FLEXIBLE THERMAL MANAGEMENT CIRCUITS
BONDED DIRECTLY TO ALUMINUM HEAT SINKS

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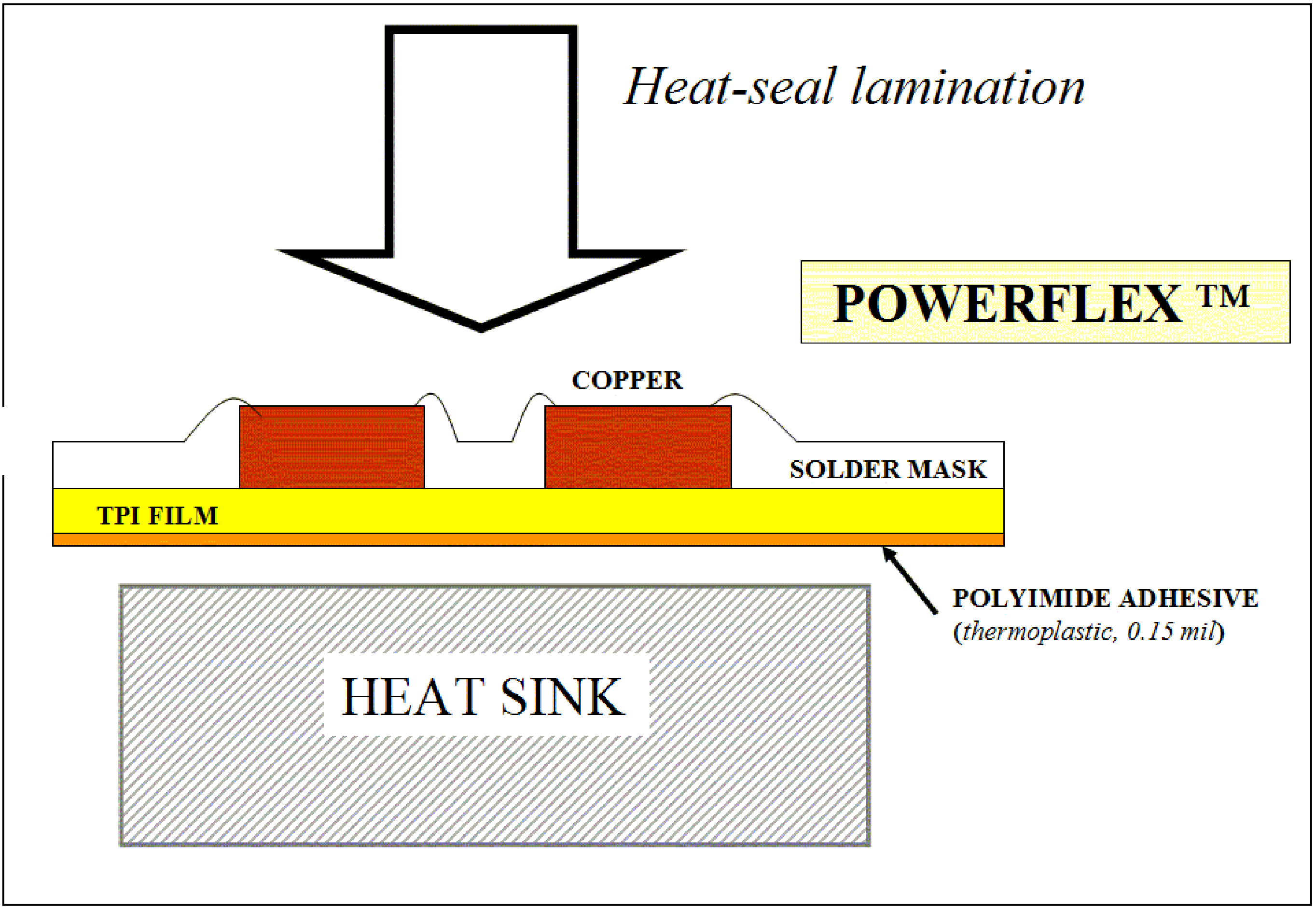
PowerFlex™

Cost-effective thermal management with design flexibility

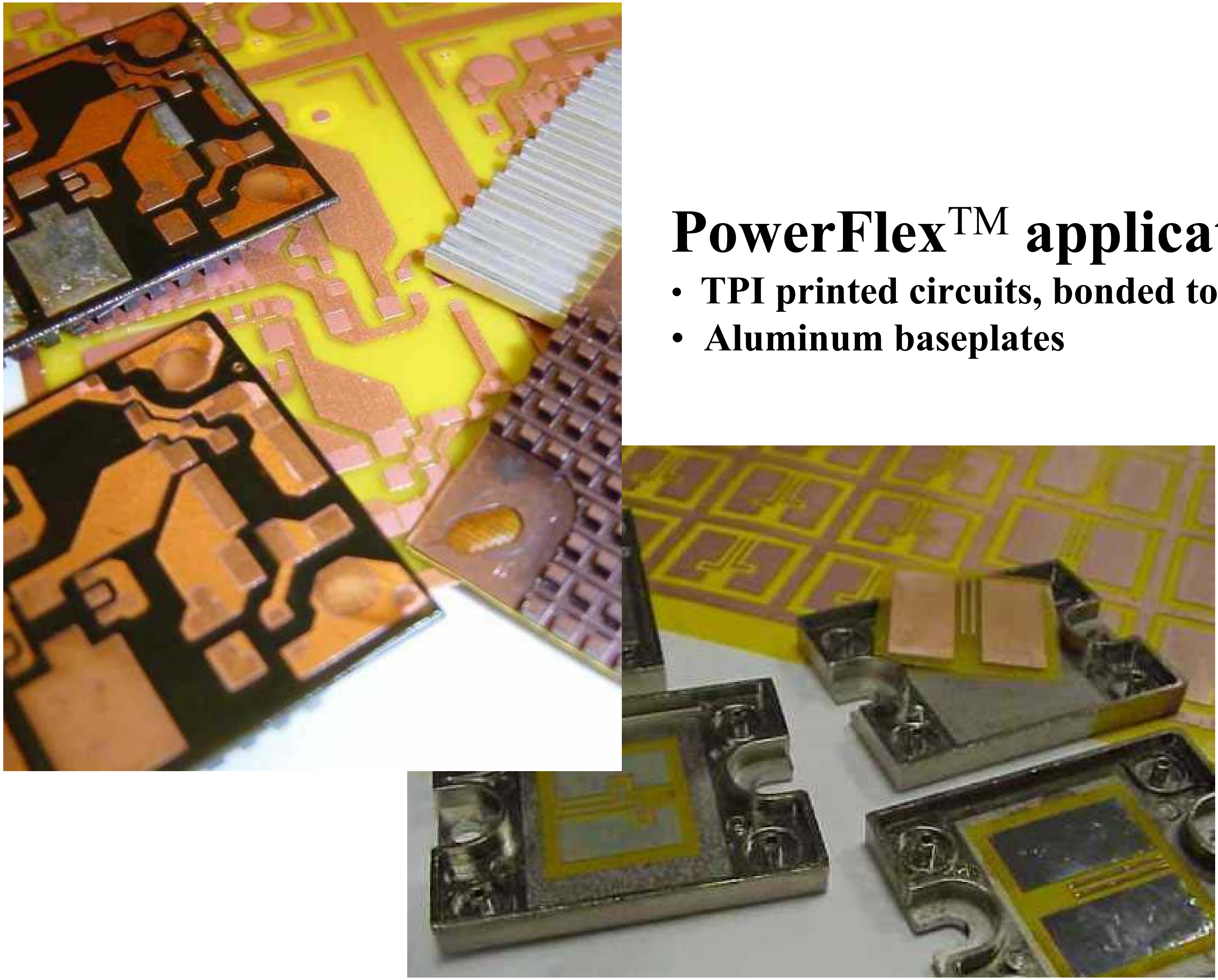
- *4000 Vdc*
- *200°C continuous*
- *300°C peak*

All-polyimide construction



Why PowerFlex?

- Thermal transfer
- Electrical properties
- Thermal durability
- *Cost-effective*
- Design flexibility
- Supply-chain options

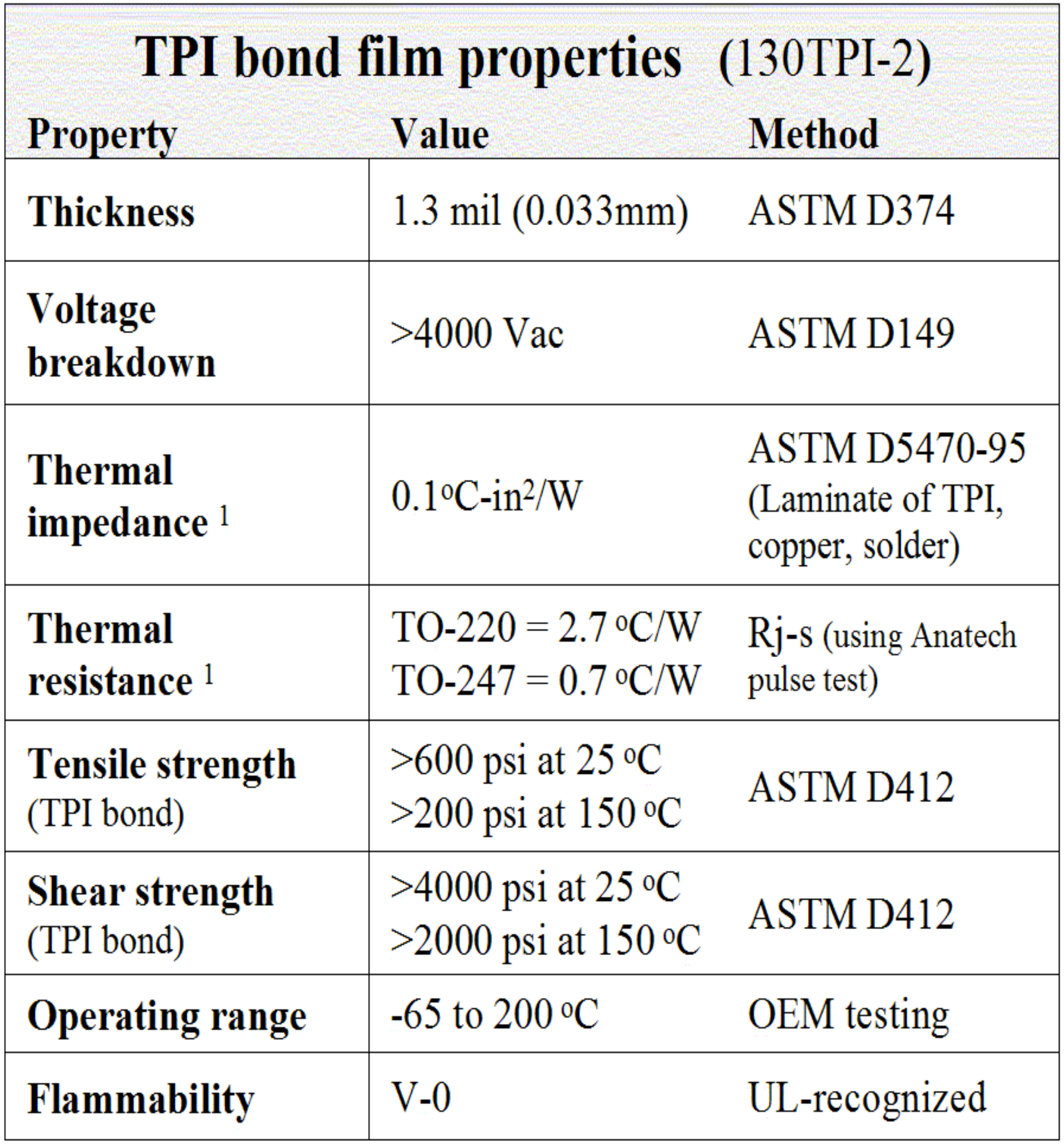


PowerFlex™ applications

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

TPI bond film

- Single-layer circuits
- Multilayer circuits
- Tack-bonds at 180°C
- Heat-seals at 250-300°C to aluminum



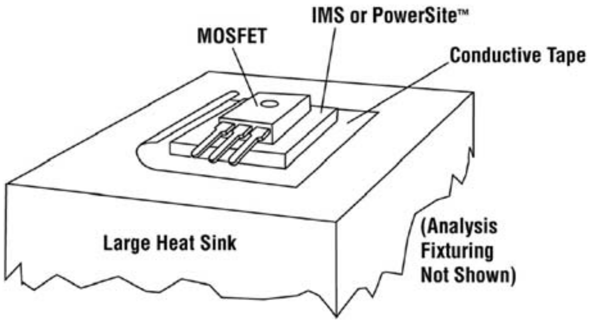
TPI bond film properties (130TPI-2)

Property	Value	Method
Thickness	1.3 mil (0.033mm)	ASTM D374
Voltage breakdown	>4000 Vac	ASTM D149
Thermal impedance [1]	0.1°C-in^2/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

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

FLEXIBLE THERMAL MANAGEMENT CIRCUITS

TEST #1

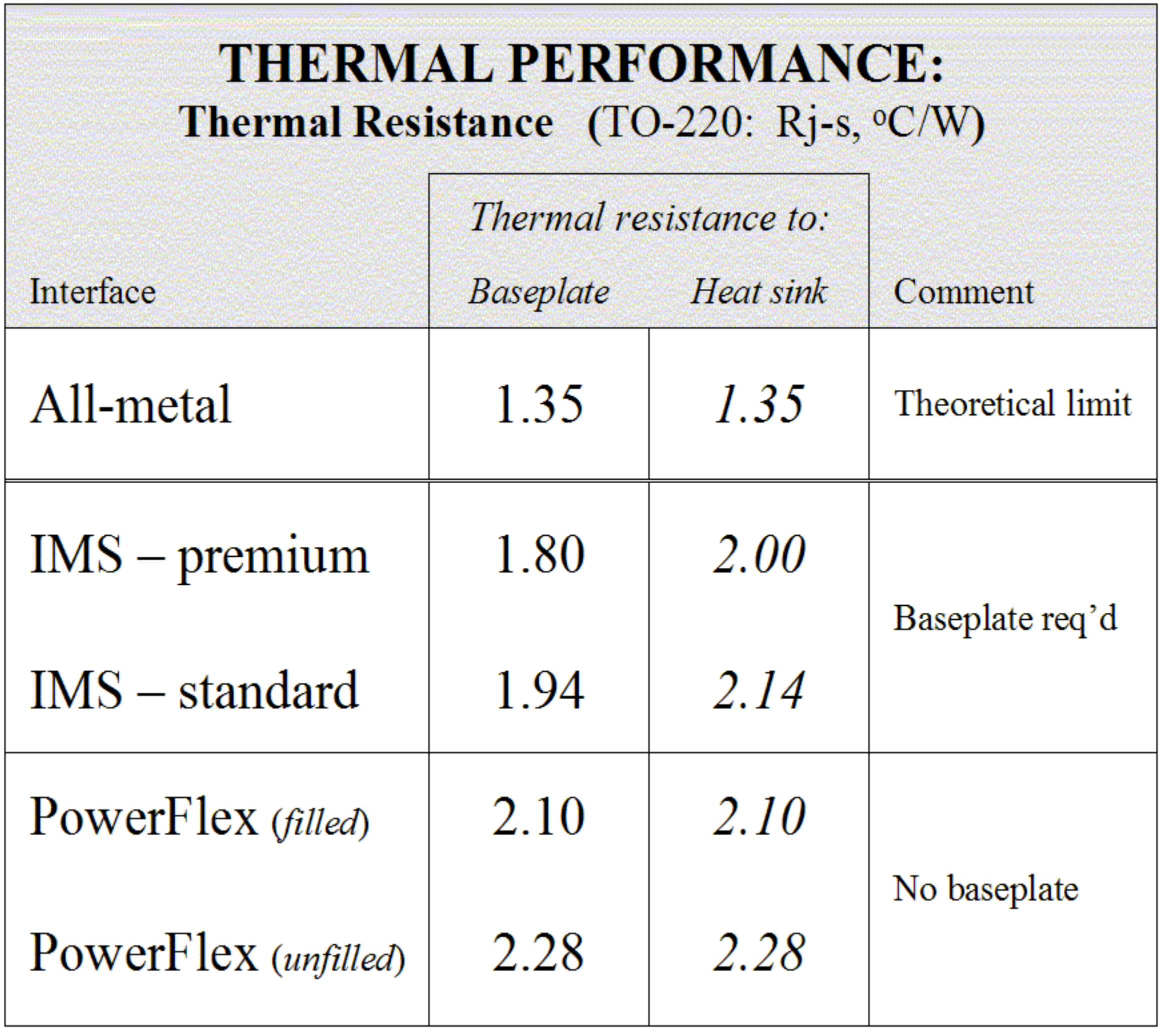
PowerFlex^{TM} thermal transfer performance

COMPARISON:

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

NOTE: 0.2°C/W resistance assumed for attaching IMS baseplate to heat sink.

TEST #2



THERMAL PERFORMANCE:

Thermal Resistance (TO-220: Rj-s, °C/W)

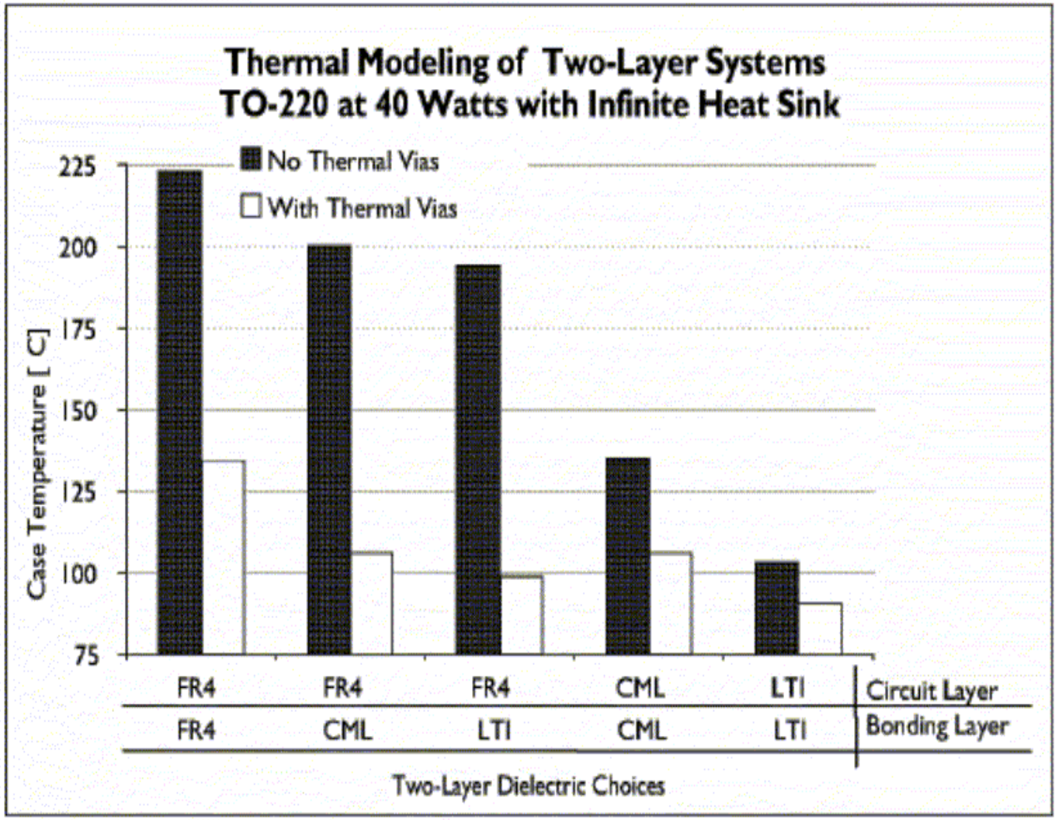
	Thermal resistance to:		
Interface	*Baseplate*	*Heat sink*	Comment
All-metal	1.35	*1.35*	Theoretical limit
IMS – premium	1.80	*2.00*	Baseplate req'd
IMS – standard	1.94	*2.14*	
PowerFlex *(filled)*	2.10	*2.10*	No baseplate
PowerFlex *(unfilled)*	2.28	*2.28*	

Relative importance of *"bond film layer"* in multilayer circuits

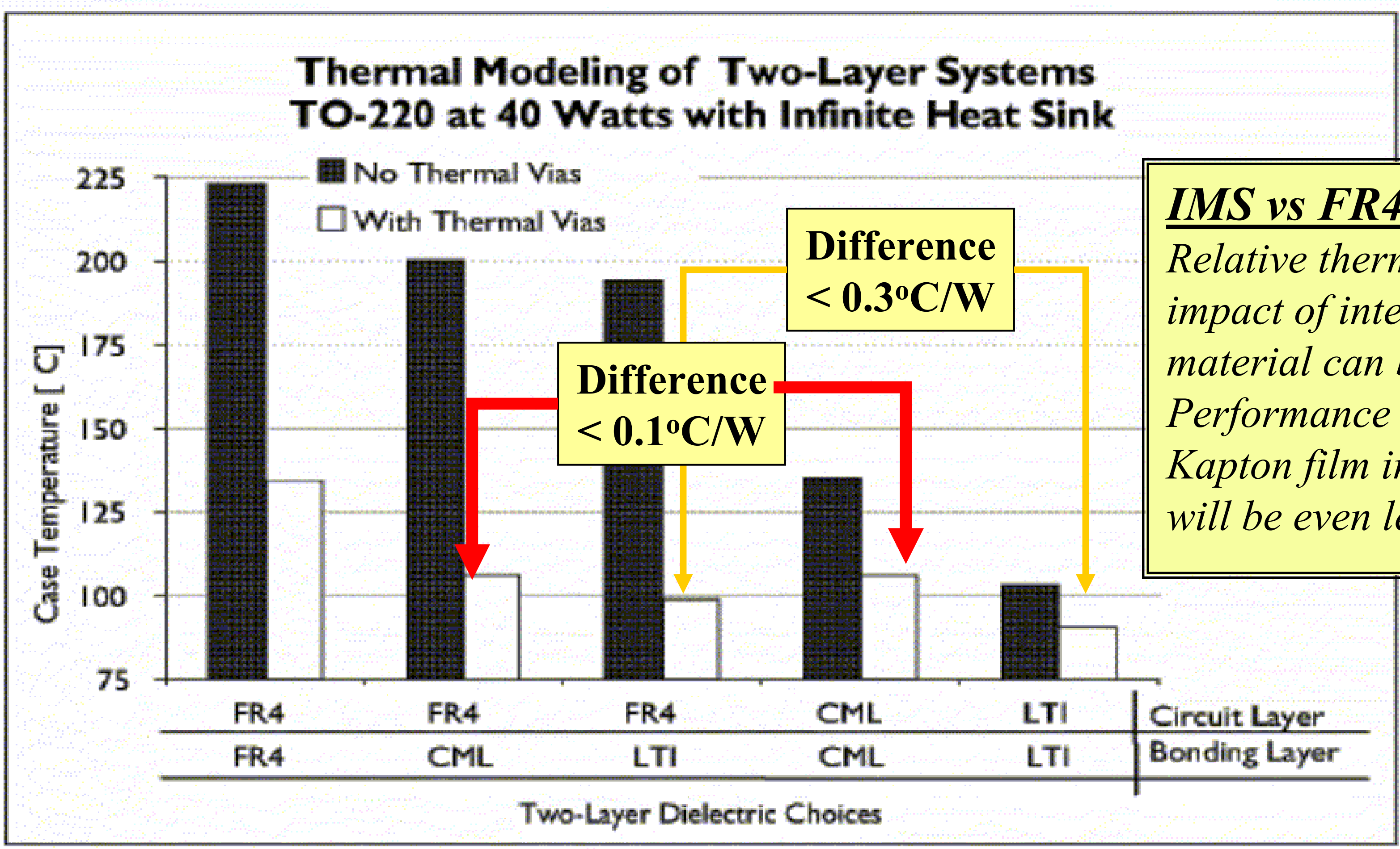
- Conventional thermal vias (plated-thru holes) carry most of the heat load *through* the PCB

- The bond film layer (*adheres aluminum*) dictates thermal performance

- 'Interlayer' dielectric thermal transfer has relatively low impact



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



Difference
< 0.3^{o}C/W

Difference
< 0.1^{o}C/W

***IMS vs FR4*:**
Relative thermal impact of interlayer material can be small. Performance gap with Kapton film interlayer will be even less.

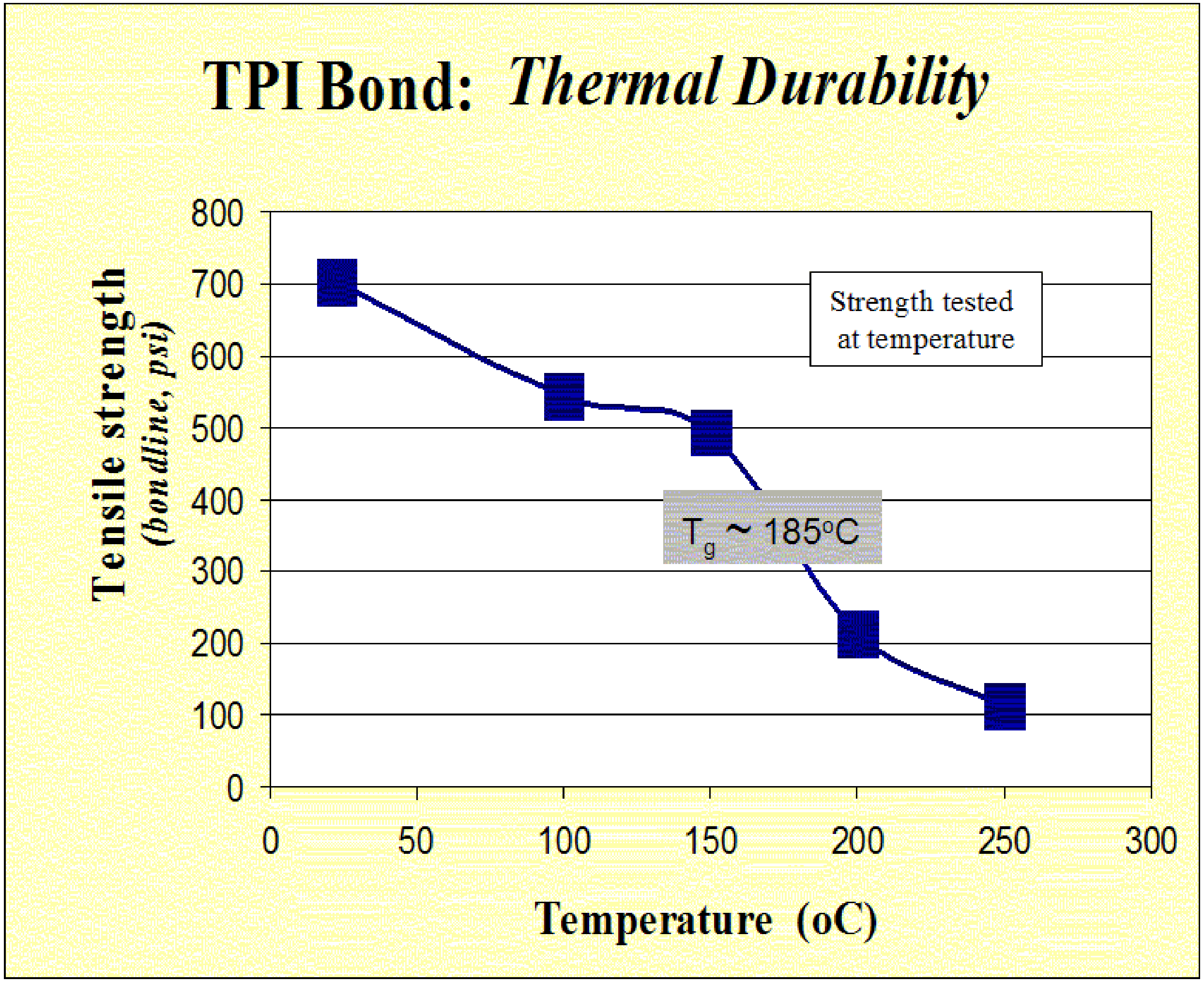
Relative importance of thermal vias and bond film
(*The Bergquist Company chart*)

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

PowerFlex^{TM} thermal durability

ALL-POLYIMIDE:

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

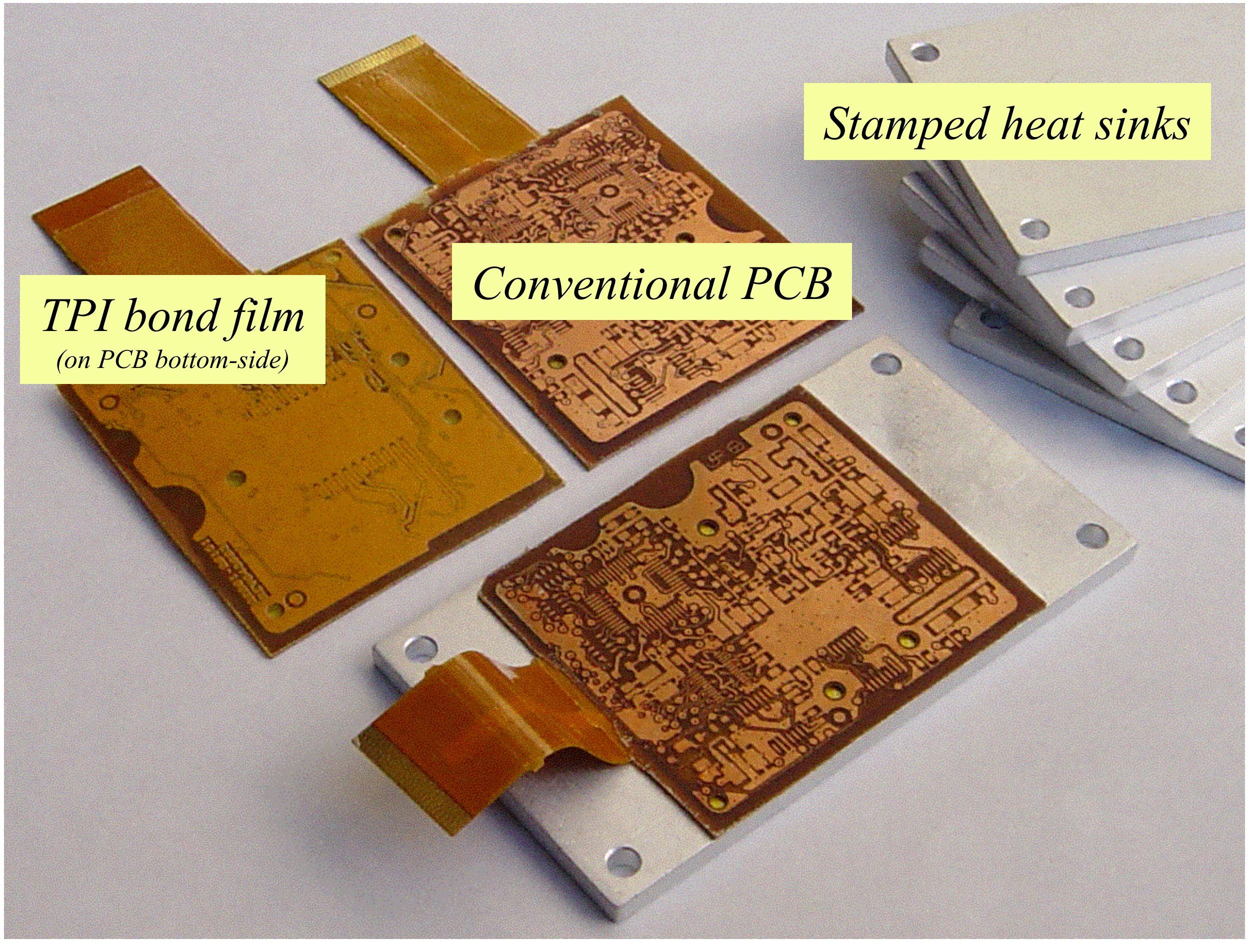


FLEXIBLE THERMAL MANAGEMENT CIRCUITS

PowerFlex™ flexible interconnects

DESIGN OPTIONS:

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



PowerFlex™ relative cost

RELATIVE SYSTEM COST (Area Basis)

	PCB layers:		
Interface	*Single-*	*Double-*	Comment
PowerFlex	*1*	*1.5*	No baseplate, Bonding req'd
IMS (standard)	*1.5*	*3*	With baseplate, Hardware req'd
DBC	*2.5*	*5*	Hardware req'd

NOTE:

- IMS baseplate and DBC need to be adhered to a heat sink with hardware and thermal compound.
- PowerFlex can be bonded directly to a heat sink.
- The cost of heat sink processing (bonding the PowerFlex, or hardware-attaching the IMS or DBC) are application-dependent and are not considered above.

PowerFlex technical challenges

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

PowerFlex applications

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

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