



# Product Training Module for the use of the GT series in motor control units

April 2013



# Introduction

- Purpose
  - This training module is used to give an introduction to t-Global Technology's GT series which is specifically designed for thermal management in motor systems
- Objectives
  - To identify the key properties of the product range
  - To identify the key design criteria for product selection
- Content
  - Introduction and background to the product range
- Learning time
  - 30 mins

# Introduction

- The U.S. Department of Energy (DOE) Freedom CAR Program's technical targets for the electric traction system (power electronics and electric machines) of advanced vehicles require significant reductions in volume, weight, and cost while also meeting performance and 15 year life requirements
- The performance of the semiconductor switches and diodes, the ripple-current capability of the capacitors, and the life of the electronics all decrease as the operating temperature is increased
- To achieve Freedom CAR goals for cost, weight, and volume significant advancements in the thermal management of both the power electronics and motors for the electric propulsion system must be achieved





# Introduction

- Thermal interface materials (TIMs) are essential to remove heat from the IGBT package which forms the core of the motor control unit
- Typically, an IGBT is used in a three-phase inverter leg where the control signals are generated via a PWM scheme so, the prediction of the temperature rise is important in the pulse operation conditions of the device.
- Therefore, improving the thermal management of the IGBT can also significantly aid in the Freedom CAR Program's goals of using glycol water at 105°C or even air cooling

# Introduction

- The pressure to decrease the size of power electronics systems and, subsequently, the module, has resulted in a 50% footprint area reduction of some IGBT modules
- This has resulted in higher power dissipation densities for the IGBT die as well as the module due to denser packing of the die. Increases in switching frequencies and voltage ratings of IGBTs also result in higher power dissipation at the die level
- Even though a portion of the die power losses has been offset by advances in both MOSFET and IGBT chip design, the cooling capabilities of present modules limit the device performance
- Thermal management therefore is becoming critical.



# Introduction

- Most conventional power modules have been designed to be cooled by bolting the module to an external heatsink or cold plate cooled by forced air or circulated liquid
- The critical layers in the thermal path of a conventional IGBT module are the IGBT die, the die attach solder, a metal-clad ceramic substrate (copper directly bonded on alumina or aluminium nitride), substrate attach solder, metal or composite baseplate, thermal interface material (TIM), and the external heatsink
- The TIM material must not only provide good thermal conductivity but also excellent dielectric breakdown characteristics
- T-Global has developed such a series of materials aimed specifically at this market place



# GT Series

- The GT series is t-Global Technology's range of high performance, thermally conductive insulators designed for demanding applications where good thermal management and a high dielectric breakdown voltage are a key requirement
- The GT series is based on a low cost alumina thermal material which has electrical and thermal properties approaching those of higher cost boron nitride filled materials. This allows for the use of thinner interfaces for decreased thermal resistance, weight, and cost
- The GT series offers a high dielectric breakdown strength at a relatively high thermal conductivity
- The GT series retains its high dielectric breakdown strength even under conditions of high ambient moisture
- The GT series have been developed specifically for power applications where long-term reliability is a top concern.



# GT Series

- The GT series are resistant to heat, humidity, and shock while conforming to surface topography to maximize contact area at low fastener pressures
- The GT series are electrically insulating are UL listed with a UL94 V-0 flame rating
- The GT series also meets RoHS specifications and exhibits extremely low outgassing.

# GT-15

- GT-15 has a thermal conductivity of 1.5 W/mk
- It has a breakdown voltage of 6 KV DC
- It has excellent resistance to tearing and cut through in screw mounting applications
- It has a thermal impedance of 0.61  $\text{Cin}^2/\text{W}$  (50 PSI)
- It is designed for applications that require high thermal performance and electrical isolation
- GT-15 has a smooth and highly compliant surface to optimize thermal resistance at low mounting pressures



# GT-15 Datasheet

Property	GT15	Unit	Test Method
Colour	Yellow	-	Visual
Reinforcement	Fiberglass	-	-
Thickness	0.23	(mm)	-
Op. Temp. Range	-45 to 180	°C	-
Density	2.35	g/cm <sup>3</sup>	ASTM D792
Thermal Conductivity	1.5	W/mK	ASTM D5470
Hardness	75	Shore A	ASTM D2240
Breakdown Voltage AC	4000	V	ASTM D149
Breakdown Voltage DC	6000	V	ASTM D149
Dielectric Constant	5.8	1000 Hz	ASTM D150
Thermal Impedance		°C in <sup>2</sup> /W	
t=0.23mm 20psi	0.70	psi	ASTM D5470
t=0.23mm 50psi	0.61	psi	ASTM D5470
t=0.23mm 100psi	0.49	psi	ASTM D5470
t=0.23mm 200psi	0.43	psi	ASTM D5470
t=0.23mm 400psi	0.40	psi	ASTM D5470
TML	< 0.2 %	%	ASTM E595
Tensile Strength	200	psi	ASTM D412
Elongation	60	%	ASTM D412
UL Flammability	V-0	-	UL 94

# GT-20

- GT-20 has a thermal conductivity of 2 W/mk
- It has a breakdown voltage of 6 KV DC
- It has a thermal impedance of 0.43  $\text{Cin}^2/\text{W}$  (50 PSI)
- It is designed for applications that require high thermal performance and electrical isolation
- GT-20 has a smooth and highly compliant surface to optimize thermal resistance at low mounting pressures

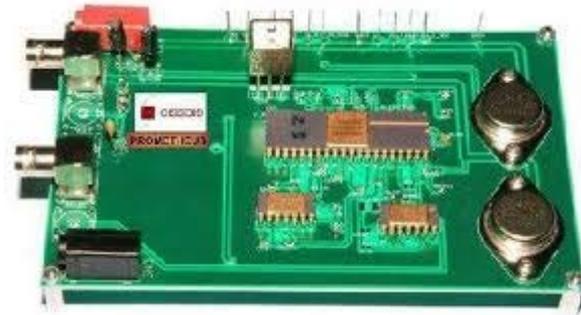


# GT-20 Datasheet

Property	GT20	Unit	Test Method
Colour	Green	-	Visual
Reinforcement	Fiberglass	-	-
Thickness	0.23	(mm)	-
Op. Temp. Range	-45 to 180	°C	-
Density	2.52	g/cm <sup>3</sup>	ASTM D792
Thermal Conductivity	2	W/mK	ASTM D5470
Hardness	80	Shore A	ASTM D2240
Breakdown Voltage AC	4000	V	ASTM D149
Breakdown Voltage DC	6000	V	ASTM D149
Dielectric Constant	5.7	1000 Hz	ASTM D150
Thermal Impedance		°C in <sup>2</sup> /W	
t=0.23mm 20psi	0.60	psi	ASTM D5470
t=0.23mm 50psi	0.43	psi	ASTM D5470
t=0.23mm 100psi	0.35	psi	ASTM D5470
t=0.23mm 200psi	0.32	psi	ASTM D5470
t=0.23mm 400psi	0.30	psi	ASTM D5470
TML	< 0.2 %	%	ASTM E595
Tensile Strength	200	psi	ASTM D412
Elongation	60	%	ASTM D412
UL Flammability	V-0	-	UL 94

# GT-30

- GT-30 has a thermal conductivity of 3 W/mk
- It has a breakdown voltage of 5 KV DC
- It has a thermal impedance of 0.28  $\text{Cin}^2/\text{W}$  (50 PSI)
- It is designed for applications that require high thermal performance and electrical isolation
- GT-30 has a smooth and highly compliant surface to optimize thermal resistance at low mounting pressures



# GT-30 Datasheet

Property	GT30	Unit	Test Method
Colour	Pink	-	Visual
Reinforcement	Fiberglass	-	-
Thickness	0.23	(mm)	-
Op. Temp. Range	-45 to 180	°C	-
Density	2.8	g/cm <sup>3</sup>	ASTM D792
Thermal Conductivity	3.0	W/mK	ASTM D5470
Hardness	80	Shore A	ASTM D2240
Breakdown Voltage AC	3000	V	ASTM D149
Breakdown Voltage DC	5000	V	ASTM D149
Dielectric Constant	6.0	1000 Hz	ASTM D150
Thermal Impedance		°C in <sup>2</sup> /W	
t=0.23mm 20psi	0.38	psi	ASTM D5470
t=0.23mm 50psi	0.28	psi	ASTM D5470
t=0.23mm 100psi	0.25	psi	ASTM D5470
t=0.23mm 200psi	0.32	psi	ASTM D5470
t=0.23mm 400psi	0.30	psi	ASTM D5470
TML	± 0.2 %	%	ASTM E595
Tensile Strength	100	psi	ASTM D412
Elongation	30	%	ASTM D412
UL Flammability	V-0	-	UL 94



# Summary

- In summary to meet the demands for future technologies in the electric traction system area, significant reductions in volume, weight, and cost are required
- The key to these developments in an efficient and cost effective way of handling the critical thermal management issues present
- T-global technology has developed a range of high performing products, the GT series, which are specifically designed for these demanding applications
- The GT series is available in a number of different formats which allow the engineer to address all the common thermal issues in an economical and technically viable manner