TECHNICAL DATA SHEET

Thermal Ground Plane for Wide Band Gap Semiconductor Thermal Management

Boyd's Thermal Ground Plane (TGP) solution is used in conjunction with high power, Wide Band Gap (WBG) electronic components to significantly reduce the package internal thermal resistance from junction-to-case (θj-c). The high power components are IGBTs, Power Amplifiers, LEDs and more. Figure 1 is an example of TGPs used in two regions of a WBG semiconductor package: the first region is directly under the devices (Die TGP); the other region is under the ceramic insulator (Substrate TGP). TGPs are vapor chamber heat pipes that are a thin planar (1-3mm thick), high heat flux (350+W/cm2) accommodating spreader to which the electronic devices can be directly mounted, minimizing thermal interfaces. Coefficient of Thermal Expansion (CTE) matching is the key feature of the TGP. TGP's are constructed from low-CTE (5- 7ppm/K) matching materials such as copper/moly/copper. TGP vapor chambers were developed to spread heat from multiple, small (10's of mm2) devices over larger (10's of cm2) areas in high packaging density applications.

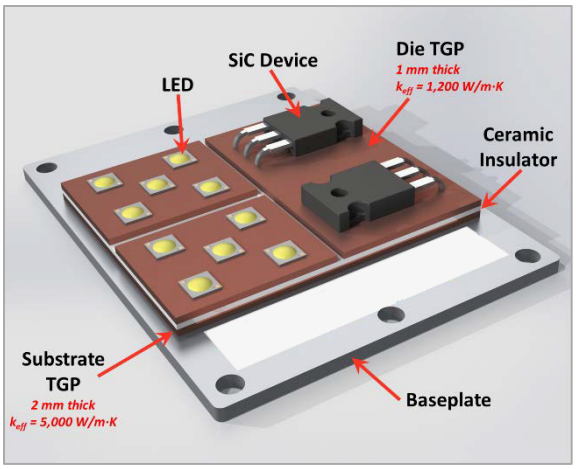

Figure 1 – Example of TGP in 2 Regions of a WBG Semiconductor Package

The TGP represents a proven two-phase cooling approach, where the benefits include very high effective thermal conductivity, extreme reliability, no moving parts, and no need for external power, allowing the attached devices to run cooler as a result of improved heat spreading, or with increased current (Figure 2). In addition, the TGP offers tremendous cost savings through reduced die count, which constitutes most of the module cost (Figure 3). A reduction in junction temperature (T_j) of 20-30°C through the introduction of a TGP heat spreader is typical. Figure 4 below provides a graph of typical electronic packaging materials CTE versus their thermal conductivity (W/m·°C). In comparison, the TGP offers up to 1,200 W/m·K or more, (depending on the size). The TGP can be active up to 350 W/cm^2 heat flux coming from the devices mounted onto it.

The thin, flat form factor of the TGP makes it ideal for directly mounting electronic devices for improved thermal dissipation and reduced interface resistance. From there, design engineers can thermally control electronic components for increasingly demanding military, aerospace, industrial, and medical applications.

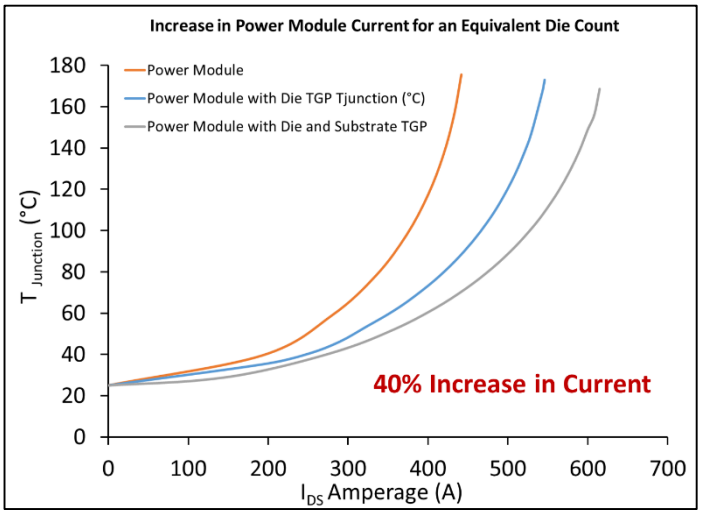

Figure 2 – Junction Temperature (T_j) vs. Current

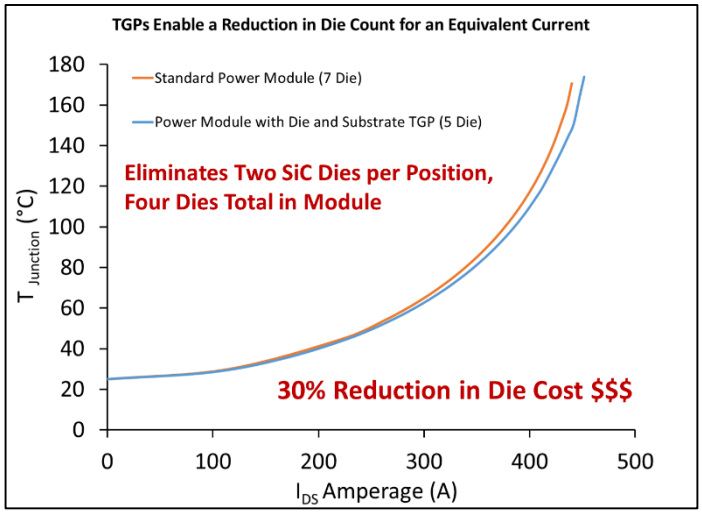

Figure 3 – Reduced Die Count, T_j vs. Current

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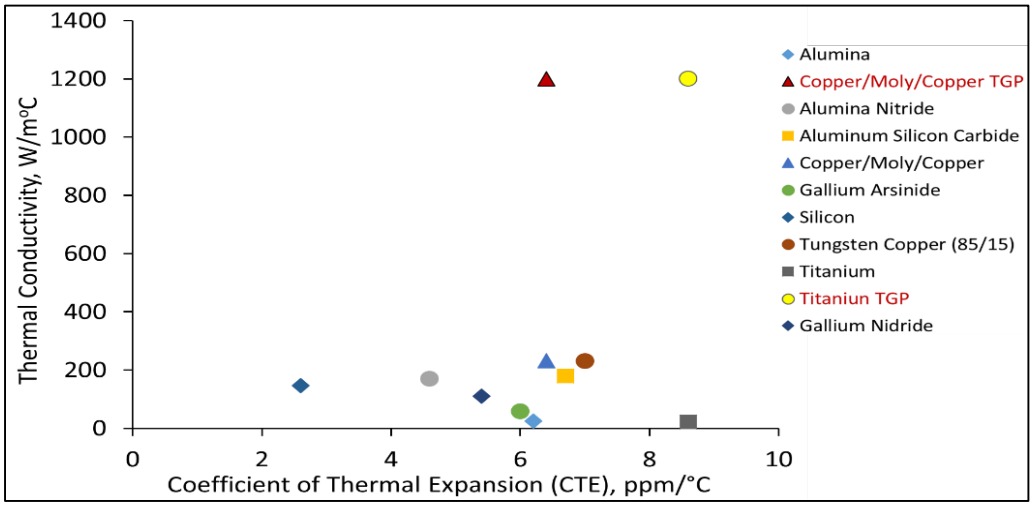

Figure 4 – Electronic Packaging Materials CTE versus Thermal Conductivity (W/m·°C)

Key Features and Benefits

- CTE matching improves cooling and increases reliability through reduced junction temperature and reduced thermal stress in the bonding material between the TGP and semiconductor.
- TGP substrate can be tailored to closely match various semiconductor materials such as silicon (Si), silicon carbide (SiC), gallium arsenide (GaAs), and gallium nitride (GaN).
- TGP-based thermal solutions can run at higher power density
- High Heat Flux - effective up to 350 W/cm^2.
- Effective thermal conductivity over 1,200 W/m·K
- 40%+ Increase in Module Current
- Reduced Die Count (40%+)
- Significant Cost Savings through reduced die count
- Lower Cost than Diamond spreader alternatives
- *Patented thru-hole technology allows both straight and threaded holes through the highly conductive vapor space region for ease in design of attachment hardware*
- More than 30,000 hours of vapor chamber continuous life and reliability testing
- Ideal for SWAP-C constrained systems such as radar T/R modules, power electronics, embedded computers, and avionics

CTE Thermal Ground Plane (TGP)	
Thickness	0.04 to 0.118 inches (1 to 3 mm)
Bulk density	≤ 3.0 grams/cm^3
Sizes	Any size made custom to given application
Effective Thermal Conductivity	> 1,200 W/(m K)
Shape Options	Various Shapes (Square, Round, Rectangular)
Maximum heat flux	350 W/cm^2
Wall Material	Copper/Moly/Copper
Working Fluid	Water (TGP is freeze tolerant and reliably temperature cycled)
Wick	Sintered Powder

Critical Application Need

- Electronics Cooling
  - Military, Medical Equipment, Power Electronics, Telecom
  - Radar Transmit/Receive Modules
  - Power Amplifiers, RF Devices, MMIC
  - Computer CPU, GPU's
  - IGBTs, MOSFETs, TWTs, and SGTs
  - Embedded Computers, Hand-Held Devices
- High Temperature Applications (>100°C)
- High Strength and Clamping Force Applications