



# Introduction to Thermal Clad™ Insulated Metal Substrates (IMS™)

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## Agenda

- What can Thermal Clad do?
- What is Thermal Clad?
- Dielectric Characteristics
- Competitive Comparison
- Boards & Packages (Design)

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## What Can Thermal Clad Do?

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## What Can Thermal Clad Do?

Application examples:

### Watt-density:

- ? Challenge of 100 watts per square inch
- ✓ A well known audio company has exceeded 100 watts per square inch with Bergquist IMS!
- ✓ A maker of sense resistors has exceeded 400 watts per square inch!

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## What Can Thermal Clad Do?

### Application example: Motor controls

#### Watt density examples

- Typical AC Inverter Motor Drive – 3 HP motor
  1. Physical size: 253 cubic inches
  2. Estimated watt dissipation @ 85%: 360 watts
  3. Thermal requirements: 1.4 watts/cubic inch
- Thermal Clad based AC Inverter– 3 HP
  1. Physical size: 35 cubic inches
  2. Estimated watt dissipation @ 85%: 365 watts
  3. Thermal requirements: 10.5 watts/cubic inch

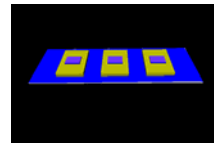
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## What Can Thermal Clad Do?

### First Thermal Example:



- Customer runs about 30 watts combined on 3 transistors
- Comparison of alumina build with Thermal Clad
- Direct substitution of Thermal Clad decreases junction temperature 4°C
- Other Bergquist solutions decrease junction a total of 15°C over current construction

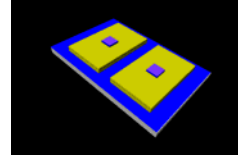
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## What Can Thermal Clad Do?

Second Thermal Example:



- Customer runs about 3 watts on 2 transistors
- Comparison of silicone insulator with Thermal Clad
- Direct substitution of Thermal Clad decreases junction temperature 4°C
- Thermal Impedance reduces from 2.4°C/W to as low as 0.6°C/W.

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## What Can Thermal Clad Do?

LED's powered to die junction temperature of 50C



0.13 W/mK  
FR-4



1.3 W/mK  
Bergquist MP



2.2 W/mK  
Bergquist LTI

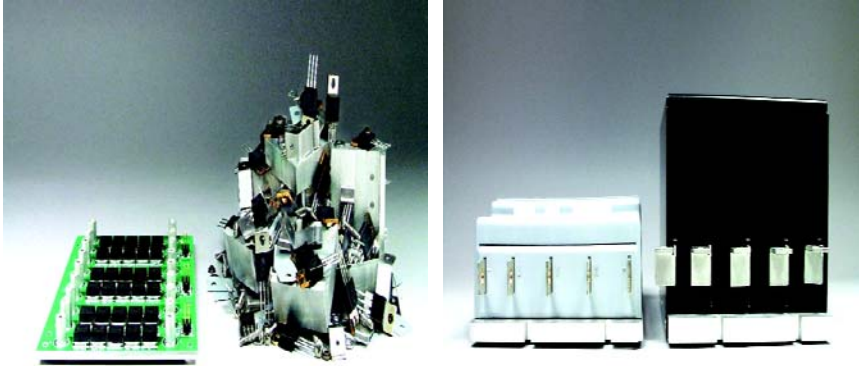
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## What Can Thermal Clad Do?

Simplify Manufacturing



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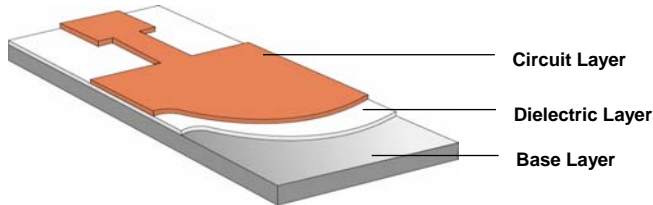


## What is Thermal Clad?

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## What is Thermal Clad?



**Circuit Layer (1 oz – 10 oz / 35 – 350 mm)**

One or two-layer circuit is common  
Multilayer construction available

**Dielectric (0.003”- 0.006” / 75 - 150 mm)**

Bergquist engineered thermally conductive & electrical insulator

**Base Layer (0.020”- 0.125” / 0.5 – 3.2 mm)**

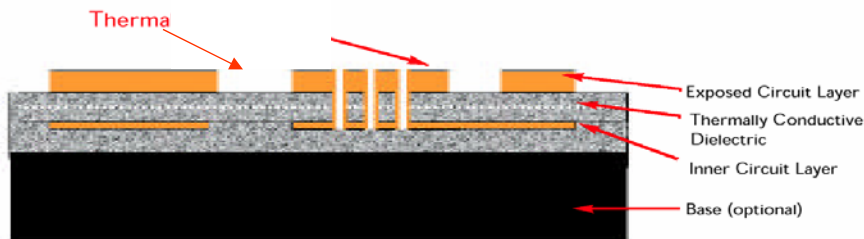
Aluminum, Copper, Steel, AlSiC, AlSi

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## What is Thermal Clad?

- Examples of Two-Layer Product:



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## What is Thermal Clad?

Comparisons of IMS, DBC, Glass Epoxy, Thick Film Hybrid

	Format	Density	Proc Temp	Oper Temp
IMS	Large	Inter	280	150
DBC	Inter	Low	High	High
G/E	Large	High	250	150
TFH	Small	Higher	High	High

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## What is Thermal Clad?

- Four dielectric choices
- Each available in various thicknesses

<b>MP™ : Multi Purpose</b>
<b>LTI™ : Low Thermal Impedance</b>
<b>HT™ : High Temperature</b>
<b>CML™ : Circuit Mounting Laminate</b>

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## Dielectric Characteristics

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## Dielectric Characteristics

Question: What is our testing authority?

Answer: Standard test methods!

### ASTM:

- D149 AC Breakdown Voltage
- D150 DC Breakdown Voltage
- D257 Volume Resistivity
- D5470 Thermal Resistance, Thermal Impedance, Thermal Conductivity
- Etc...

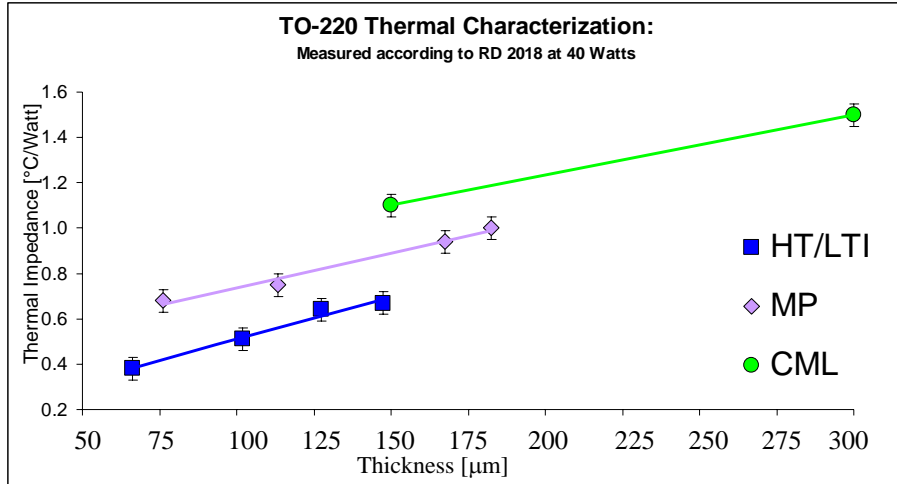
### IPC:

- TM 650
- Etc...

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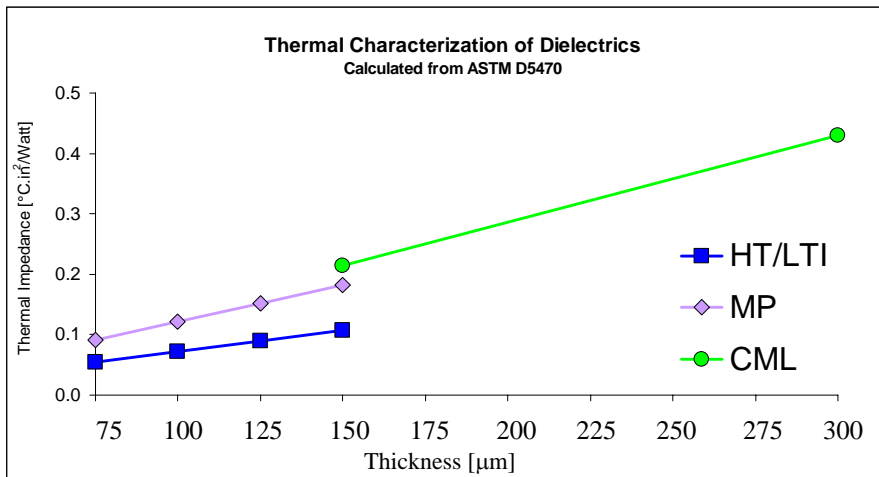
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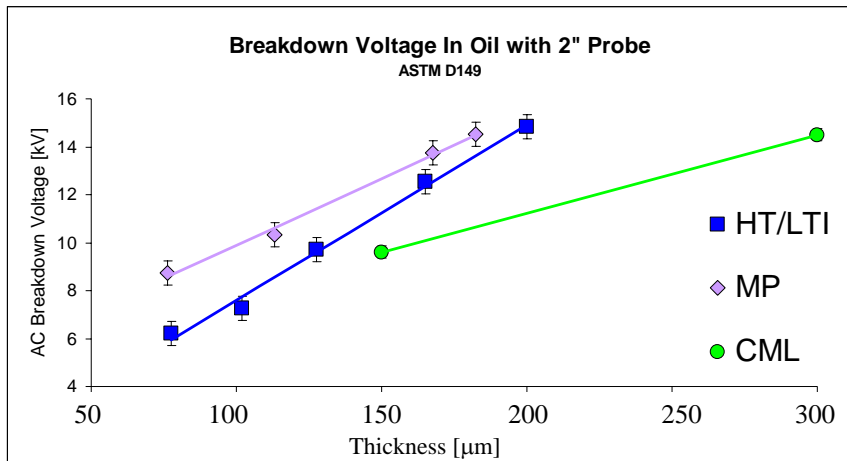
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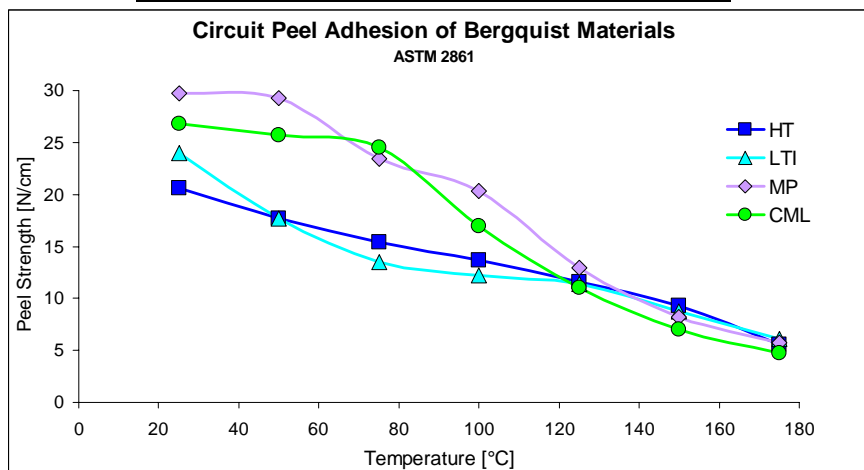
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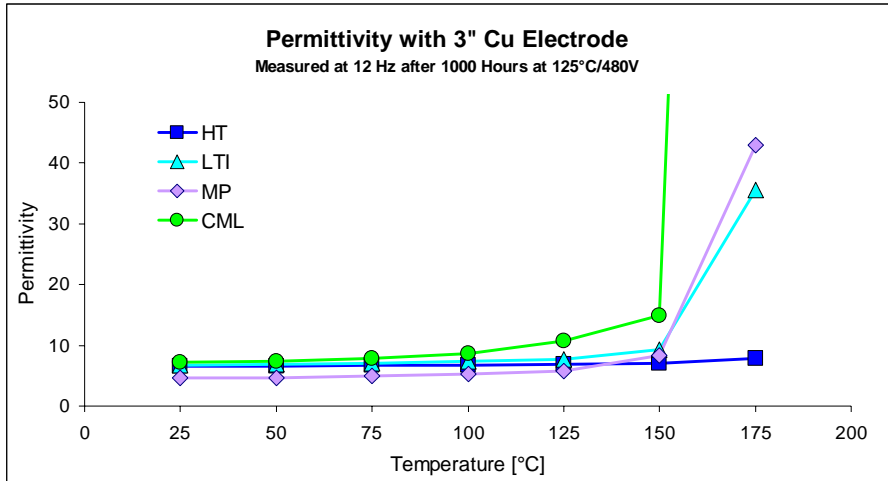
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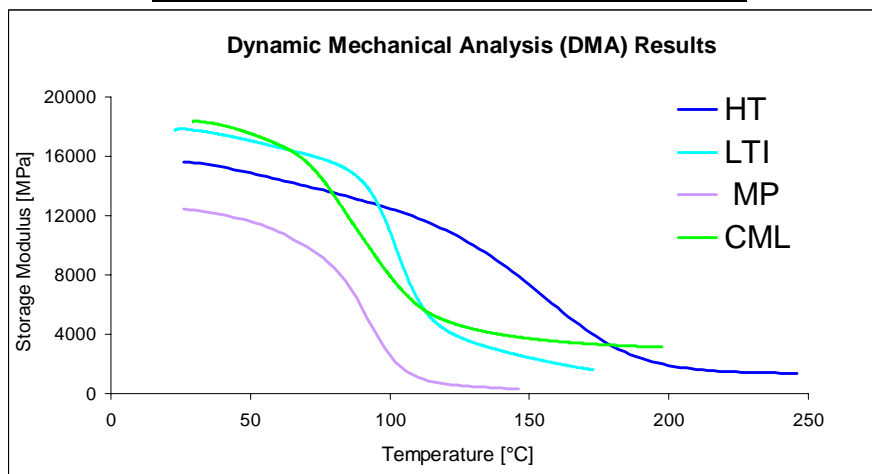
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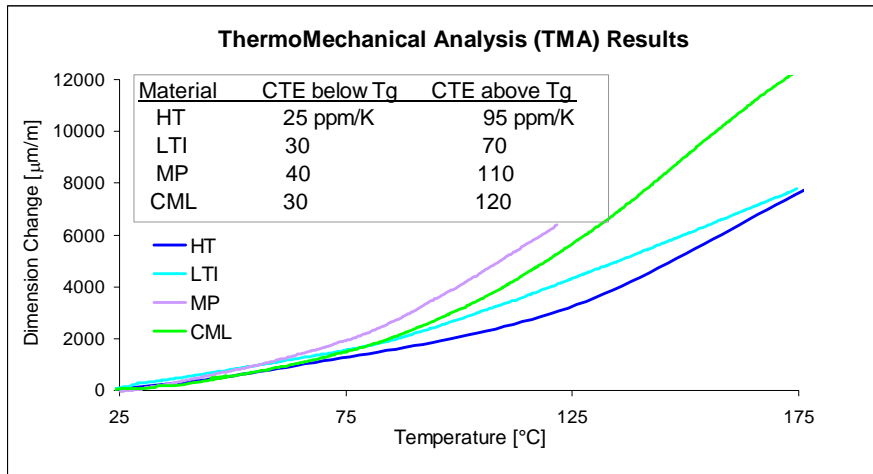
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## Dielectric Characteristics

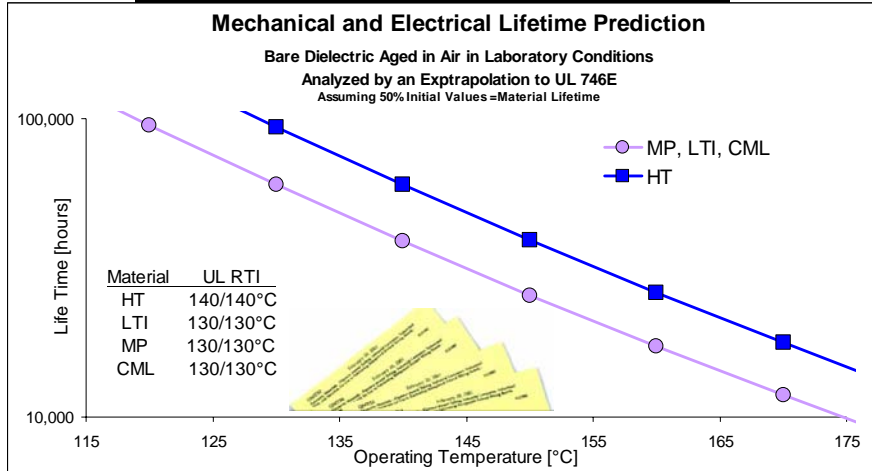
### Service Temperature:

- Office Equipment
  - UL 1950 (100k hours) service temp in air: 130-140°C
- Motor Controls
  - IEEE (20k hours): Class F insulation 180°C
- Automotive
  - Experience (4k hours) says ~175°C

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## Dielectric Characteristics



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## Dielectric Characteristics

	Thermal Conductivity [W/m-K]	Permittivity	Glass Transition [°C]	Peel Strength [N/cm]
HT	2.2	7	150	14
LTI	2.2	7	90	11
MP	1.3	6	90	16
CML	1.1	7	90	18

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# Dielectric Characteristics

2000 hours aging, 500 hour testing intervals

## Testing Conditions for MP, LTI:

- 85°C/85% RH, 100VDC
- 125°C / 100VDC
- 125°C / 480VDC
- 125°C / 960VDC
- 175°C / 100VDC
- 500-cycles -50°C to 125°C

## Testing Conditions for HT:

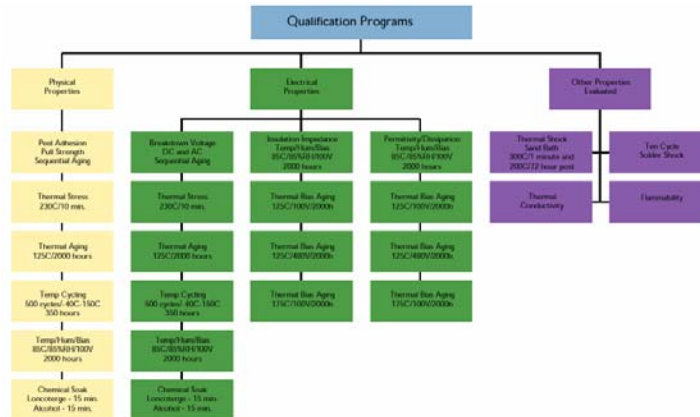
- 85°C/85% RH, 100VDC
- 125°C / 480 VDC
- 150°C / 960 VDC
- 175°C / 480 VDC
- 175°C / 960 VDC
- 200°C / 100 VDC
- 500-cycles -50°C to 125°C

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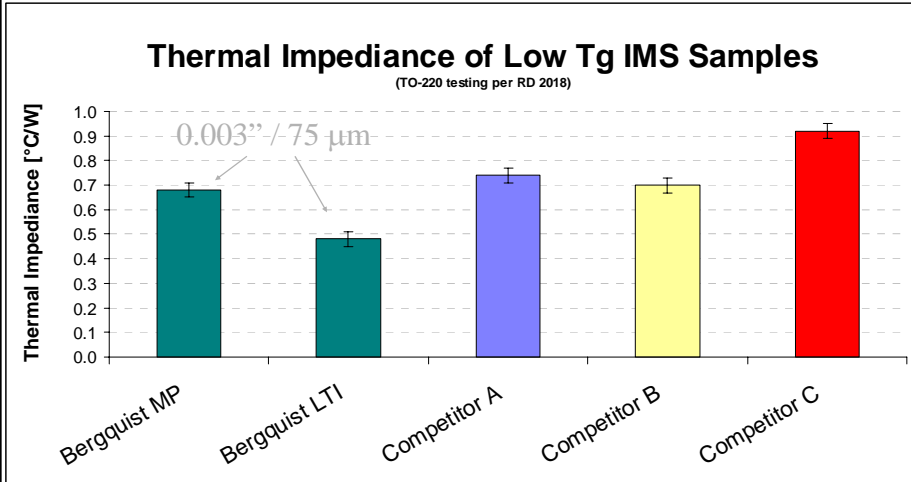


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## Competitive Comparison



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## Packaging

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## Packaging

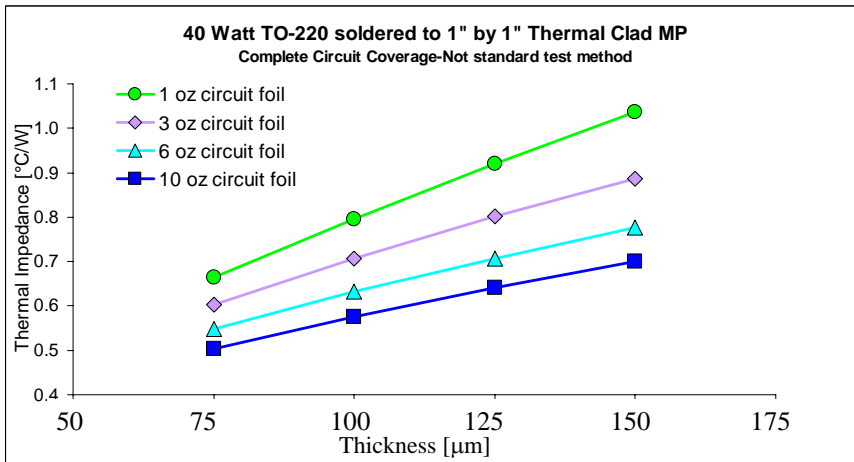
### Solder joint reliability authorities

- John Lau – 100  $\mu\text{m}$  minimum
- Paul Vianco – Blind Lap
- Werner Engelmaier

✓ Reliability is component specific

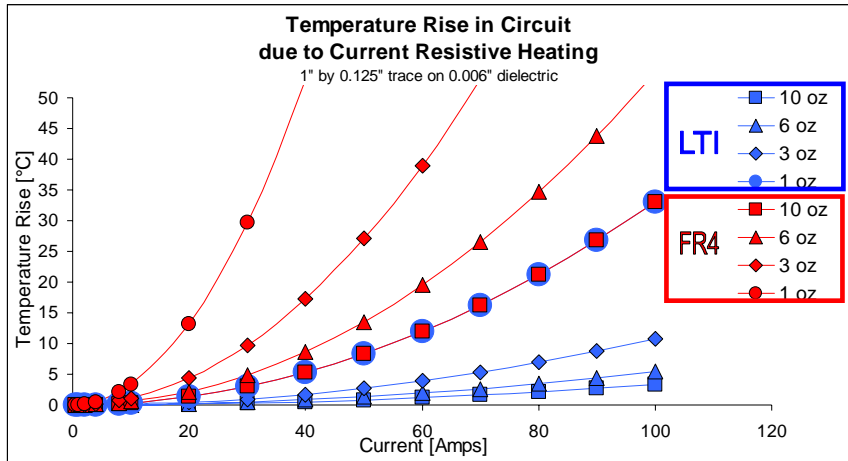
## Packaging

### Foil Selection



## Packaging

### Foil Selection



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## Packaging

### Encapsulation

- Allows safety agency testing without surface partial discharge (corona)
- Alleviates shock and vibration
- Visual security
- **Caution:**

Encapsulation is for clean parts only!

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## Fabrication

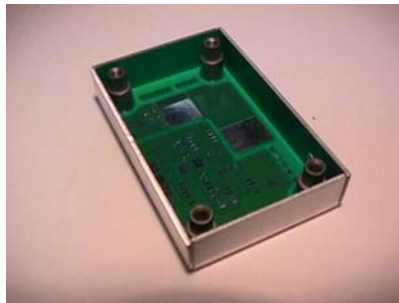
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## Fabrication

### Metal Rules

- Substrate metal is mechanically dominant
- Part tolerance is set by the punching die
- Shape (bending)



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## Fabrication

### Contours and Flatness

- Differential expansion (Al base layer / Cu circuit layer)
  - You get flat parts at ONE temperature!
  - Flatness is not a problem unless circuit layer exceeds 10%
  - Copper coverage and artwork affect flatness after etching
  - Temperature excursions (HASL) affect flatness

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## Conclusions

- Bergquist Thermal Clad IMS products are an effective way to increase Watt density in electronics

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