S-Bond
Technologies, LLC

S-Bond® Joining
Graphite Foams

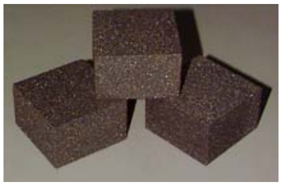
Application Bulletin

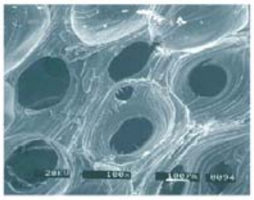
Bulletin No.
A14.2.1.12

Graphite Foams

Gr-Foams offer revolutionary advancements in thermal management. MRi has teamed with Poco Graphite to investigate their types of Gr-Foam and the suitability of SBT's S-Bond® joining as a fabrication method. PocoFoam is a lightweight, porous graphite foam with exceptionally high thermal conductivity and very efficient thermal energy transfer characteristics. PocoFoam is produced through a licensed, patented foaming process developed by Oak Ridge National Labs (Patent # US6037032, US6033506)] that creates a structure of highly graphitic aligned ligaments within the foam's cell walls. These ligaments are the key to the material's high thermal conductivity.

Thermal Conductivity	Heat Capacity
100 to 150+W/m-K 58-87 BTU·ft/ft^2·hr·°F	0.7 J/g-K 0.17 BTU/lb·°F
CTE	Density
2 to 3 µm/m°K 1.1 to 1.6 µin/in-°F	0.2-0.6 g / cc 12-37 lb / ft^3





For other properties see www.pocofoam.com

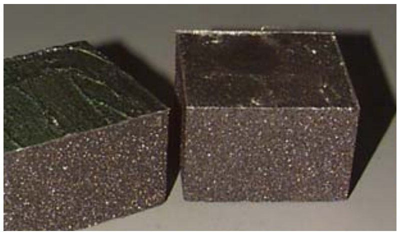
S-Bond Joining

SBT's patented S-Bond joining process has been found to have unique capability to join Gr-foams.

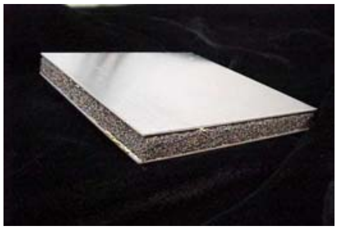
S-Bond characteristics include…

- Alloy 220 joins from 250-270°C.
- Alloy 400 joins from 410-420°C.
- Low capillarity, pre-placement required.
- No filling of pores with alloy.
- No flux required, no filling of pores.
- No pre-metallization required.
- Joins to most metals, ceramics and composites.

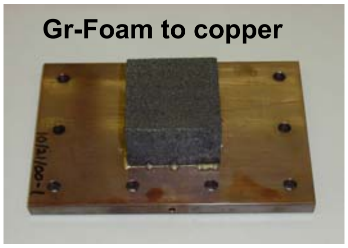
S-Bond Alloy 220 has been shown to wet and adhere to the surface of the graphite foams. After precoating with melted S-Bond alloy, the heated graphite foams can be joined to aluminum face sheets or other types of metals and composites.



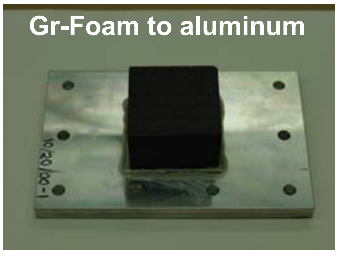
Gr-Foam wetted with S-Bond



Al-face sheets joined to Gr-Foam with S-Bond.



Gr-Foam to copper



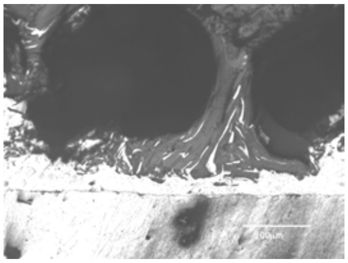
Gr-Foam to aluminum

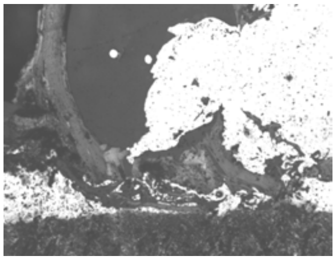
Gr-Foam to AlSiC

Versatile Fabrication Method

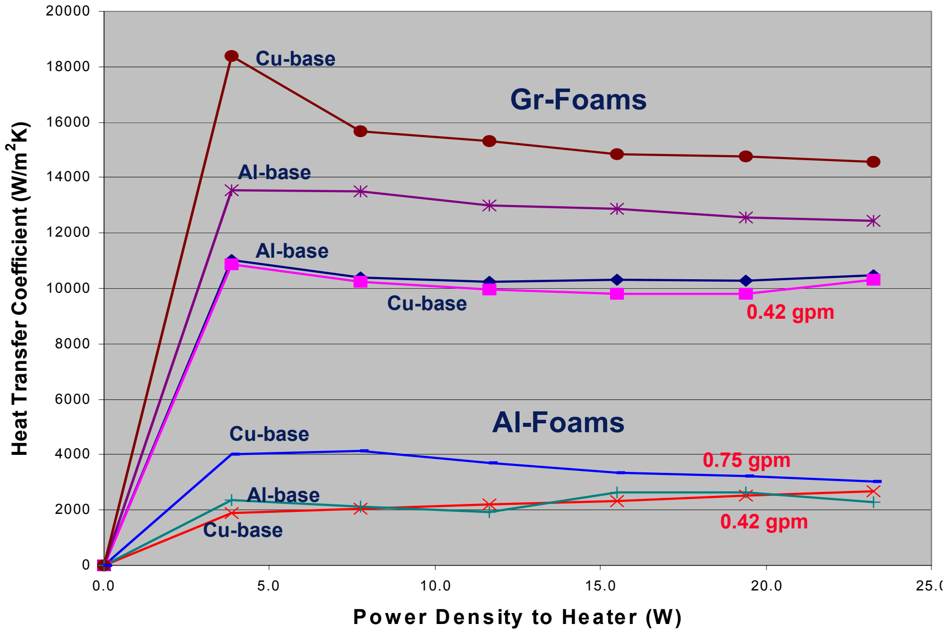
- Joins to Cu, Al and Al:SiC.
- Similar processing methods.
- Joins at low temperatures.
- No flux.
- No pre-metallization.
- No clean up required.

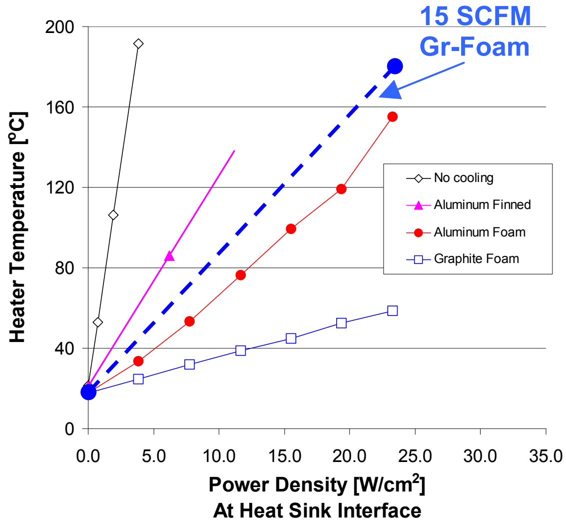
S-Bond alloys wet and encapsulate the Gr-foam webs, leading to adherence and gripping around the Gr-foam webs, thus creating strong and thermally conductive joints.





S-Bond joining has been shown to be an effective and promising method for joining highly conductive graphite foams to metallic and composite face sheets.





Joint strengths, tested in double lap shear, far exceeded the strength of the Gr-foams themselves [over 2 MPa] and after 100 thermal cycles, cycling from –50 to 150°C, the joint strengths did not decrease. Thermal properties (heat transfer coefficients in closed loop water) were measured and showed the Gr-foam samples to possess superior heat transfer coefficients compared to commercial aluminum fin-plate heat exchangers, having heat transfer coefficients between 10,000 and 20,000 W/m^2K, compared to 500 – 1200 W/m^2K for commercial aluminum fin-plate designs. Thus, demonstrating S-Bond joined Gr-foam cores to be a factor of over 15 times better. Comparative investigations on S-Bond joined Al-foam cores resulted in coefficient values of 1500 – 2000 W/m^2K. These results have clearly demonstrated that S-Bond joining, in combination with Gr-foam, has the potential to revolutionize thermal management devices, increasing their cooling power, lowering weight and decreasing their size.

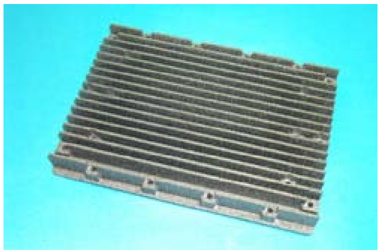
The design flexibility that S-Bond joined Gr-Foam materials allow may radically change future shapes, sizes and locations of thermal management systems.

- *Industrial heat exchangers may be reduced as much as 10 times.*
- *Re-designed heat sinks for electronics will offer reduced weight and may eliminate the need for refrigerated or forced air-cooling.*
- *Changes in the design and position of automobile radiators may lead to next generation automobile designs.*

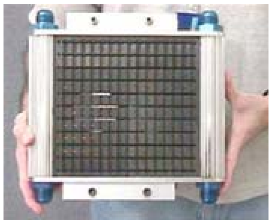
Applications include…

- Cooled electronic packages
- Power electronics cooling
- Cross flow heat exchangers
- Transpiration/evaporative cooling
- Sandwich panels as thermal doublers
- Personal cooling devices

Gr-Foam cooled Al_2O_3 Substrate

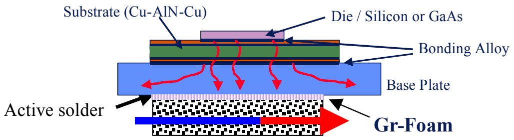


Al/Gr-Foam cold plate



Al-Tube / Gr-Foam Cross Flow Heat Exchanger

Gr-Foam Cooled Electronic Package



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