SURFACE-MOUNTING OF POWER DEVICES TO ALUMINUM HEAT SINKS

SMTA PanPacific
Thermal Management
Hawaii
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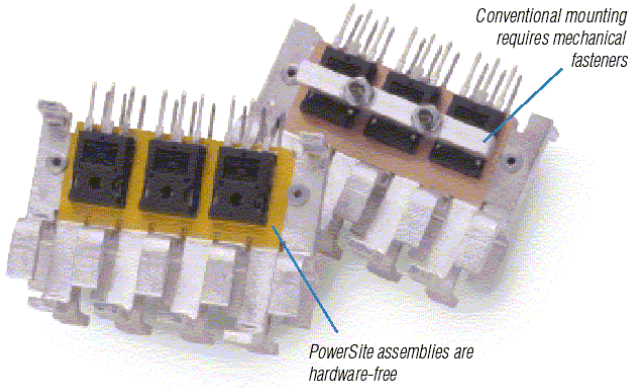
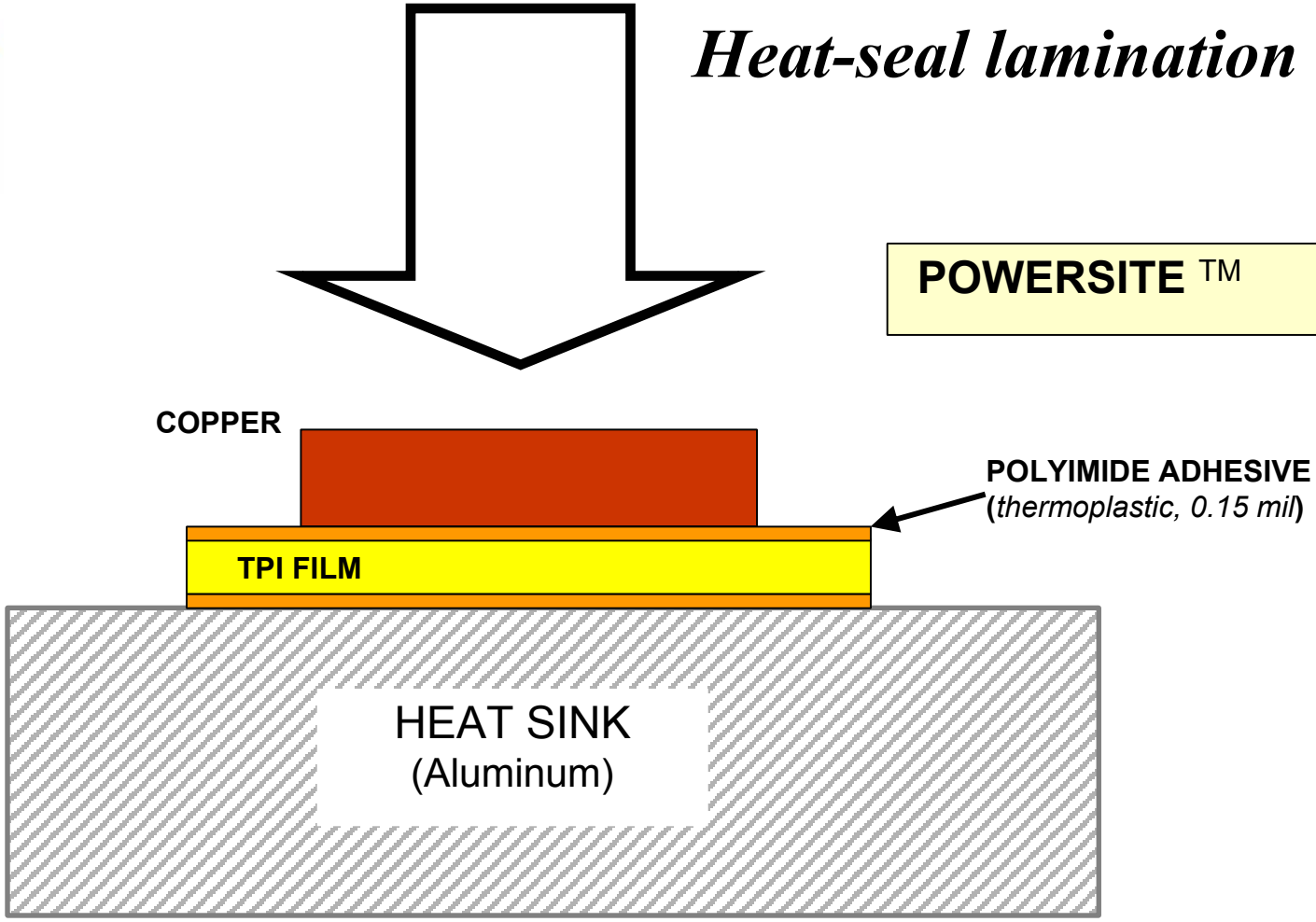
PowerSite technology

- Convert aluminum heat sinks to surface-mount applications => *solder-on power devices*
- Heat-seal copper to aluminum with all-polyimide 'TPI' bond film insulation
- *Excellent thermal management*
- Improved performance with lower cost
- Patented



Heat-seal lamination

POWERSITE TM



Performance advantages of PowerSites:

- *Thin, highly thermally-conductive insulation*
- *All-polyimide durability*
- *Any heat sink*
- *No device attachment hardware*

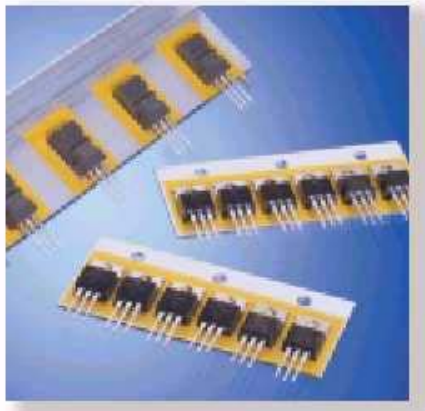
TPI bond film

- 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

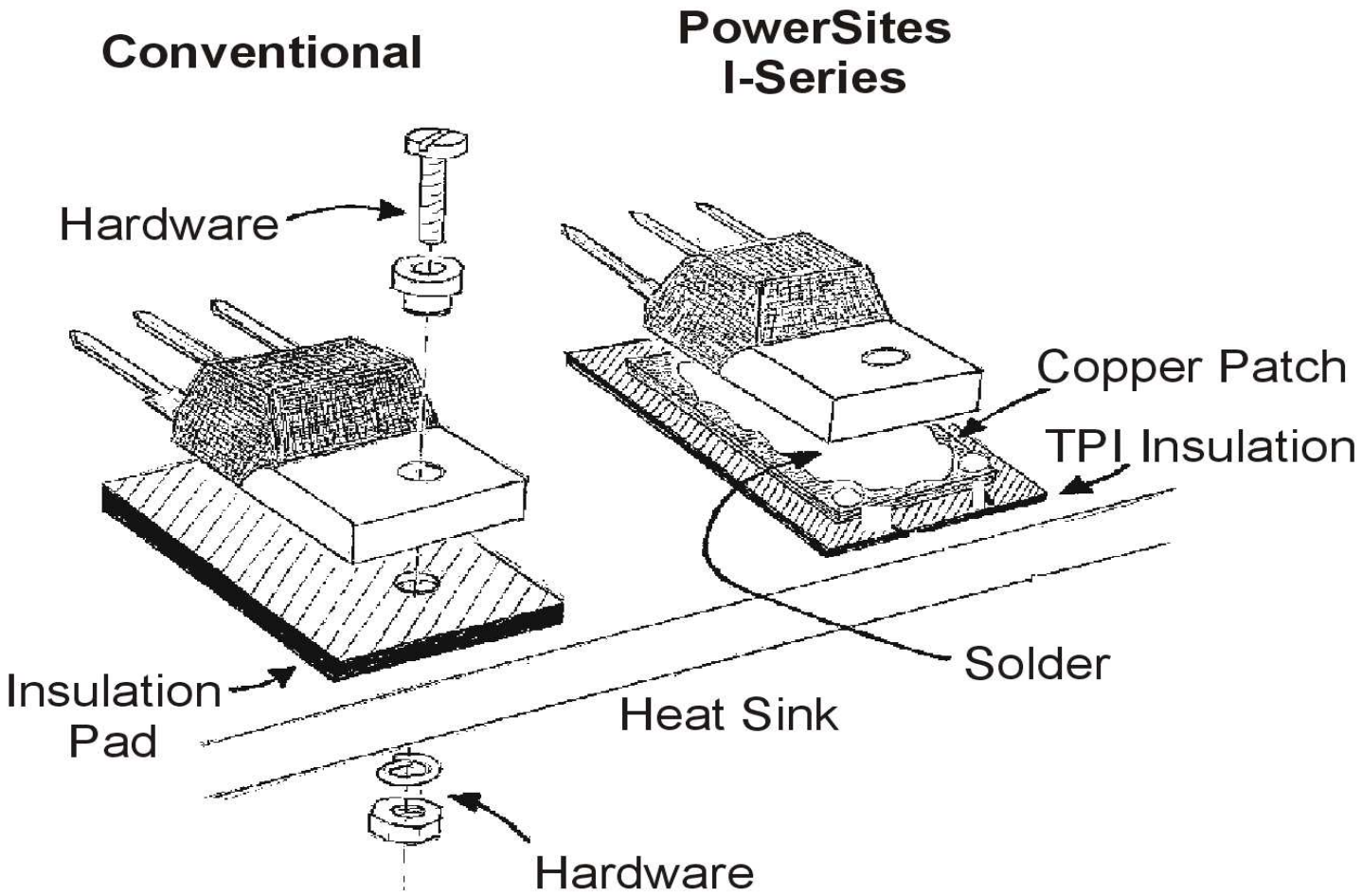
Next-Generation Thermal Management

THERMAL INTERFACE	Introduction
Mica/grease	1940s
Sil-Pads	1960s
Ceramic (DBC)	1960s
Insulated metal substrate (IMS)	1980s
PowerSites	***2000***

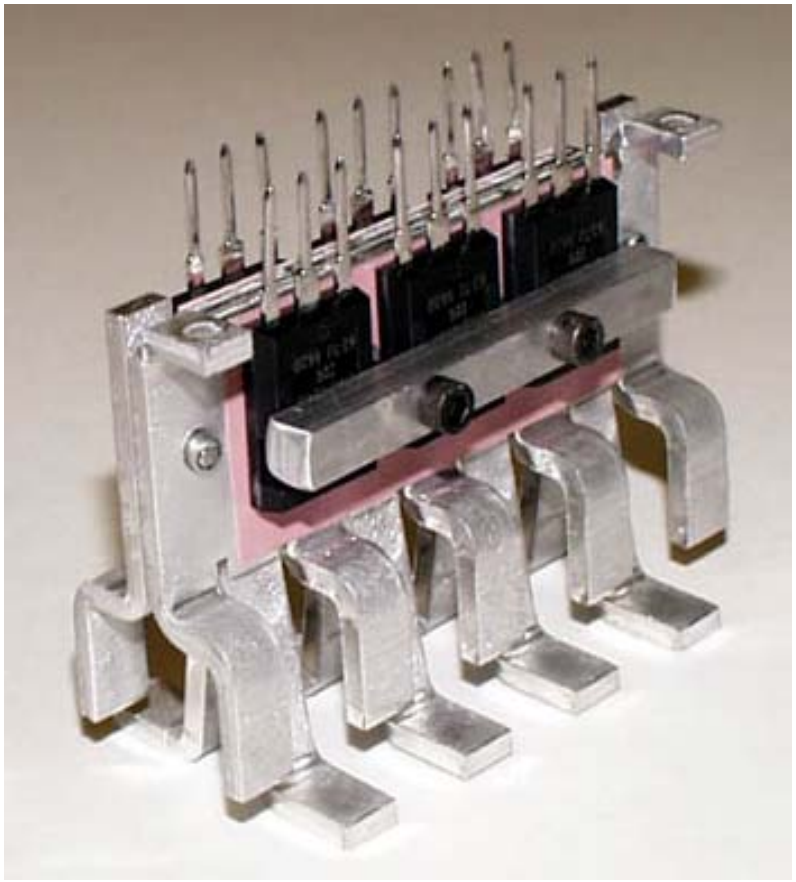


SURFACE-MOUNTING OF POWER DEVICES ON ALUMINUM HEAT SINKS

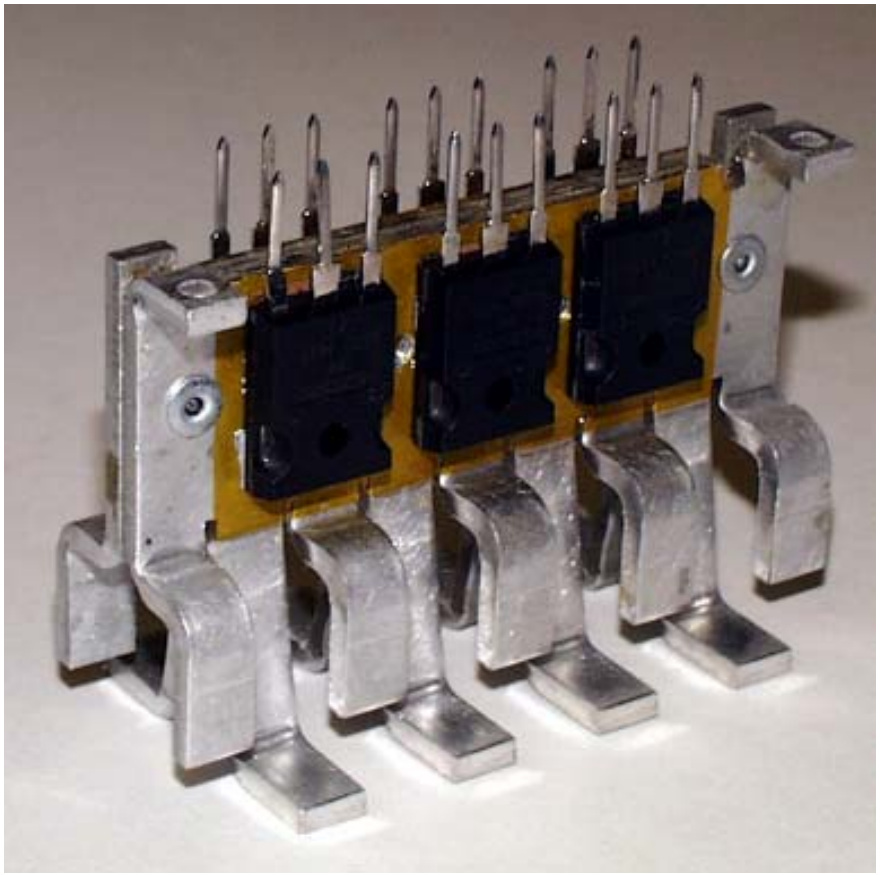
Device Mounting Comparison



Typical PowerSite™ design conversion



Conventional Method with
Thermal Pads, Screws, Nuts, Clamps



PowerSite Assembly

FT's TPI-based technologies

ALL-POLYIMIDE 'TPI' BOND FILM

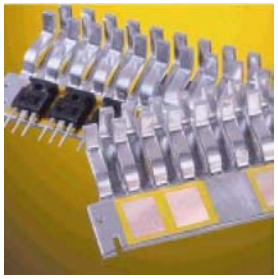
- Sold as stand-alone insulation in punched parts
- Kapton MT + thin coating of thermoplastic polyimide adhesive (0.15 mil each side)
- Used as basis of other FT products

'POWERVIA' THERMAL COLUMNS

- Mounting discrete power devices on PCB, providing thermal path to heat sink
- Present market standard: *Plated-thru holes + Sil-Pad*
- Patented

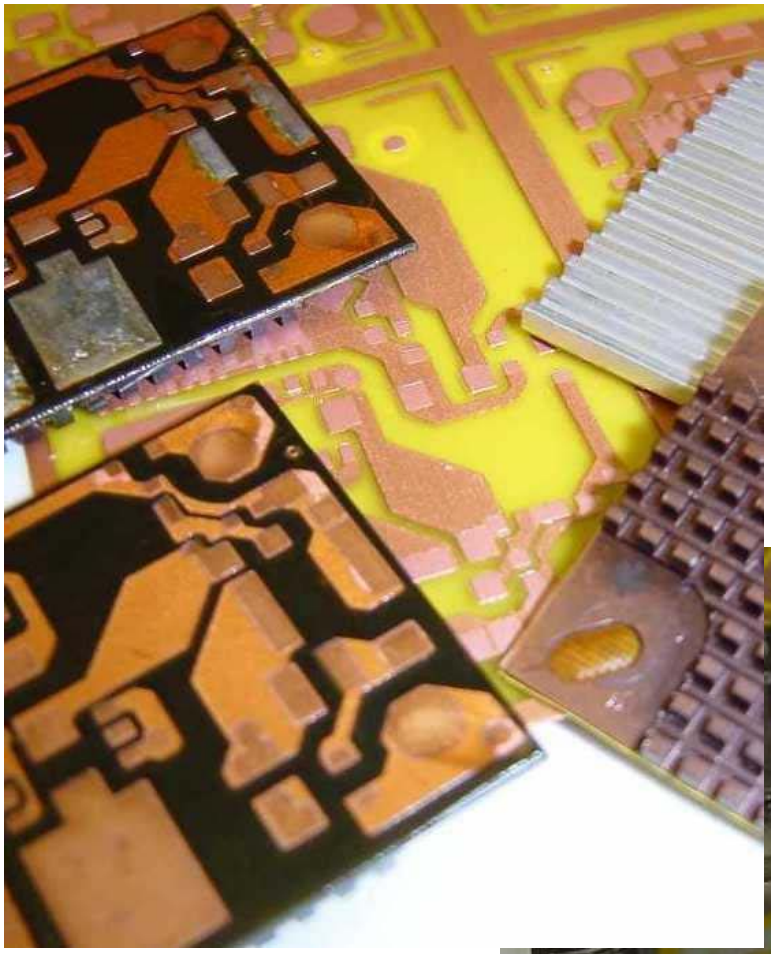
'POWERSITE' SOLDERABLE PADS

- Mounting discrete power devices to heat sinks
- Present market standard: *Sil-Pads with attachment hardware*
- Patented



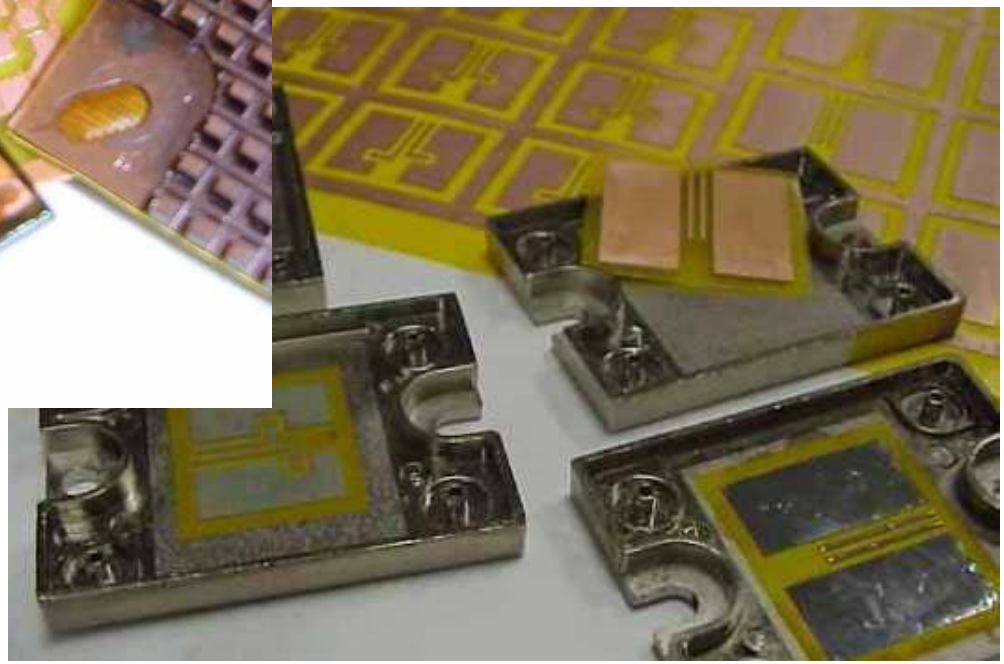
'POWERFLEX' PRINTED CIRCUITS

- Power circuit pattern bonded to aluminum heat sink
- Present market standard: *IMS ('Thermal Clad')*
- Patents pending



PowerFlex™ applications

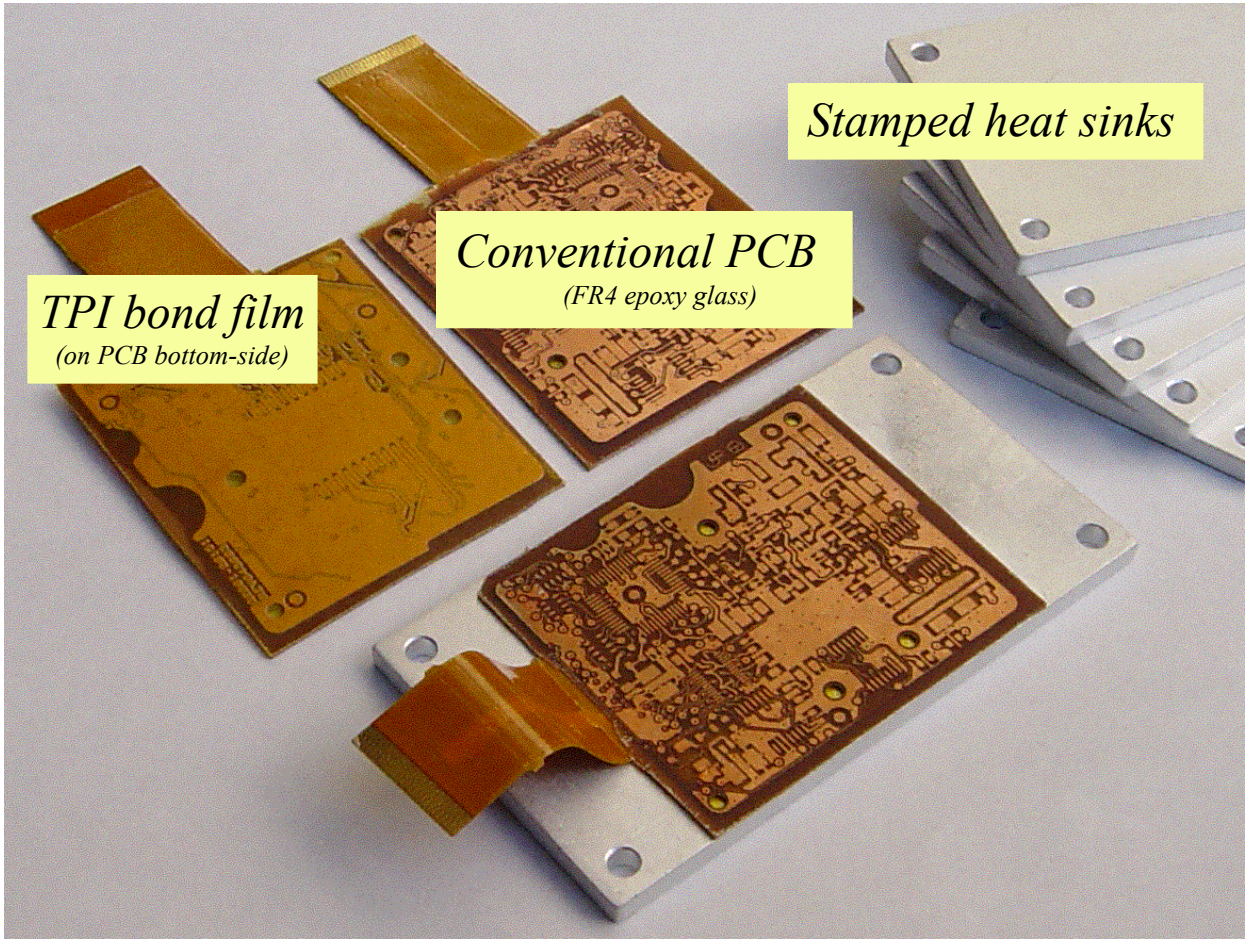
- **TPI printed circuits, bonded to...**
- **Aluminum baseplates**



PowerFlex™ flexible interconnects

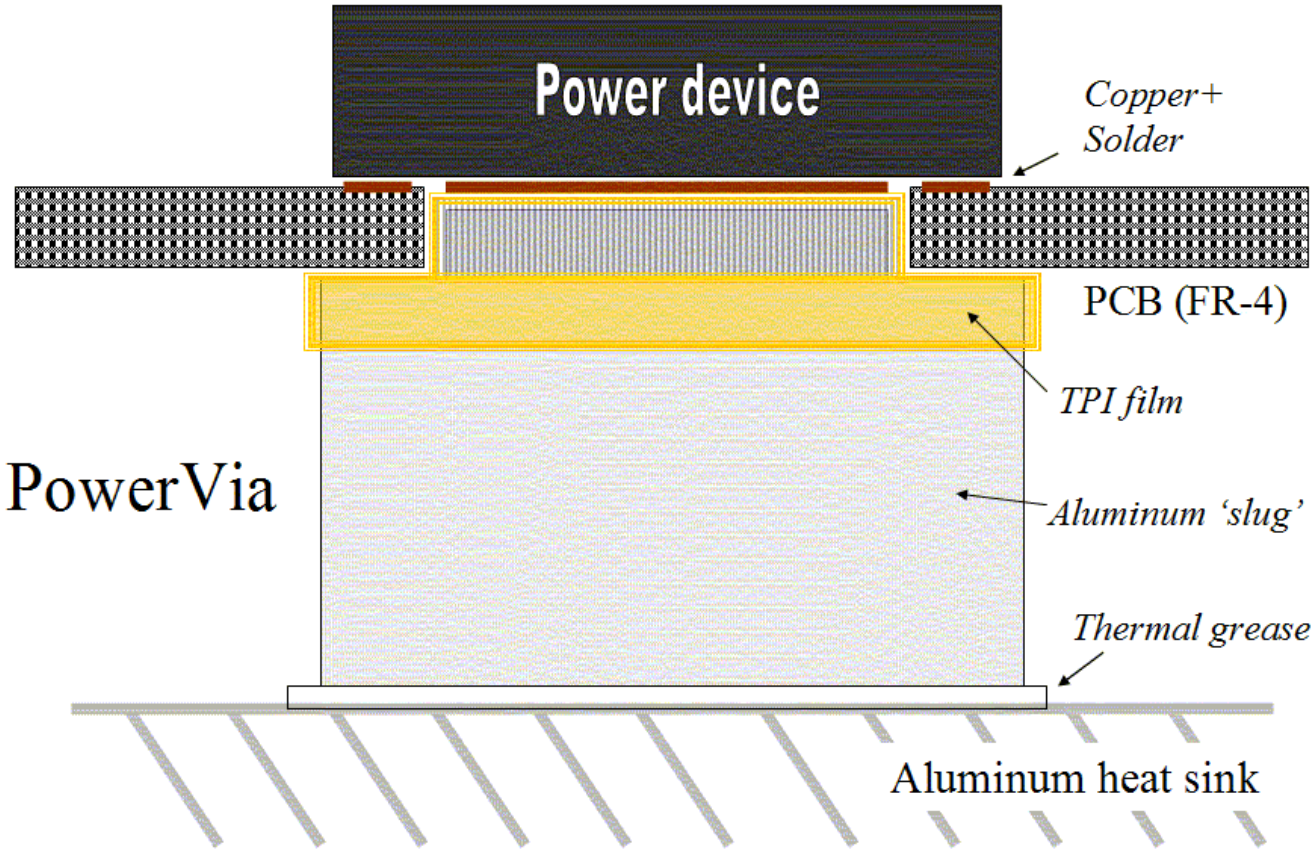
DESIGN OPTIONS:

- **Layer interconnection (to control board)**
- **Reduce 'footprint' (*'brick' size*)**
- **Increase power density**
- ***Bond to any heat sink***



PowerVia technology

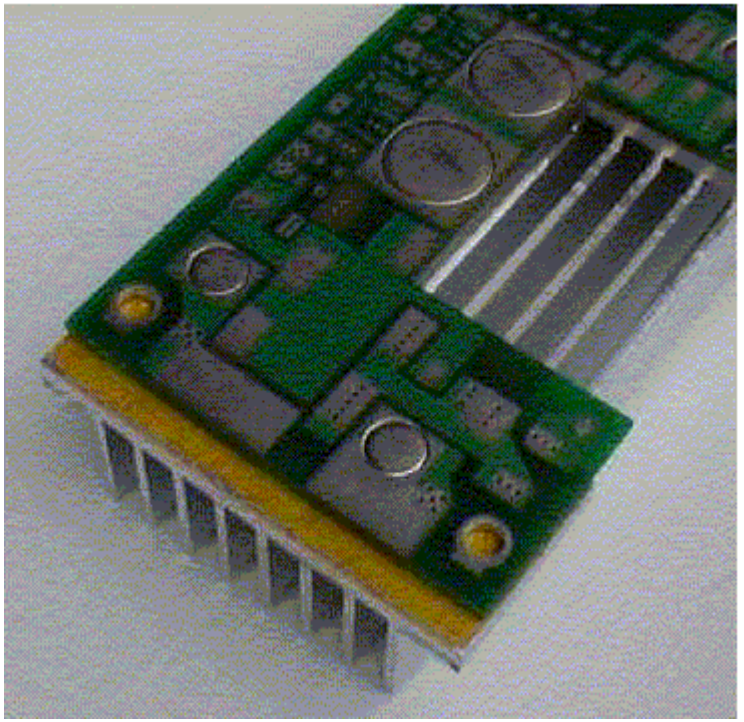
Optimal through-hole thermal transfer



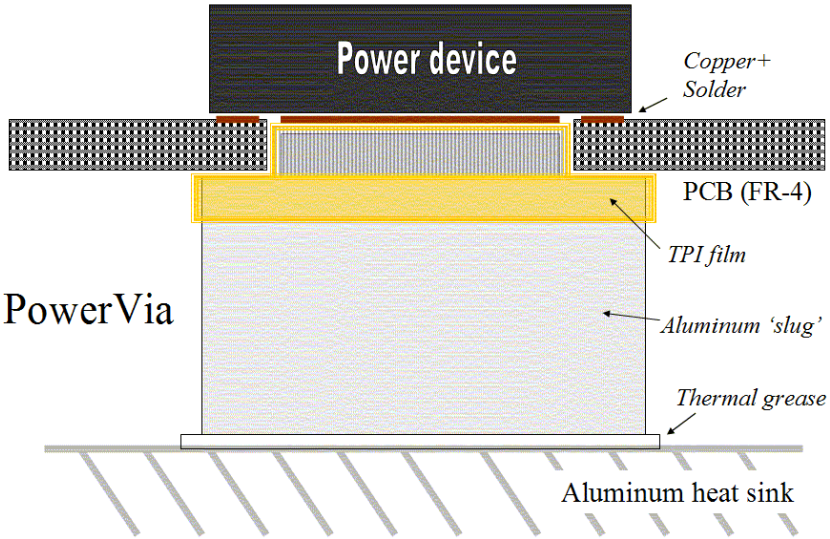
PowerVia technology

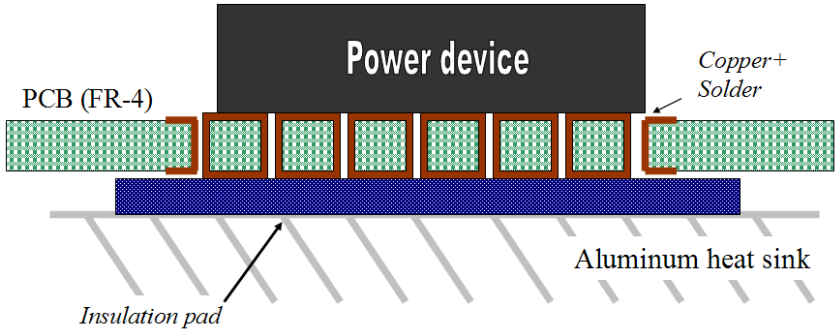
Optimal through-hole thermal transfer

PowerVias for D2Paks



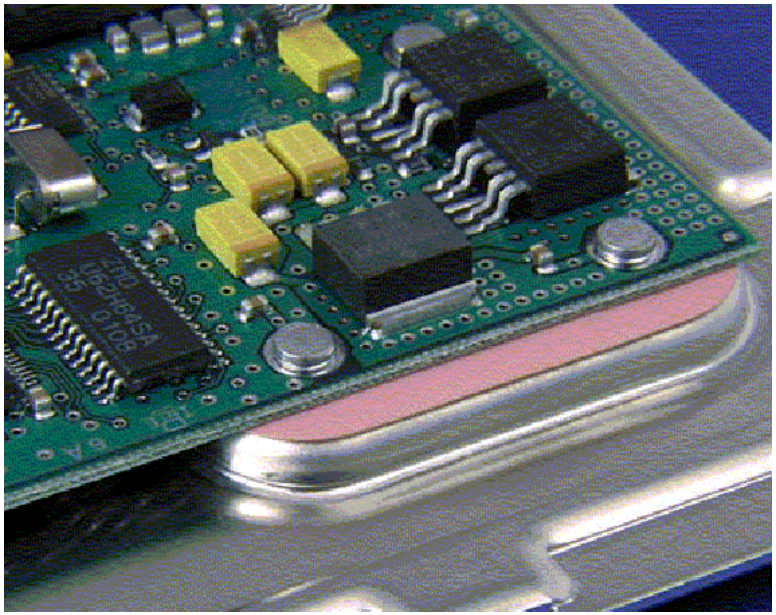
PowerVias inserted into PCB





Conventional thermal via (drilled-and-plate)

Comparison of PowerVia *with* conventional thermal via



SURFACE-MOUNTING OF POWER DEVICES ON ALUMINUM HEAT SINKS

PowerSite thermal comparisons

Versus insulator pads

Table 3B
Maximum power dissipation to reach a junction temperature of 150°C

THERMAL PERFORMANCE: Maximum Power Dissipation to reach Tj = 150 °C				
Interface Material	**TO-220 (watt)**		**TO-247 (watt)**	
(Air Flow, lfm =>)	0	100	0	100
Mica / grease	14.6	18.8	22.7	32.9
BN-filled silicone sheet	13.7	17.6	22.0	31.6
Kapton MT / phase change	14.1	17.9	22.9	33.1
Kapton MT / BN-filled silicone	13.3	16.9	21.8	30.5
Alumina-filled silicone sheet	12.5	15.8	20.4	28.4
Laminated copper	15.9	21.3	24.6	36.4

"Laminated copper" = PowerSite technology

Versus IMS

Table 5
Maximum power dissipation to reach a junction temperature of 150°C

THERMAL PERFORMANCE: Maximum Power Dissipation to reach Tj = 150 °C				
Interface Material	**TO-220 (watt)**		**TO-247 (watt)**	
(Air Flow, lfm =>)	0	100	0	100
Insulated metal substrate	16.6	23.1	25.4	40.1
Laminated copper	16.8	23.7	24.2	38.0

SOURCE: Parker Chomerics Technical study, 2000

PowerSite thermal comparisons

Versus insulator pads

Table 3B
Maximum power dissipation to reach a junction temperature of 150°C

THERMAL PERFORMANCE: Maximum Power Dissipation to reach Tj = 150 °C				
Interface Material	**TO-220 (watt)**		**TO-247 (watt)**	
(A				100
Mica / grease				32.9
BN-filled silicone sh				31.6
Kapton MT / phase c				33.1
Kapton MT / BN-fill				30.5
Alumina-filled silico				28.4
Laminated copper	15.9	21.3	24.6	36.4

PowerSite™ advantage:
TO-220 2° C/W
TO-247 1° C/W
(*compared to alumina-filled pad material*)

"Laminated copper" = PowerSite technology

Table 5
Maximum power dissipation to reach a junction temperature of 150°C

Versus IMS

THERMAL PERFORMANCE: Maximum Power Dissipation to reach Tj = 150 °C				
Interface Material			**247 (watt)**	
(Air Flow				100
Insulated metal substr				40.1
Laminated copper				38.0

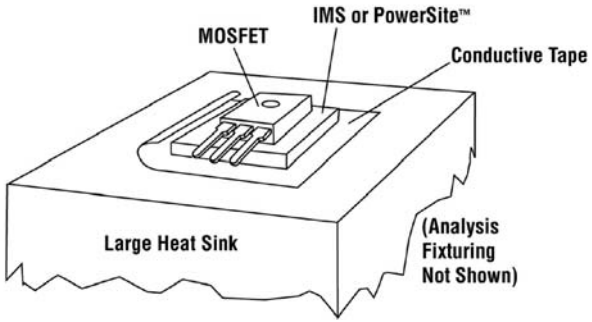
PowerSite™ pads are equivalent to IMS
(*alumina-filled IMS material*)

SOURCE: Parker Chomerics Technical study, 2000

PowerFlex™ thermal transfer performance

COMPARISON:

- **TPI single-layer**
- **IMS single-layer**
- **Tested with Anatech pulse**



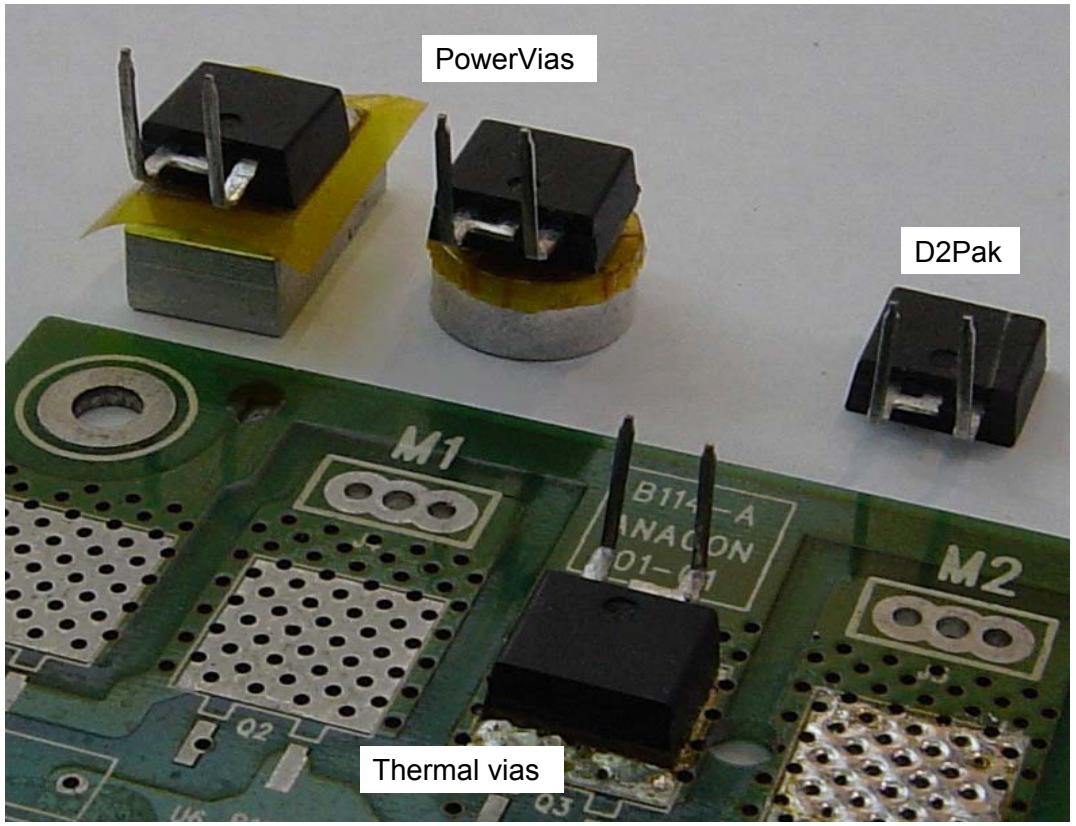
THERMAL PERFORMANCE:
Maximum Power Dissipation [2] at Tj = 150 °C

Interface Material (*Air Flow, lfm =>*)	TO-220 (watt) 0	TO-220 (watt) 100	TO-247 (watt) 0	TO-247 (watt) 100
IMS	16.6	23.1	25.4	40.1
PowerFlex	16.8	23.7	24.2	38.0

PowerVia™ thermal transfer testing

Thermal resistance testing of D2Pak ($R_{j\text{-}s}$), using Anatech pulse tester:

- Conventional thermal via (plated-thru-hole + insulation pad + attachment hardware)
- *Cylindrical* column PowerVia
- *Rectangular* column PowerVia



Thermal resistance comparison [5]

Control board with soldered-on D2Pak, bolted to heat sink

Thermal method	Active area	Rj-s
PowerVia (circular footprint)	0.08 => 0.20 sqin (Face-to-base)	4.4 °C/W
PowerVia (rectangular footprint)	0.20 => 0.30 sqin (Face-to-base)	2.7 °C/W
Thermal via + pad	0.30 sqin	11.4 °C/W

NOTE:

- Thermal resistance is junction-to-sink.
- Anatech measurement taken at steady-state.
- PCB secured to heat sink on PCB edges only (50-100 psi?).
- *Thermal via + pad thermal resistance* is about 7°C thru the power device+PCB and 4°C/W thru the insulation pad.

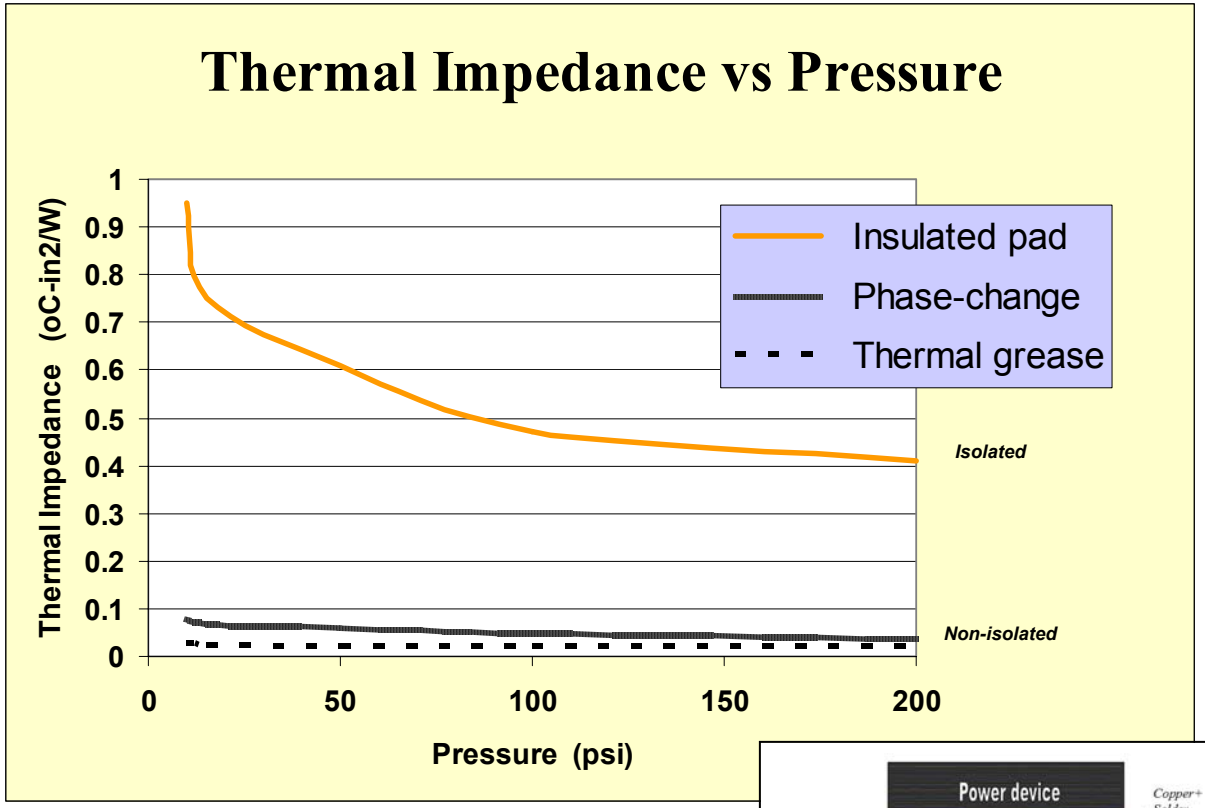
Pressure dependency not a factor with PowerVias

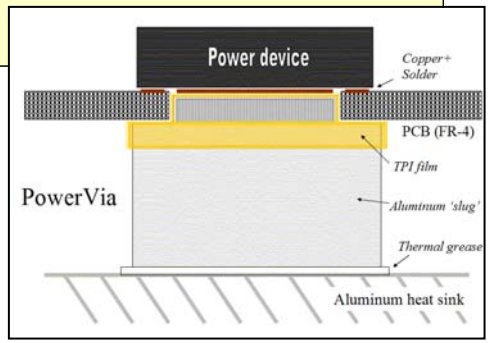
Conventional thermal vias require insulation pads…

…***insulations pads require high-pressure to optimize thermal transfer*** to the heat sink.

PowerVias use non-isolating thermal grease or phase-change material…

….***these thermal compounds have little pressure dependency*** (and very high thermal transfer).





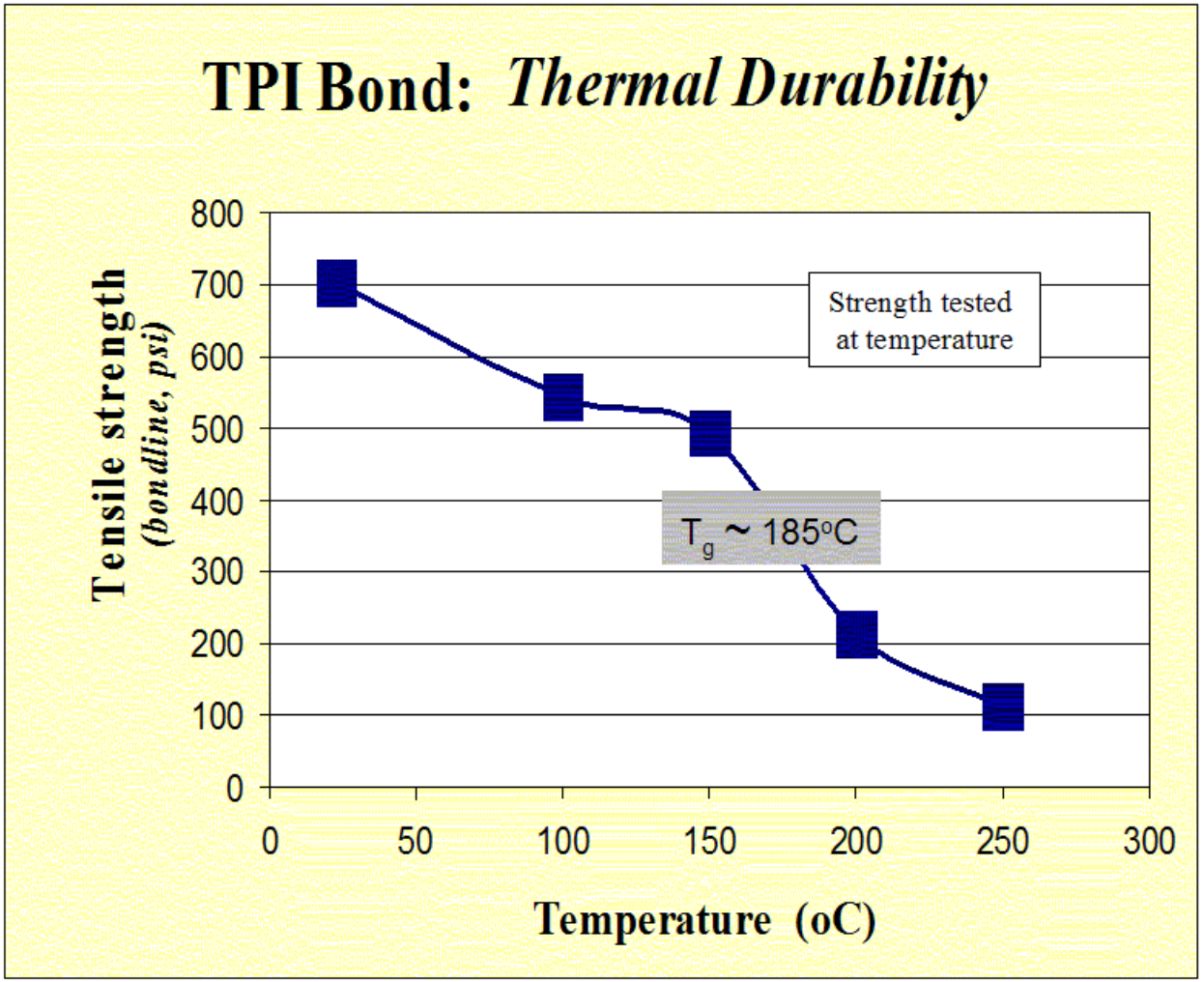
SURFACE-MOUNTING OF POWER DEVICES ON ALUMINUM HEAT SINKS

PowerSite™ thermal durability

ALL-POLYIMIDE:

- **200°C continuous**
- **300°C exposure**
- **No-lead solder,** ***no problem***

NOTE: PowerFlex and PowerVias use same TPI bond film, and have same thermal durability.



PowerSite technical challenges

- Technology inertia
- Heat-seal processing
- Compatible PCB materials, configurations
- Heat sink surface
- Heat sink size and shape
- *Volume drives cost*

PowerSite applications

- Telcom power supplies
- Portable devices
- Automotive controls
- Multi-chip modules

- *Thermally-demanding applications, where cost and reliability are critical*

PowerSite worldwide supply

Fraivillig Technologies – developed PowerSites, PowerFlex and PowerVias

www.Fraivillig.com

EIS Fabrico – U.S. technology licensee

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