The Optimal Cost-Effective Thermal Substrate…

MULTILAYER FR4 PCBs + ALUMINUM BASEPLATES WITH ULTRA-THIN POLYIMIDE BOND FILM

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Jim Fraivillig
Fraivillig Technologies
Boston, MA

BONDING POWER CIRCUITRY TO ALUMINUM BASEPLATES

Cost-effective thermal management with design flexibility

- *4000 Vdc*
- *200°C continuous*
- *300°C peak*

***TPI**: All-polyimide construction*

Heat-seal lamination

TPI TECHNOLOGY

COPPER

FR4 PCB
(Multi-layer with thermal vias)

SOLDER MASK

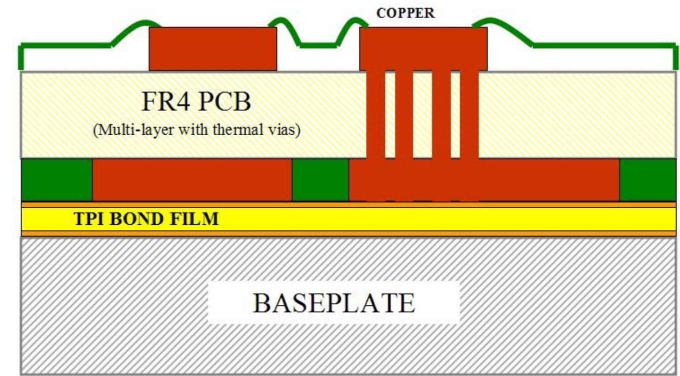
TPI BOND FILM (Total thickness = 1.3 mils, 33um)

POLYIMIDE ADHESIVE
(*thermoplastic, 0.15 mil*)

BASEPLATE

NOTE: *Not to scale.*

FR4-on-aluminum



<u>Potential impact of improved cooling of power circuits</u>:

* Improved life and reliability of power devices

* More compact design, with power components closer together.

* More power output from the same design
(*Assuming that die temperature restricts higher power*)

* Enables the use of less-expensive power devices
(*Assuming lower-efficiency devices are available at lower cost*)

Thermal Modeling of Two-Layer Systems
TO-220 at 40 Watts with Infinite Heat Sink

No Thermal Vias
With Thermal Vias

Case Temperature [C]

225
200
175
150
125
100
75

Difference
< 0.3°C/W

Difference
< 0.1°C/W

Circuit Layer	FR4	FR4	FR4	CML	LTI
Bonding Layer	FR4	CML	LTI	CML	LTI

Two-Layer Dielectric Choices

NOTE:

Relative thermal impact of circuit interlayer material is very small (FR4 vs IMS).

Bond film construction is critical.

Thermal vias are critical.

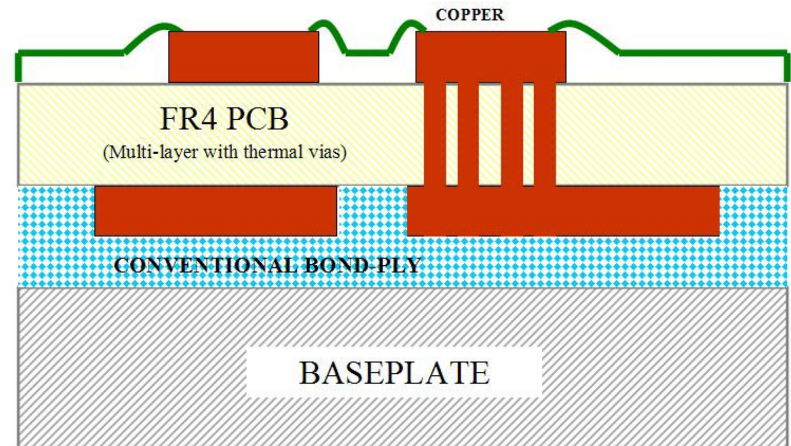
Relative importance of thermal vias and bond film
(*The Bergquist Company chart*)

CML = Alumina-based IMS
LTI = BN-based IMS

Thick bond ply *vs* Thin bond film

Conventional bond ply is B-staged epoxy + ceramic powder on a fiberglass scrim.

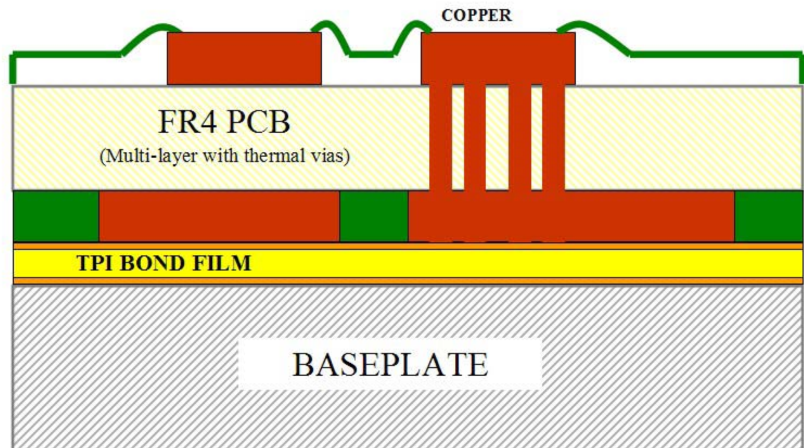
- The epoxy needs to fill-and-flow to encapsulate the conductors. This often dictates the thickness of the bond ply.
- Voiding in the epoxy could result in dielectric shorts.
- Need to machine the baseplates from a laminated metal sheet/plate.



Not to scale

TPI bond film advantages:

- Thinner… better thermal transfer
- Reliable Kapton dielectric layer
- Polyimide bond durability
- Fast thermoplastic processing
- Can laminate stamped baseplates



(*Patents pending*)

TPI bond film

- All-polyimide
- Heat-seals at 250-300°C to aluminum
- 200C operation OK
- 300C exposure OK

TPI bond film properties (130TPI-2)

Property	Value	Method
Thickness	1.3 mil (0.033mm)	ASTM D374
Voltage breakdown	>4000 Vac	ASTM D149
Thermal impedance [1]	0.1°C-in²/W	ASTM D5470-95 (Laminate of TPI, copper, solder)
Thermal resistance [1]	TO-220 = 2.7 °C/W TO-247 = 0.7 °C/W	Rj-s (using Anatech pulse test)
Tensile strength (TPI bond)	>600 psi at 25 °C >200 psi at 150 °C	ASTM D412
Shear strength (TPI bond)	>4000 psi at 25 °C >2000 psi at 150 °C	ASTM D412
Operating range	-65 to 200 °C	OEM testing
Flammability	V-0	UL-recognized

TPI bond durability

TENSILE STRENGTH

- High and consistent to 150°C+ *(see chart opposite)*
- No/little degradation with thermal aging to 150°C+

SHEAR STRENGTH

- Room temp = 4000 psi
- 150°C = 2000 psi

THERMAL TRANSFER

Unchanged with:

- Thermal shock
- Thermal cycling
- Thermal aging
- 85/85 aging

TPI Bond: *Thermal Durability*

Tensile strength *(bondline, psi)*

800
700
600
500
400
300
200
100
0

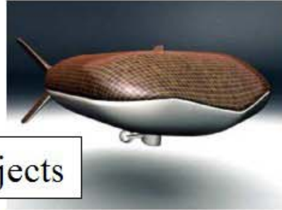
0 50 100 150 200 250 300

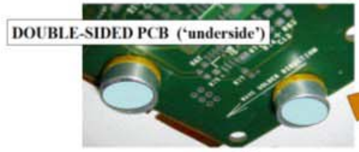
Temperature (oC)

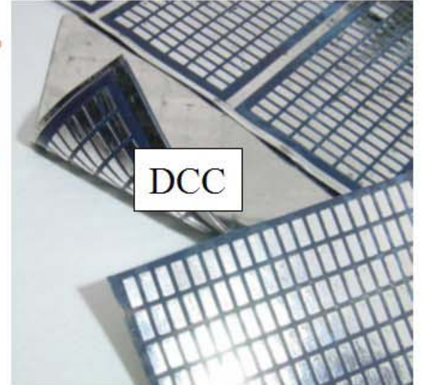
$T_g \sim 185^{o}C$

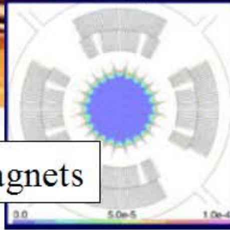
BONDING POWER CIRCUITRY
TO ALUMINUM BASEPLATES

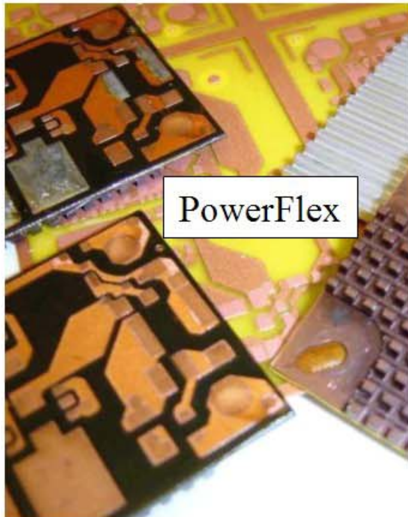
FT's main commercial focus is thermal mgmt of power electronics







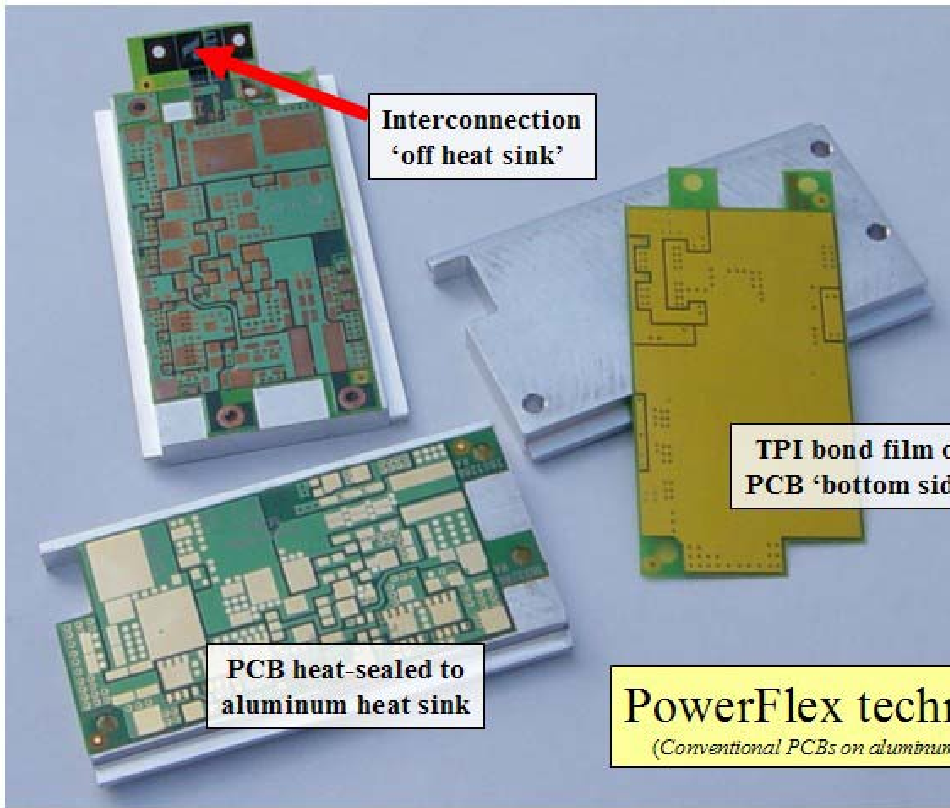




High-Performance, Cost-Effective Electronic Packaging

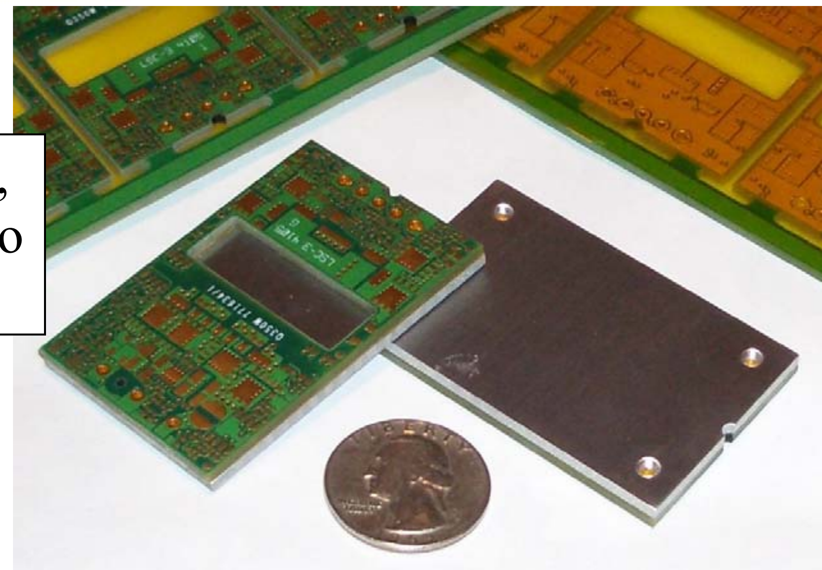
- All-polyimide durability
- SMT-reliability
- Low thermal impedance
  - => 0.10°C-sqin/W at 4000V
  - => 0.02°C-sqin/W at 300V
- Meet next-gen requirements
- Reduce operating temperature
- Improve reliability
- Increase power output
- Patented technologies

www.Fraivillig.com



Fraivillig Technologies
is the world-leader
in high-performance, durable
all-polyimide bond films
for the thermal management
of power electronic packaging.

Our **TPI bond film** adheres thick, heavy-copper, multi-layer PCBs to aluminum baseplates.



BONDING POWER CIRCUITRY TO ALUMINUM BASEPLATES

Baseplate lamination onto PCB panel

Standard multilayer FR4 PCBs

+

TPI bond film

+

Standard punched-and-machined aluminum baseplates

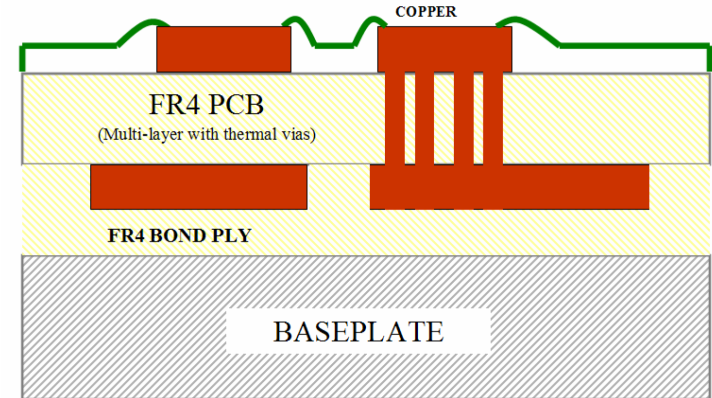
Baseplate lamination process with TPI bond film

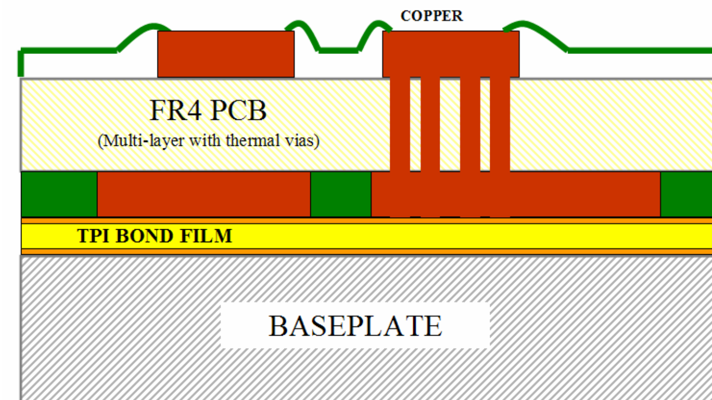
- Standard platen press equipment
- Heat-seal lamination
- Only minutes of cycle-time
- Temperature: 250-300°C
- Pressure: 200-600 psi
- Vacuum-assist desirable

SYSTEM THERMAL IMPEDANCE

(FR4 PCB with thermal vias)

Bond layer	Type	R_{j-s} (oC/W/in2)
Epoxy bond ply	Filled	0.2-0.3
	Unfilled	1.0 (approx)
TPI bond film	Filled	0.15
	Unfilled	0.25





Potential applications for TPI-bonded FR4 + Aluminum

- Power supplies (DC/DC board-mounted, AC laptop adapter, etc)
- Power modules
- Motion control
- Motor control
- Automotive control
- Multi-chip modules