S-Bond Technologies, LLC

S-Bond® Joining Graphite and Carbon to Metals

Application Bulletin

Bulletin No.
SBT-GR-001-RevA

S-Bond® active solders enable the joining of graphite and other carbon or carbide based materials to each other and to metals. S-Bond alloys have active elements such as titanium and cerium added to Sn-Ag, Sn-In-Ag, and Sn-Bi alloys to create a solder that can be reacted directly with the carbon surfaces prior to bonding. S-Bond alloys produce reliable joints between graphite and carbon based materials with all metals including steel, stainless steels, titanium, nickel alloys, copper and aluminum alloys…

The joints produced are:

- Strong (> 5,000 psi shear)
- Ductile, based on Sn-Ag or Sn-In alloys
- Exceeds the strength of carbon and graphite
- Thermally conductive, over 50 W/(m-K)
- Electrically conductive with a metallurgical bond

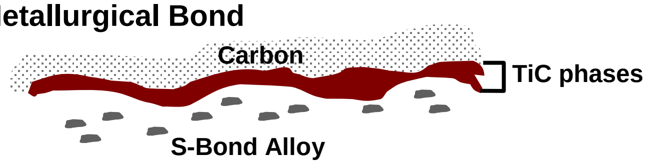
S-Bond Joining

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

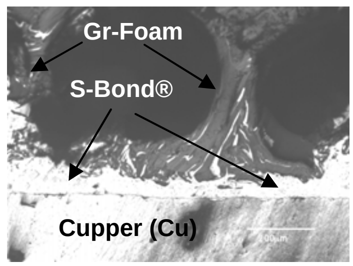
- Alloy 220 joins from 250-270°C.
- Alloy 400 joins from 410-420°C.
- Low capillarity, pre-placement required.
- No filling of pores with alloy.
- No flux.
- No plating.
- Joins carbon to most metals.

S-Bond Alloy 220 has been shown to wet and adhere to the surface of the graphite foams. S-Bond joining to carbon based materials is thermally activated using a proprietary process, which prepares the graphite-carbon surfaces and develops a chemical bond to the surface, through reactions of the active elements in S-Bond alloy. These joints start with an elevated temperature treatment in a protective atmosphere furnace with S-Bond alloy placed on the graphite-carbon surfaces to be joined. At the elevated temperatures, the active elements in S-Bond react with the ceramic to develop a chemical bond, as shown in the figure directly (top right). This chemical bond forms TiC based and the S-Bond layer in a subsequent joining step provides a much higher level of joint strength and creates high performance joints. After pretreatment with S-Bond alloy, the re-heated graphite or carbon can be joined to aluminum face sheets or other types of metals and composites.

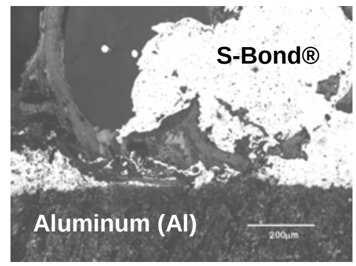
Metallurgical Bond



The figures below are micrographs of the bonded interfaces between graphite foams and graphite and illustrate the intimate contact and reactions with S-Bond and carbon based materials.



Metallurgical Bond: Gr-Foam-Cu

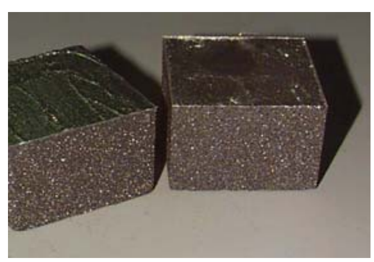


Mechanical Bond: Gr-Foam-Al

S-Bond processes have been developed that can adhere to graphite foam materials and to solid graphite. Examples of the interfaces are shown above. The metallurgical bond and the mechanical bond (encapsulation of foam) work well for Gr-Foam. For solid graphite, the metallurgical bonding process is required.

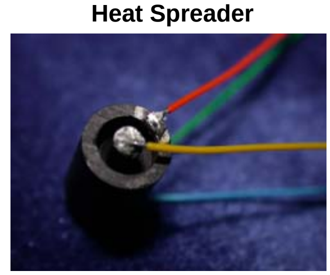
Applications

Graphite and carbon based materials are normally used in thermal management or electrical connections or sensors.


Solderable Graphite Foam


Al-Graphite Core Heat Spreader

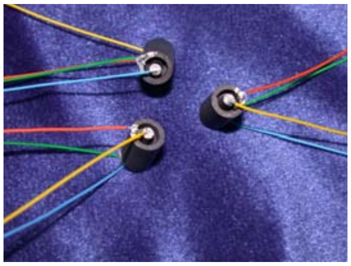

Carbon Composite-Al Battery Case


Graphite Conductivity Sensor Electrodes

811 W. Fifth Street, Unit 2
Lansdale, PA 19446
215-631-7114 FAX 215-631-7115
www.s-bond.com
Email: info@s-bond.com

S-Bond Technologies, LLC	S-Bond® Joining Graphite and Carbon to Metals	Application Bulletin Bulletin No. SBT-GR-001-RevA

Electrical Connections



Wire-lead Bonded Graphite Sensor

Graphite Electrical Brushes

Graphite and carbon components are used for their high electrical and thermal conductivity, and low friction properties. They find application in electrical sensors, power leads and feed throughs, and motor brushes. Metal conductor leads need to be attached and many times the attachment has been mechanical staking or epoxy. S-Bond joining creates a metallurgical bonded solder connection, creating much lower profile electrical connections, especially useful for small sensors and brushes.

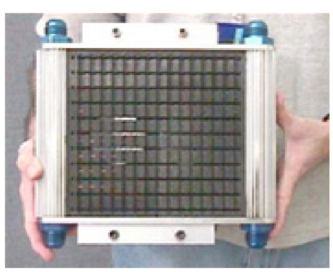
Graphite Foams

Gr-Foams offer revolutionary advancements in thermal management. Graphite foams, graphite fibers and pyrolytic graphite can all be joined using S-Bond processes. Examples of applications and components are shown below. S-Bond joints have been proven to be thermally conductive and enhance the performance of graphite based thermal management devices, especially those made from graphitic foams.

Gr-Foam to copper

Gr-Foam to alumina

Gr- Foam to Al Heat Spreader



Gr-Al Cross Flow Radiator

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 S-Bond joined Gr-foam samples had superior heat transfer coefficients compared to commercial aluminum fin-plate heat exchangers, which have 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. These results have clearly demonstrated that S-Bond joining, in combination with Gr-foam have significantly enhanced the performance of Gr-cored 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.

Graphite-Carbon Joining Application

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

Adopting S-Bond joining for carbon based materials typically results in:

- Yield Improvement
- Better Quality
- Improved Deliveries w/ Less Process Steps
- Reduced Costs
- Improved Reparability

Contact us to evaluate S-Bond joining solutions for your graphite and carbon joining applications.

811 W. Fifth Street, Unit 2
Lansdale, PA 19446
215-631-7114 FAX 215-631-7115

www.s-bond.com
Email: info@s-bond.com