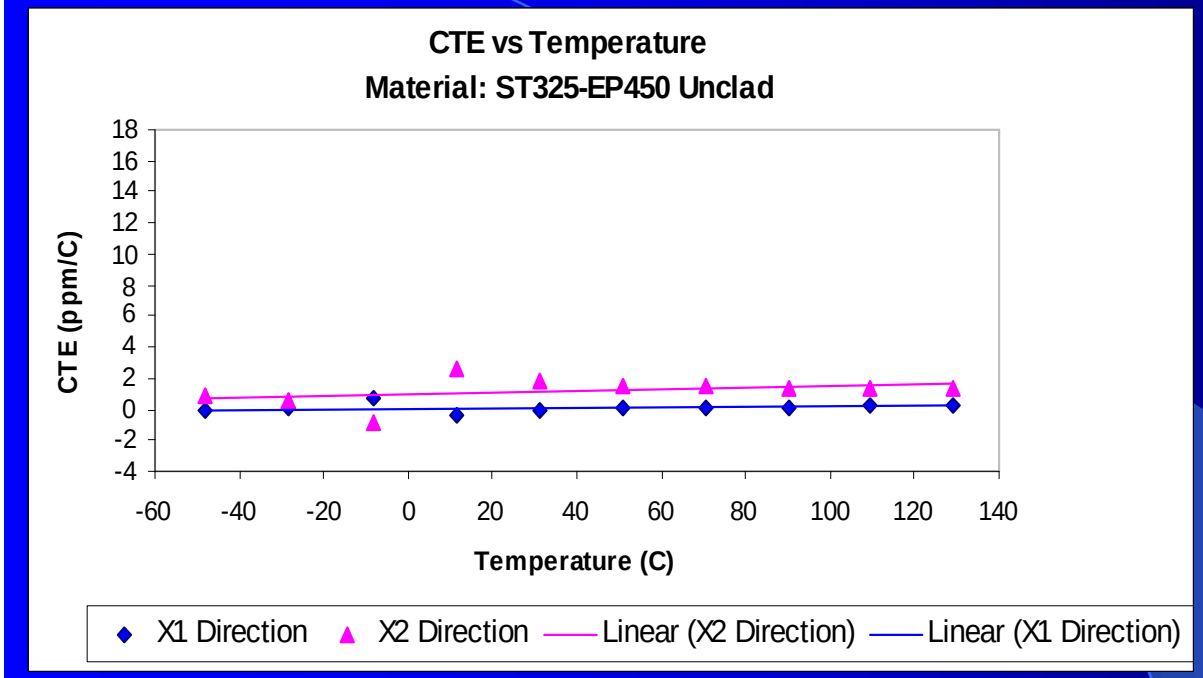
What is Carbon Fiber Composite?

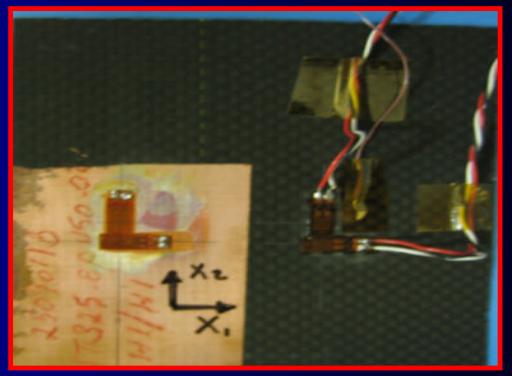
- Made of Continuous Carbon Fiber reinforced with resin matrix
- It is a thermally & Electrically Conductive Composite Material
  - **It has very good In-plane Thermal Conductivity**
  - **It has low In-plane CTE (1-5 ppm/C)**
  - **It can be used as a plane layer, Preferably GND plane**



CTE – Carbon Composite

In-Plane CTE



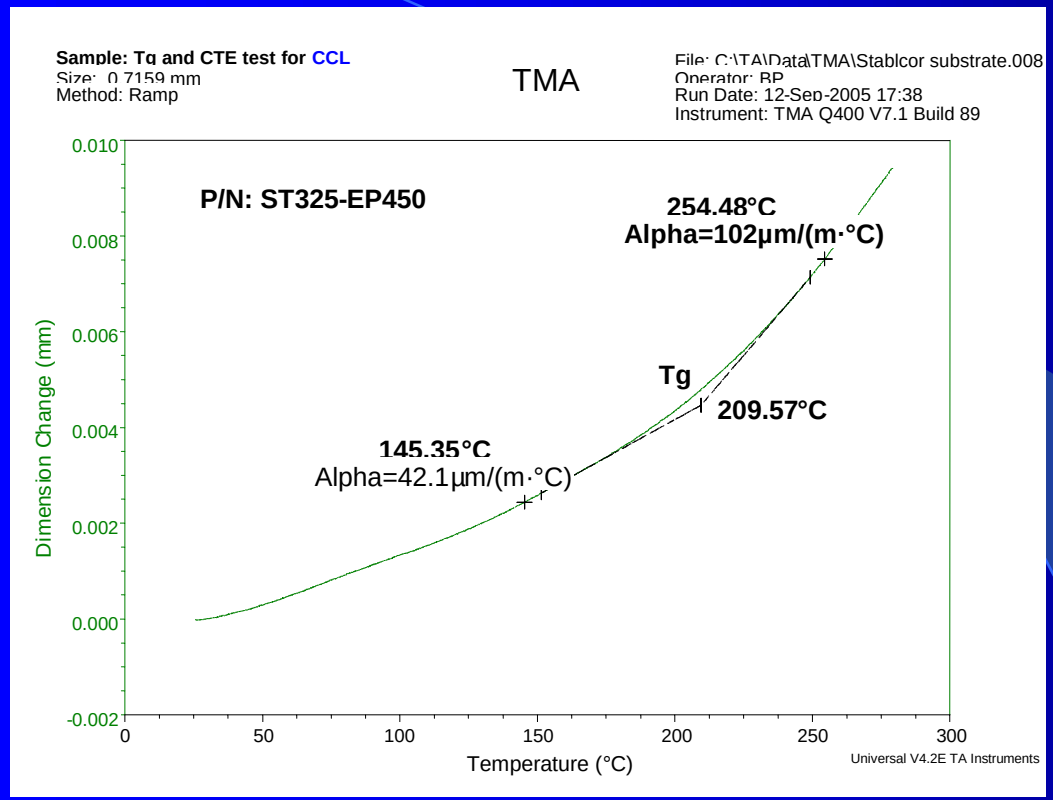


DIELECTRIC MATERIAL	In Plane CTE (ppm/C)
FR-4 / E-glass	16 to 20
Polyimide/E-glass	15 to 19
Non Woven Aramid/Epoxy	9 to 12
PTFE Ceramic (RO3000)	17.00
Non-PTFE Ceramic (RO4000)	12 to 16

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

CTE – Carbon Composite

Through Plane CTE



Z-axis CTE measurement by TMA method

Run number	Z-CTE before Tg (ppm/°C)	Tg (°C)
1	**42.1**	209.57
2	**34.8**	201.87

DIELECTRIC MATERIAL	Through Plane CTE (ppm/C)
FR-4/E-glass	55 to 60
Polyimide/E-glass	50 to 55
Non Woven Aramid/Epoxy	110 to 120
PTFE Ceramic (RO3000)	25 to 40
Non-PTFE Ceramic (RO4000)	50 to 55

Thermal Management, CTE, Stiffener Material Comparisons

Thermal Management, CTE Control, Stiffener Materials Comparison				
MATERIAL	**Thermal Conductivity (W/m.K)**	**IN-PLANE CTE (ppm/C)**	**Tensile Modulus (Msi)**	**Density (g/cc)**
Low Modulus Carbon Fiber*	8 to 12	-0.41	30 to 35	1.7 to 1.8
High Modulus Carbon Fiber*	300-620	-1.5	100 to 130	2.1 to 2.2
Heavy Copper	385 to 400	17 to 19	12 to 16	8.90
Copper-Invar-Copper (CIC)	20 to 30	5 to 6	18 to 19	9.90
Copper-Molybdenum-Copper (CMC)	180 to 220	6 to 8	N/A	9.8 to 10
Non Woven Aramid composite	0.2 to 0.3	9 to 12	2 to 2.1	1.25 to 1.3
Copper C11000 full hard	385 to 400	17.00	6.40	8.90
Aluminum 5052	150	25	3.76	2.70
Aluminum 6061 T6	150	25	3.75	2.7
Copper Clad Carbon Composite (STABLCOR®)	**X,Y:75 to 250, Z:3/5**	**1 to 5**	**11 to 40**	**1.65 to 1.7**

STABLCOR

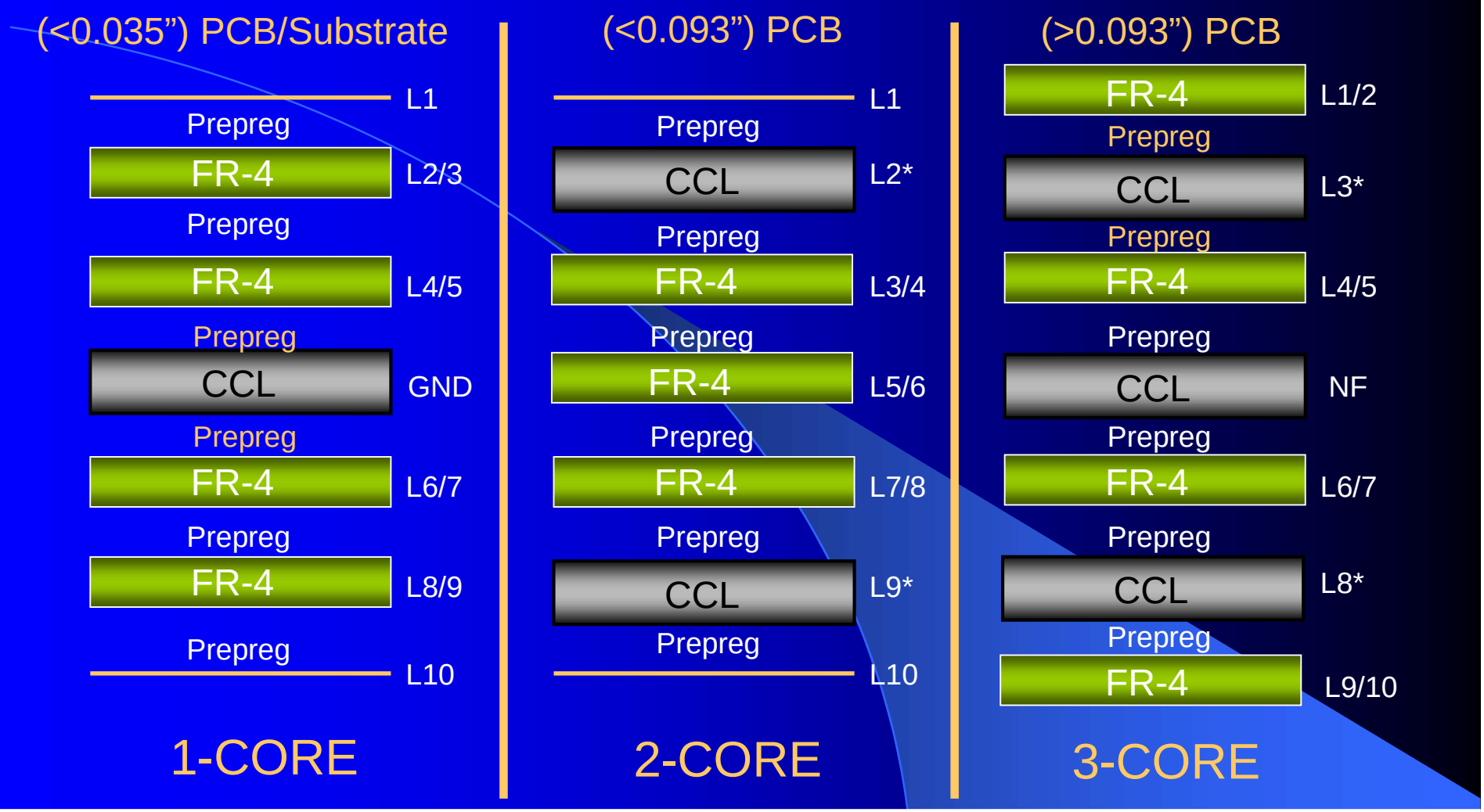
Carbon Composite Material Availability

Carbon Fiber Property Comparisons

RAW MATERIAL	THERMAL CONDUCTIVITY (W/m*K)	CTE (ppm/C)	DENSITY (g/cm3)	TENSILE MODULUS (msi)	Standard Core Thicknesses (Inch)
ST600*	620.0	-1.15	2.20	130.0	.010"
ST325*	325.0	-1.15	2.17	114.0	.008", .010"
ST10*	8.0	-1.10	1.76	34.0	.0045 .006 .009"
FR4	0.3	16-20	1.80	3.5 to 4.5	
POLYIMIDE	0.3	15-19	1.70	3.5 to 4.5	
COPPER	385.0	17.00	8.92	12 to 16	
ALUMINUM	240.0	24-25	2.70	10.2	
CIC	108.0	5 to 6	9.90	18-19	

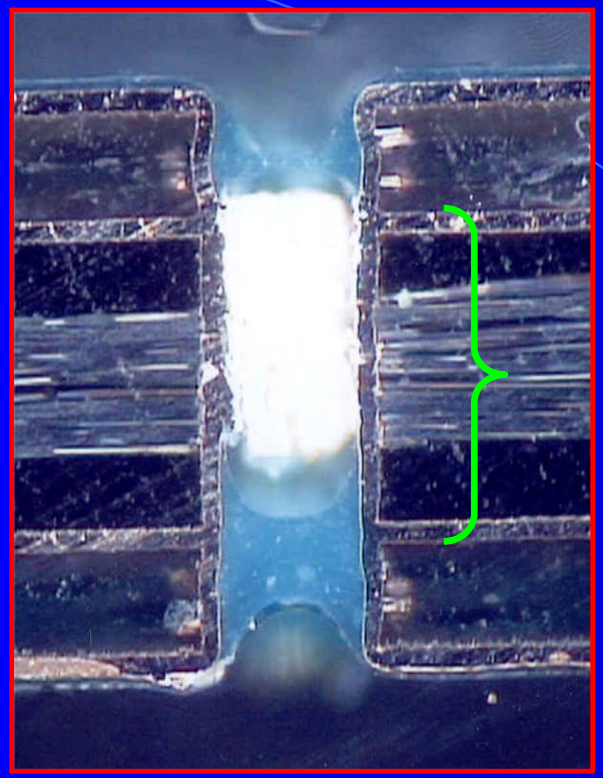
* values represents data of raw fibers

How is carbon composite used in PCB stack-up?



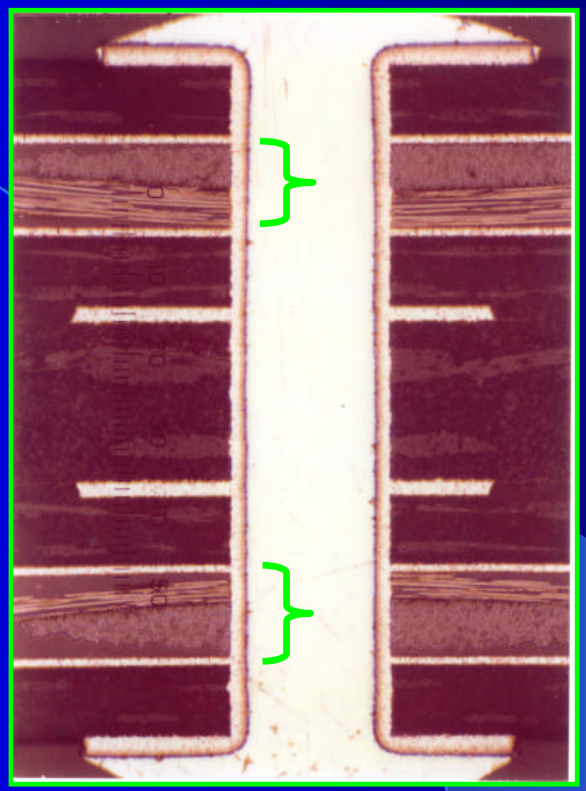
CROSS SECTIONS

3-layer PCB



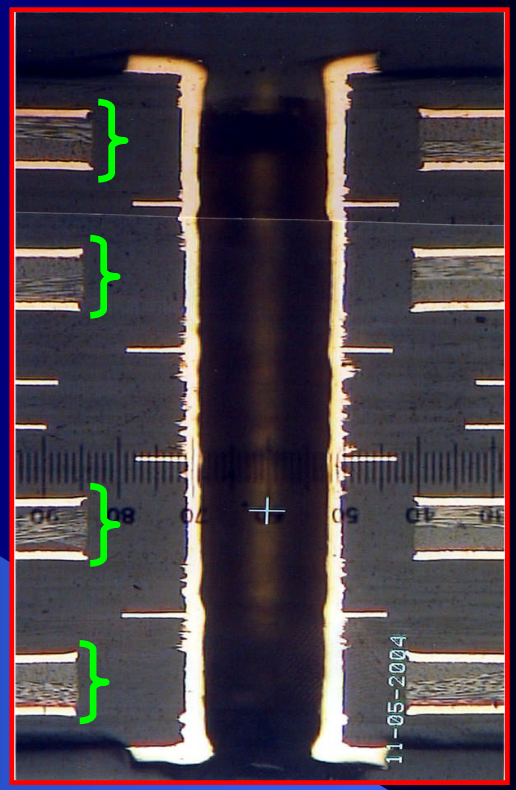
1-CORE

6-layer PCB



2-CORE

12-layer PCB



4-CORE

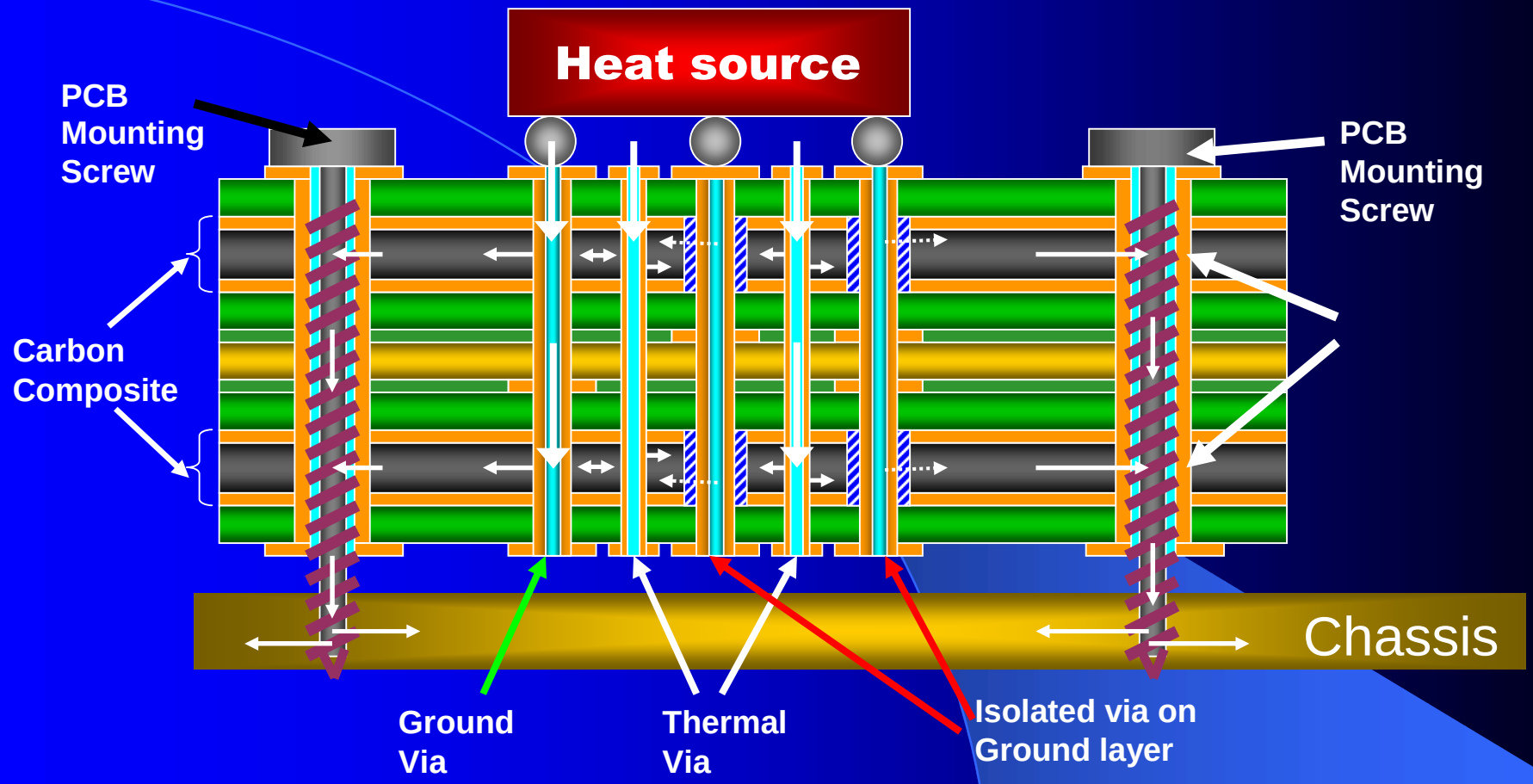
The Benefits Of Carbon in a PCB / Substrate

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

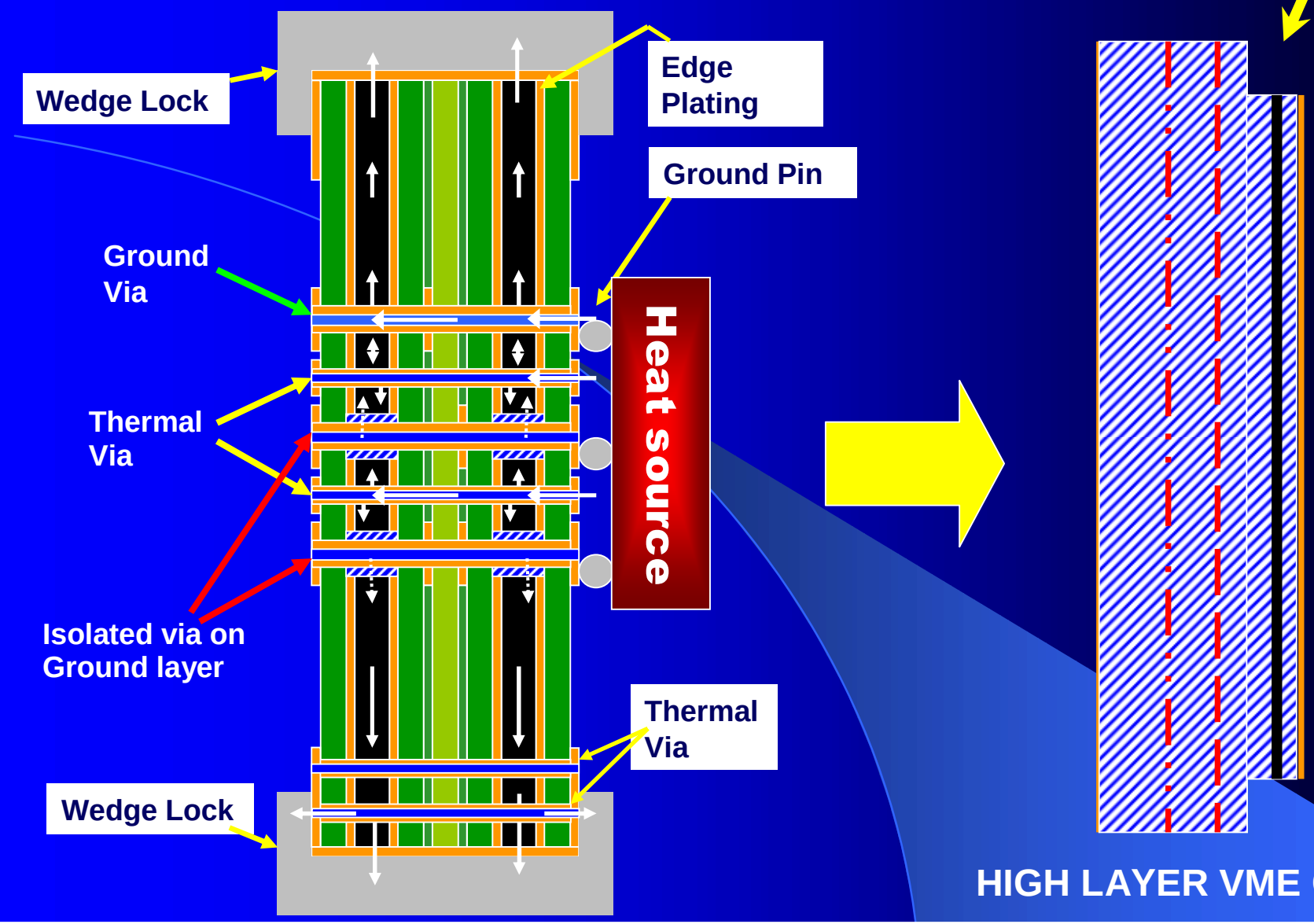
CARBON IN A PCB

Thermal / HEAT

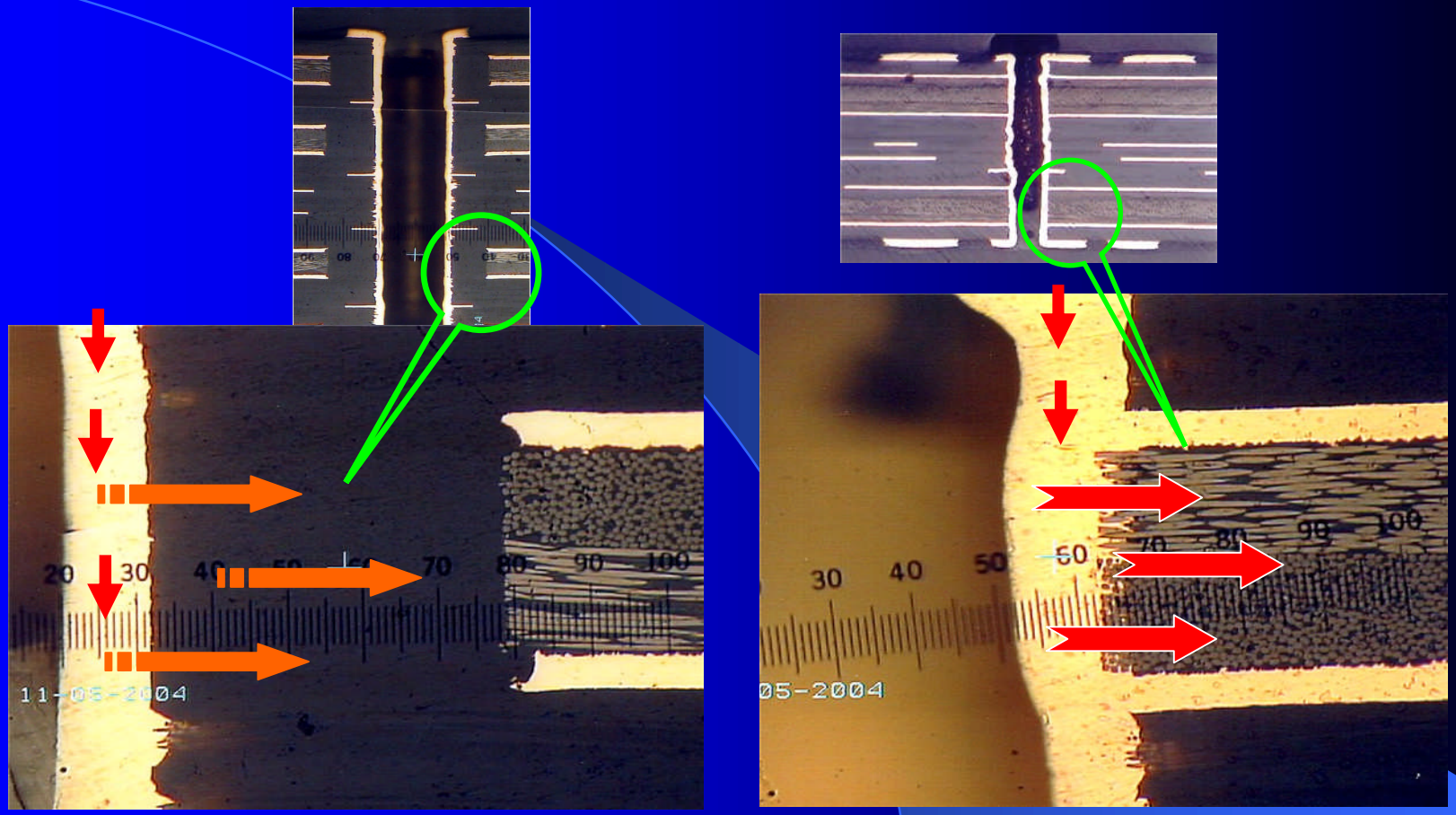
PCB Thermal Path



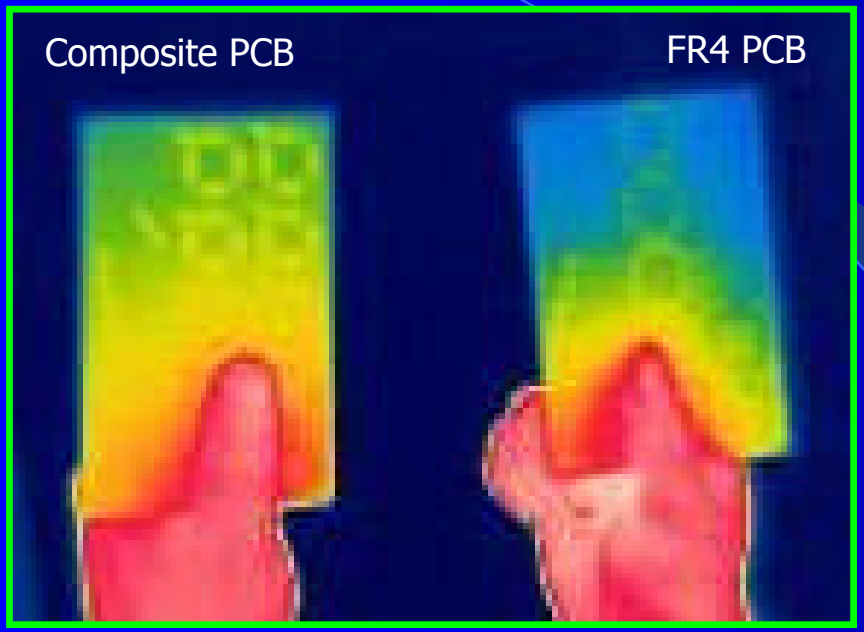
VME - Wedge Lock

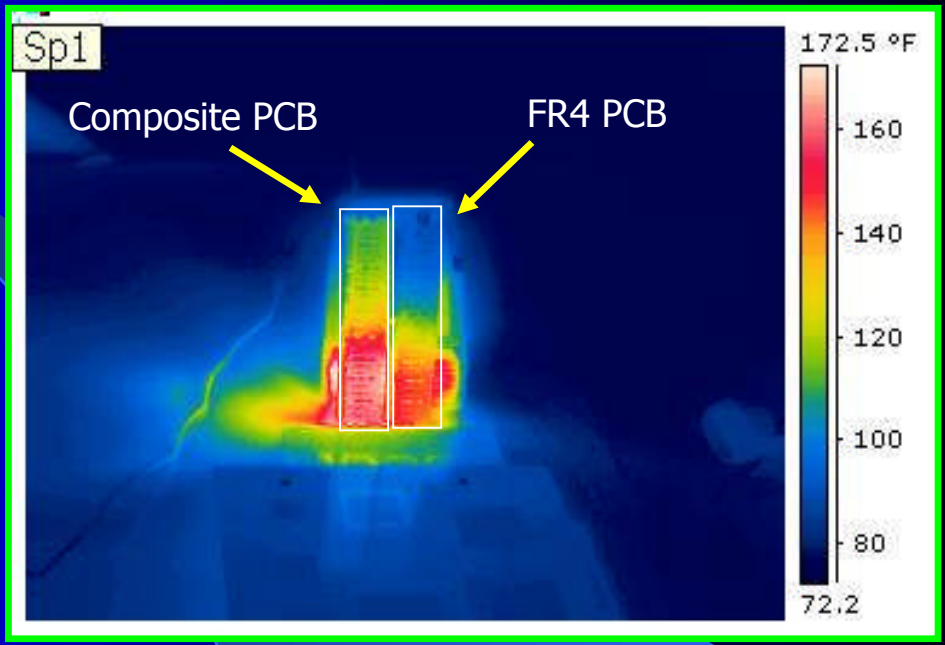


THERMAL PATH

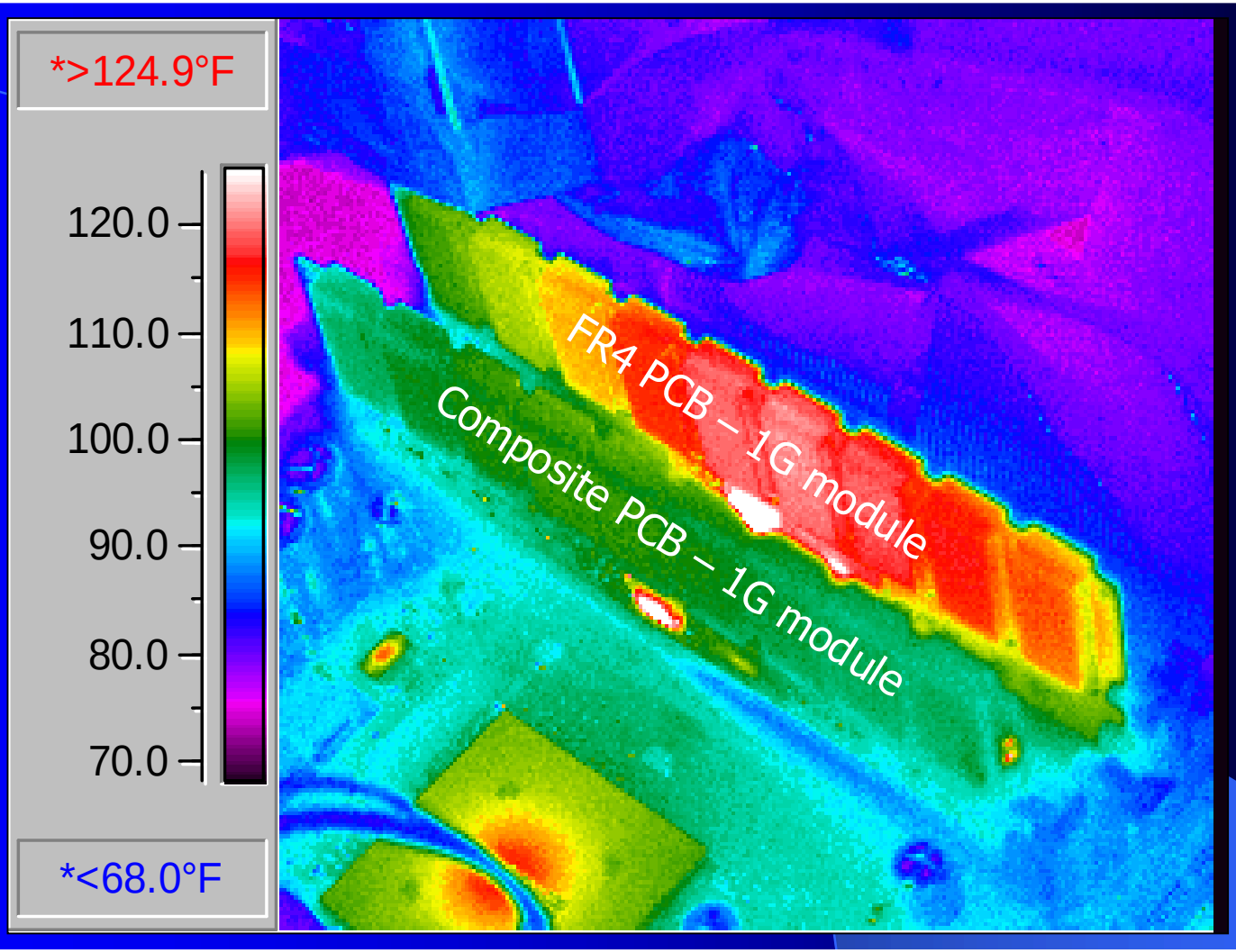


PCB acts as HEAT SPREADER





THERMAL – PRODUCT LEVEL

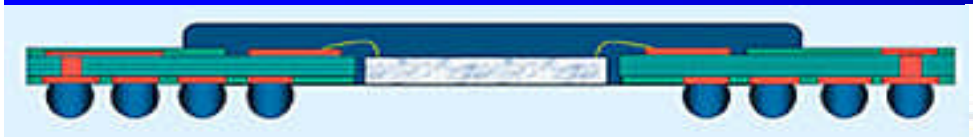


CARBON IN A PCB

Co-efficient of Thermal Expansion

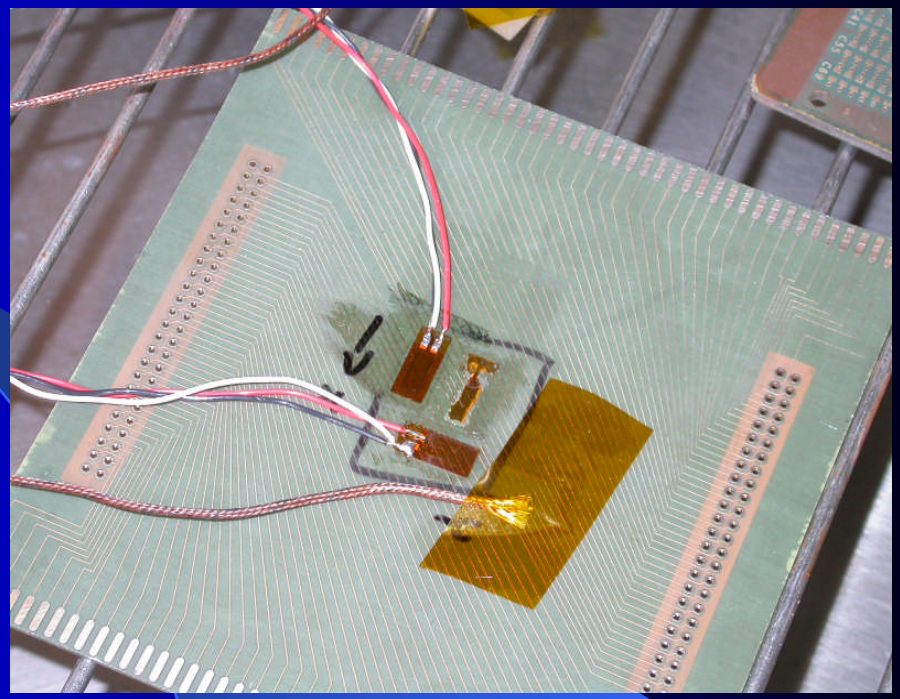
CTE Associated with Package Type

- IC PACKAGE TYPE
  - Organic Packages (CTE: 16-19ppm/C)
  - Ceramic Packages (CTE: 6-8ppm/C)
  - Flip Chip, DDA, WLP (2-4ppm/C)



CTE – Flip Chip Substrate

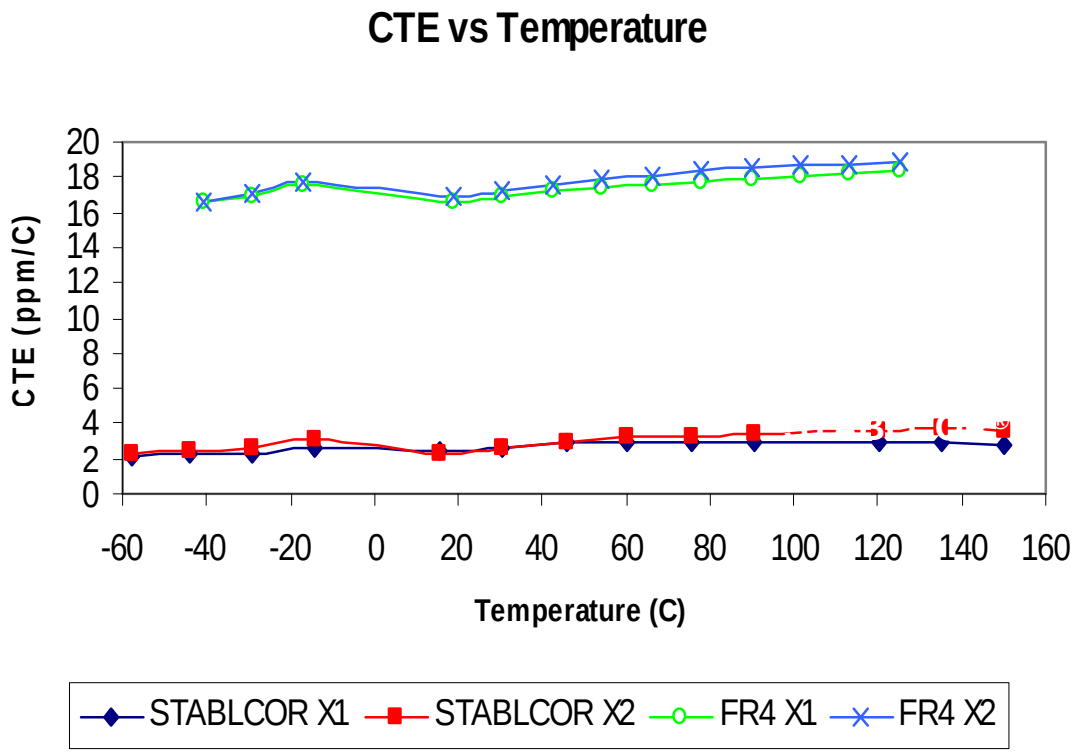
CTE Test				
FC 400				
Temp(C) - J1.0	Strain X	CTE	Strain Y	CTE
-47.8	-231		-153	
-23.2	-165	2.68	-105	1.95
0.7	-103	2.59	-60	1.88
24.5	0	4.33	0	2.52
49.4	9	0.36	32	1.29
73	65	2.37	75	1.82
96.5	119	2.30	119	1.87
121.3	170	2.06	165	1.85
144.7	218	2.05	203	1.62
CTE Overall		**2.29**		**1.85**
Correlation		0.993		0.999



CTE – Flip Chip Substrate

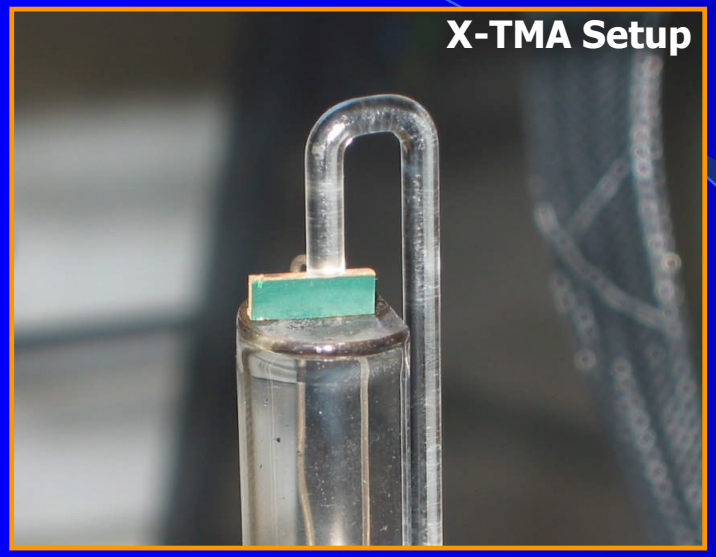
CTE over Temperature Range

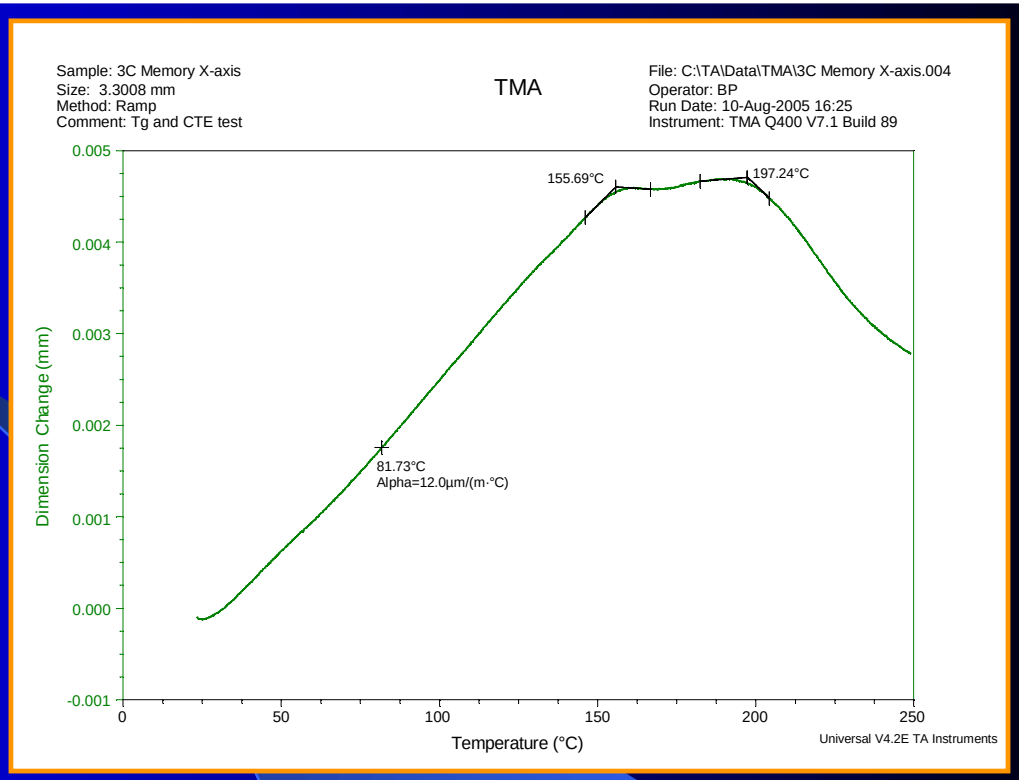
STABLCOR/FR4			FR406		
Board Temp (C)	CTE X1	CTE X2	Board Temp (C)	CTE X1	CTE X2
-57.79	2.05	2.27	-40.84	16.6	16.66
-44.12	2.2	2.45	-29.21	16.9	17.01
-28.97	2.29	2.63	-16.95	17.55	17.68
-14.24	2.61	3.11	18.68	16.54	16.84
15.73	2.38	2.22	30.56	16.94	17.28
30.66	2.68	2.65	42.41	17.21	17.57
45.61	2.87	2.97	54.26	17.43	17.9
60.46	2.96	3.18	66.08	17.61	18.13
75.37	2.98	3.33	77.95	17.79	18.31
90.39	2.92	3.36	89.77	17.95	18.49
120.2	2.87	3.53	101.49	18.08	18.62
135.11	2.86	3.66	113.35	18.2	18.77
150.01	2.75	3.65	125.03	18.3	18.85
Average =	2.65	3.00		17.47	17.85



CTE – 8-layer 50mil Thick PCB

- In-Plane CTE

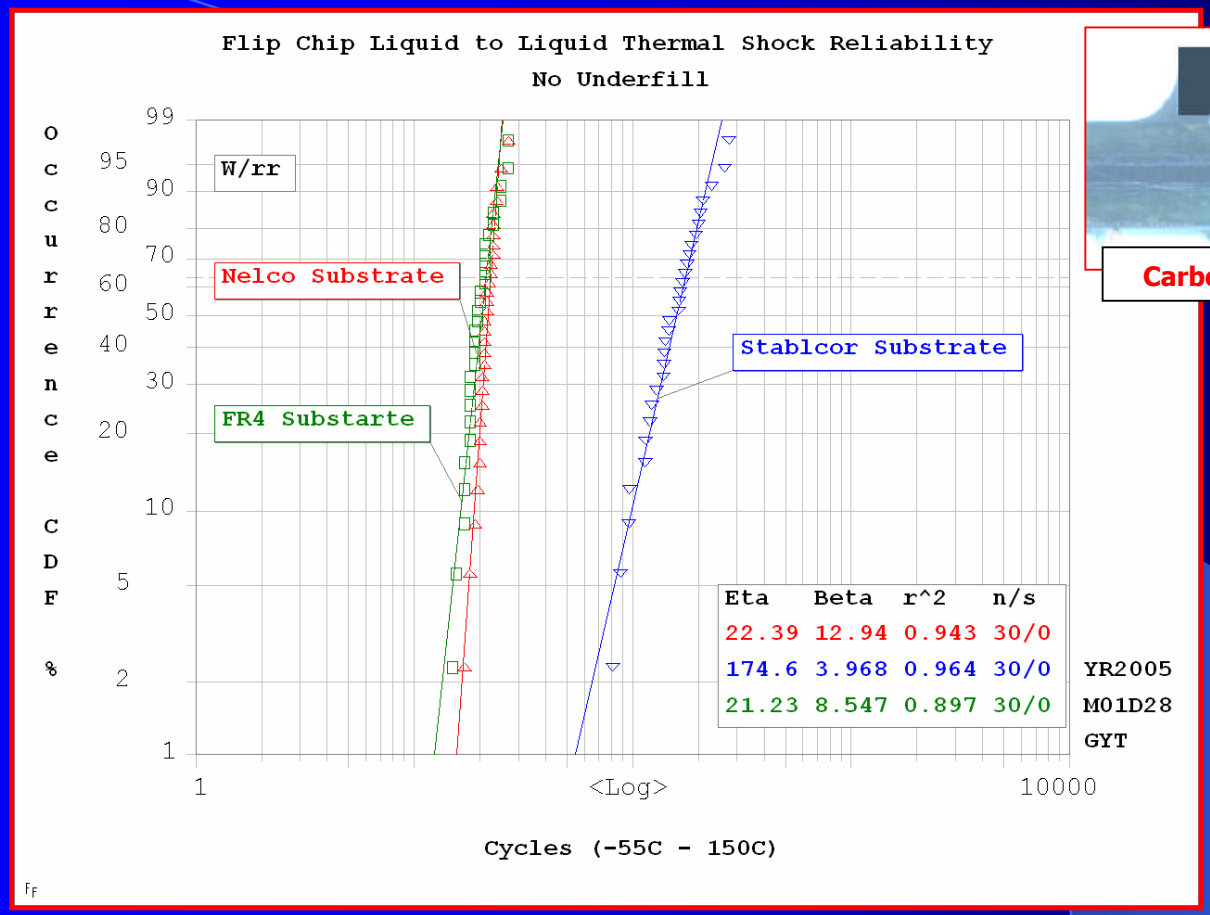




Run Number	CTE before Tg (ppm)	Tg (°C)
1	**12.0**	155.69
2	**12.3**	150.31

Solder Joint Reliability – Flip Chip

Liquid to Liquid Thermal Shock Reliability



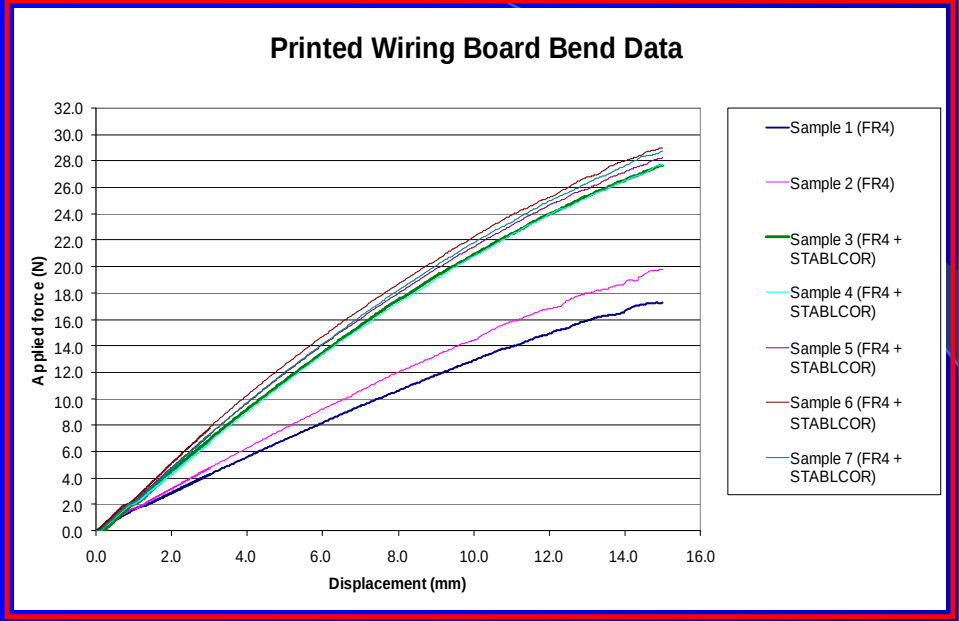
- With no underfill, the characteristic (63.2%) life of the FR-4/NELCO is about 20 cycles . The carbon composite board is about 173 cycles
- For no underfill test, the chips on Carbon Composite substrate remain attached at 353 cycles. Most of the chips detached from the other test boards at 353 cycles

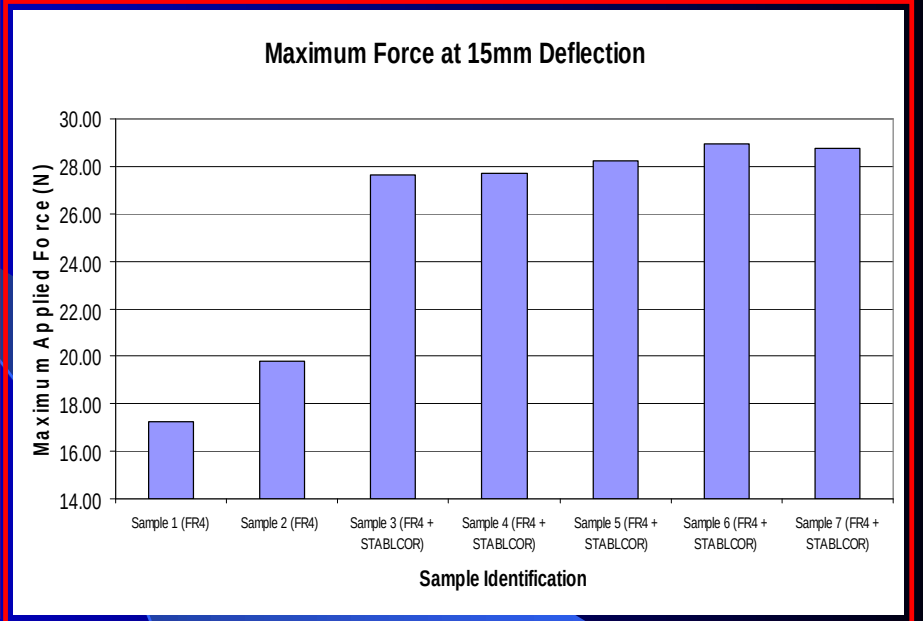
CARBON IN A PCB

RIGIDITY / STIFFNESS

Rigidity / Stiffness

- Rigidity at Room Temp

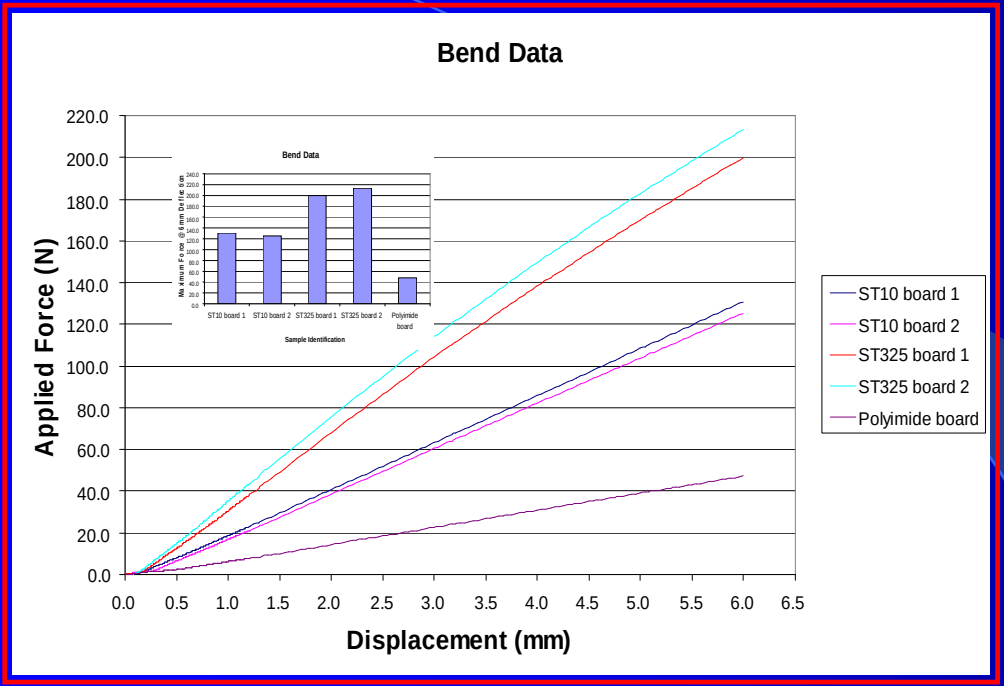




This result shows the Carbon Composite samples is ~ **66.6%** stronger than the FR4 test samples

Rigidity / Stiffness

- Rigidity of thick PCB (0.093″ – 0.125″)



Sample Number	Sample Identification	Maximum force at 6mm (N)	Strength Improvement over Sample 5
1	ST10 board 1	130.9	277.3%
2	ST10 board 2	125.4	265.7%
3	ST325 board 1	199.9	423.5%
4	ST325 board 2	213.4	452.1%
5	Polyimide board	47.2	-

- **ST10 -Composite samples are ~ 275% stiffer than the Polyimide test samples**
- **ST325-Composite samples are ~ 450% stiffer than the Polyimide test samples**

WEIGHT

Material (Laminate)	Density gm/cm3
FR4	1.80
Polyimide	1.70
Carbon Composite	1.65
Aluminum	2.7
Copper	8.92
CIC	9.9

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

For more info

www.hunterpcb.com

or

www.thermalworks.com

STABLCOR®