One Approach to S-ALTRO16 (*) Cooling
(The case of the flat installation of MCMs)

A cooling using cooling plates

Discussed on LC TPC WP Meeting on 4 April 2012

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8 April 2012

Cooling of TPC LP Module Equipped by S-ALTRO16
(Flat Installation)

I. The two purposes of the cooling for LP TPC in an open space:

(A) To control the temperature of the pad PCB within a required temperature range : probably < 1℃ to the ambient temperature.

(I assume that the operation temperature of TPC will be the ambient temperature in the ILD detector which will be the room temperature.)

(B) To keep the temperate of the outer surface of the readout electronics within an workable temperature range of the electronics : probably < a few 10 ℃.

II. For ILD TPC in ILD detector, need to keep the temperature (B) to be in the same range of (A).

Here we discuss the case of LP TPC cooling (I).

Cooling of TPC LP Module Equipped with S-ALTRO16 MCM (Flat Installation)

“A cooling using cooling plates”

(A) To control the temperature of the pad PCB within a required temperature range : probably < 1℃ to the ambient temperature:

Cool the backside of the pad PCB using good cooling plates.

Ideal if we might be able to instrument am effective cooling layer in the pad PCB.

Heat flow from S-ALTRO16 MCM through the signal connector should not be very large: need to check.

Major thermal resistance: 2PCO2 cooling pipes – cooling plate and cooling plate iteself.

Need to avoid the signal connectors and other electrical connections.

Necessary but minimum numbers of 2PCO2 cooling loops on the cooling plates

Cooling of TPC LP Module Equipped by S-ALTRO16 (Flat Installation)

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(B) To keep the temperate of the readout electronics S-ALTRO16 MCM within an workable temperature range : probably < a few 10 ℃.

Conductive cooling by using cooling plates.

(Would be easier if the PCB for MCM might be used as cooling plate and heat sinks.)

Heat dissipation of MCMs is large (w/o power pulsing).

Thermal resistance: Cooling pipe – cooling plate, cooling plate itself, and cooling plate – MCM.

MCMs mounted on both sides of their PCB – two cooling plates necessary - complication.

Almost close up MCMs by the two cooling plates?

Install necessary but minimum numbers of 2PCO2 cooling loops (pipes) on cooling plates.

We may use auxiliary cooling such as of the blow of pressurized air .

Assembly procedure: not simple.

Cooling of TPC LP Module Equipped by S-ALTRO16
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(1) Look for “good cooling plates” with good thermal conductivity :

Should be also light to minimize material .

Electrical characteristics need to be well defined (probably)

………

(2) Thermal simulation to check if this cooling using cooling plate might work . Hope that simulation might give us more idea?

Simulation should not be very difficult.

Do it at NiAS (Nagasaki) (The first meeting on 19-20 April 2012)

Philippe accepted to work on the simulation helped by Fusayasu san and his student.

(3) We have also start to make test peace's of pressurized air cooling with thin pipe for LP modules axillary cooling.

Cooling of TPC LP Module Equipped by S-ALTRO16
(Flat Installation)
“A cooling using cooling plates”

Good thermal conducting materials:

We have consulted to ATLAS Japan people working on the silicon/pixel detectors and are contacting to a few companies.

CFRP	< 100W/mK
Al and Cu plate	250W/mK – 400W/mK
(Good Carbon fiber mesh	500W/mK)
Carbon-carbon	500W/mK (directional)
(TPG : Thermal Pyrolytic Graphite	Up to 1700W/mK)
TPG composite (with Al, Cu etc) Ex. TC1050	1500W/mK (directional)

(For TPG and TC1050, find some information in below .)

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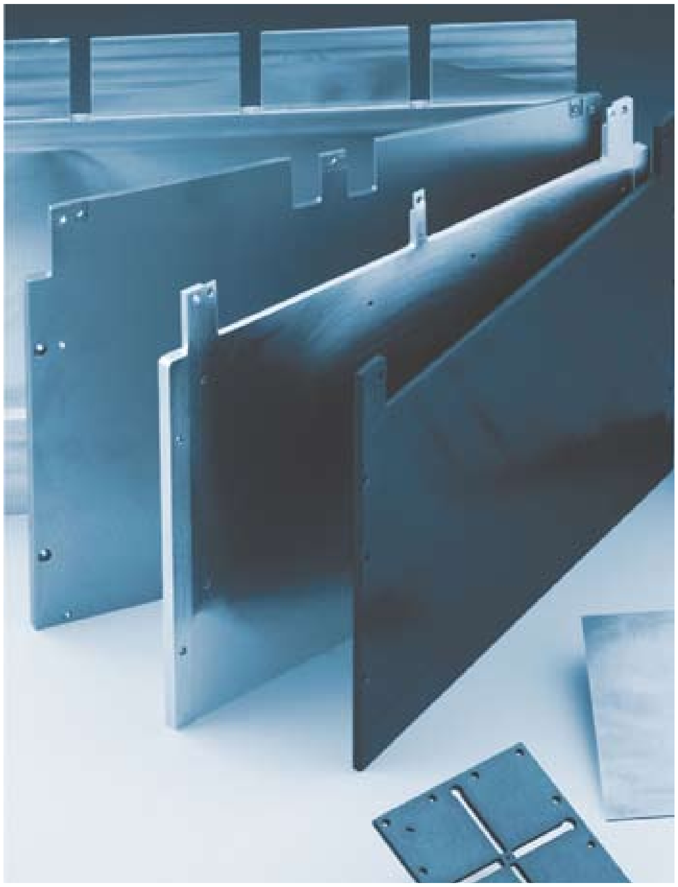
TC1050® Thermal Management Materials



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- Aluminum (TC1050.ALY)
- Copper (TC1050.COP)
- Other encapsulations and systems are often available, such as kovar, tungsten/copper, carbon fiber composites, etc.

The thermal expansion properties are defined by the selection of the encapsulating material.

Benefits

- Thermal conductivity to 3 times copper
- Lighter than aluminum
- Adjustable coefficients of thermal expansion
- Low thermal resistance
- High reliability from passive conduction
- Sizes from diode mounts to whole chassis panels

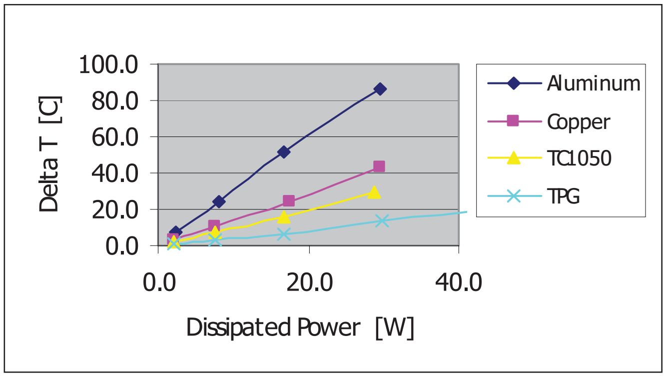
Applications

- Heat spreaders in packages
- Thermal cores for PWB's
- Improved performance of finned sinks
- Laser diode mounts
- Avionics thermal cores
- Satellite traveling wave tube mounts
- Electronic chassis

Typical TPG Properties

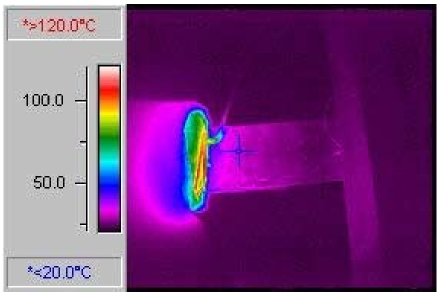
Thermal Conductivity	1500 <20	Watts/m-K, a-b axis Watts/m-K, c axis
Density	2.26	gm/cc
Thermal Expansion Coefficient	0 to -1 25	ppm/°C, a-b axis ppm/°C, c axis
Specific Heat	0.71	J/gm-°C @ 25° C
Flexural Strength	36.7 38.5	+/-4%, MPa, ⊥ab +/-4%, MPa, ll ab
Stiffness	1050 36	+/-2%, GPa, c_{11} +/-3%, GPa, c_{33}
Compressive Strength	nil	ll ab
Tensile Strength	nil	ll ab

Typical Thermal Performance



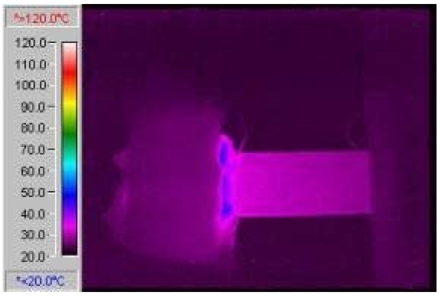
TPG shows over 5X the power dissipation capability of Al

Thermal Images



6061 Aluminum

T_{max} = 115°C



TPG

T_{max} = 44°C

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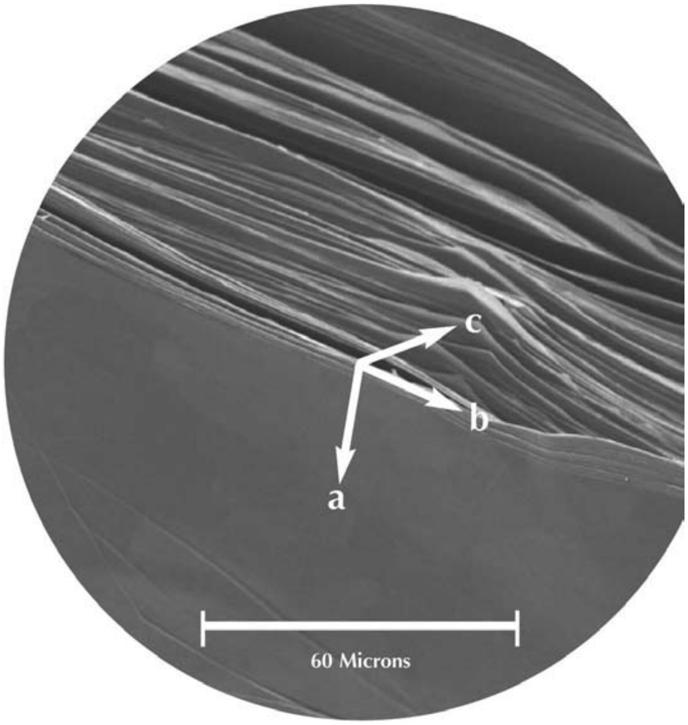
TPG® Thermal Management Material

TPG (thermal pyrolytic graphite) is a unique form of pyrolytic graphite manufactured from thermal decomposition of hydrocarbon gas in a high temperature chemical vapor deposition reactor.



Benefits

- Thermal conductivity to 4 times copper
- Lighter than aluminum
- Compatible with many encapsulating techniques
- Sizes from dies and packages to PWB's
- Passive, high performance heat transfer

Features

- Highly oriented crystals in a layered structure
- In-plane conductivity typically 1350 to 1700 watts/m-K
- Fully dense ceramic
- High c-direction modulus, contributing to improved section properties in composite structures
- Layered structure avoids brittle, catastrophic failure
- Easily machined, provided as plates or as final shapes
- Thickness ranges from less than 0.010" (0.25 mm) to over 0.200" (5 mm)
- Plate sizes up to 5" (125 mm) x 20" (500 mm)
- Special sizes can usually be provided upon request

Applications

The high thermal conductivity of TPG comes from a crystal structure that usually requires capturing the TPG material in some structural member. Final products typically include encapsulations such as aluminum, copper, AlSiC and carbon fiber composite to solve thermal problems in such needs as:

- Heat spreaders in packages
- Thermal cores for PWB's
- Heat spreaders for improved performance of finned sinks
- Laser diode mounts

ITRS Impact - The International Technology Roadmap for Semiconductors shows power dissipation increasing by 10 watts per year from 130 watts in 2002 at the 130 nm node to 160 watts in 2005 at the 100 nm node. TPG can enable transparent thermal solutions without the need for dramatic changes in fans or forced cooling.

Typical TPG Properties

Thermal Conductivity	1500 <20	Watts/m-K, a-b axis Watts/m-K, c axis
Density	2.26	gm/cc
Thermal Expansion Coefficient	0 to -1 25	ppm/°C, a-b axis ppm/°C, c axis
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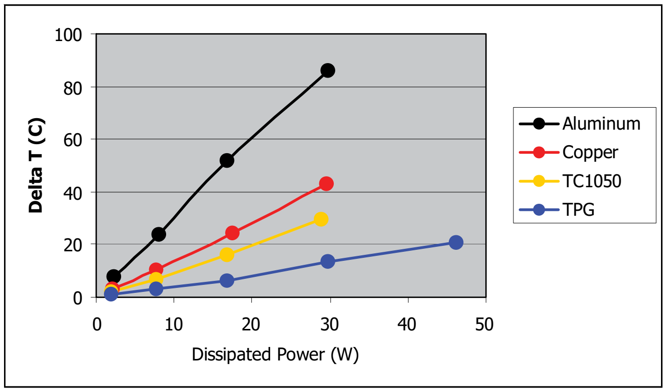
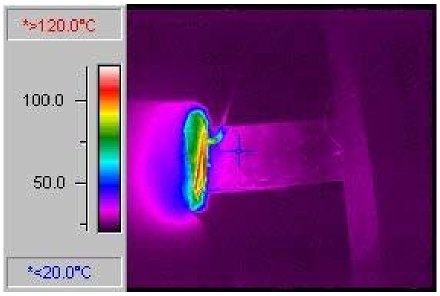


TPG shows over 5X the power dissipation capability of aluminum

Thermal Images



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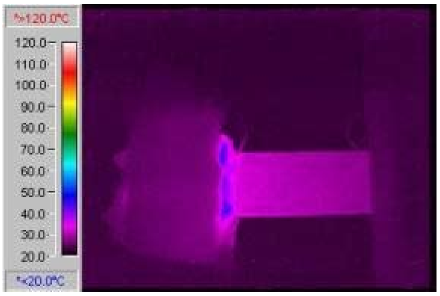
Tmax = 115°C



TPG

T_{max} = 44°C

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