S-Bond Technologies, LLC	**S-Bond® Joining Applications**	**Application Bulletin**
		Bulletin No. A14.2.1.3

Electronic Packaging

Electronic device packages that contain, support or shield electronic devices require materials that manage thermal and electrical conductivity while undergoing low thermal expansion. Normally such packaging uses metallic materials for good thermal conductivity that are then joined to electrically insulating materials. In the past, Kovar®, Invar®, beryllium and aluminum alloys were joined to alumina and or zirconia ceramics using gold metallization. Now advanced materials packaging are using AlN (aluminum nitride), Be/BeO and AlSiC composites for their superior properties, light weight and excellent stability . . . but joining these materials presents problems as fluxes, normally used to strip oxides can contaminate devices. Also, expensive and potentially damaging multi-step, high temperature brazing can lead to component damage.

MRi's S-Bond® Alloys permit the joining of dissimilar materials at low temperature, without flux and in air. These features enable economic and compatible processing for electronic packaging joining by keeping processing temperatures low. Additionally, by eliminating pre-metallizing and chemical fluxes, processing costs are reduced. S-Bond Alloy 220 is an Sn-Ag based alloy, which contains active elements including titanium and several proprietary elements to enhance the titanium activity. S-Bond Alloy 220 reacts with the tenacious surface films normally found on electronic packaging metals, ceramics and composites to create excellent bonds. The low temperature joining, 250 - 450°C, (480°F - 840°F) protects the packaged devices by lowering thermal exposure and by significantly reducing potentially damaging thermally induced stresses.

S-Bond alloys melt above many commercially available solders. Thus, it can be used as the initial bonding material in package assemblies that include multiple soldering steps as the package is built.

Results

- bond strengths of over 5,000 psi.
- active bonding creates metallurgical bonds
- highly conductive bonds / low electrical resistance.
- hermetic ceramic / metal seals without pre-metallizing
- higher soldering temperatures permit wider range of devise assembly temperatures.

Applications

- satellite electronics
- radiation shields
- computers
- low CTE substrates
- power devices
- avionics
- microwave / radar
- power interconnections

Hierarchical Soldering

There is also a need in electronic packaging for "solders" which have higher melting points. Commercial solders are limited at ~ 210°C while only alloys brazing above 800°C offer "active", fluxless joining using vacuum processing. Thus, the assembly of packages is limited by the range of soldering melting ranges and processes. S-Bond alloys can be tailored for melting ranges. For example Alloy 220 can be alloyed for solder joining from 180°C to possibly 280°C. These ranges could be developed by special request.

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Printed Circuits

The Opportunity

Environmental considerations are limiting the use of lead and cadmium containing solders that have been the "mainstay" of the printed circuit joining industry. Additionally, new solders that do not contain lead and cadmium must be "printable" and provide for fine resolutions, permitting detailed circuits to be printed.

The Solution

MRi's new S-Bond alloys DO NOT contain hazardous materials nor require hazardous / contaminating fluxes. Contamination from fluxes is especially a concern in printed circuits with pre-mounted devices and/or those with fine details and resolutions. S-Bond alloys are being developed and will be available in ultra-fine powders. Suspensions of these powder should be able to be pumped and applied through printing devices for achieving good printed solder resolutions. Another advantage is that S-Bond alloys, being an active joining alloys, have low capillarity. Therefore, S-Bond fillers remain where they are placed and, when melted, will not extensively flow to adjacent surfaces. This feature greatly reduces the need and reliance on organic "stop-off" masks.

Results

- Eliminates hazardous materials
- Reduces masking requirements
- Eliminates expensive pre-metallizing

Feedthroughs

The Opportunity

Electrical / optical connections many times must pass through metal walls into chambers or enclosures (e.g. high vacuum or chemical reactors). Ceramics are typically used to electrically and/or thermally insulate the leads. The feedthroughs must also be hermetically sealed. This requires a brazing compound, which wets and is compatible with the feedthrough materials and processing conditions. Active brazes work well, but their high brazing temperatures (> 800°C) can damage leads and cause thermal expansion mismatch cracking.

The Solution

S-Bond alloys wet most ceramics and metals and have been demonstrated to make hermetic seals without pre-metallizing the ceramic insulating materials. The low joining temperatures, 250 - 450°C (480 - 840°F) substantially reduce thermal expansion mismatches. This eliminates ceramic cracking, thus assuring hermetic seals. The ease of processing ceramic / metal joints permits a wide range of seal combinations to be made, including:

- alumina / zirconia / silicon carbide / silica
  aluminum nitride / silicon nitride
  quartz / sapphire

joined to:

- aluminum / steels / stainless steels / copper
  nickel alloys / titanium / tantalum

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Golf Clubs

The Opportunity

Titanium, beryllium, tungsten, nickel alloys, composites, advanced ceramics and even diamonds are emerging as possible materials for various golf club components. These materials, due to their unique properties such as weight, strength to weight ratios, stiffness, toughness, hardness and modulus, have the potential to increase the performance of various clubs. In particular, low club weights, localized weighting, high stiffness and high modulus are increasing the use of titanium and opening the possibility for the use of beryllium alloys. These alloys plus the need for assembly and wear resistant ball striking surfaces, make the joining of a combination of materials essential. Many times mechanical or epoxy bonding limits design flexibility, appearance and lowers reliability due to poor epoxy strengths. Thus, metallic joining alloys are needed that can wet and bond a variety of VERY difficult to join materials. Simultaneously, the joining process must be economical while producing high reliability and quality.

The Solution

MRi's S-Bond 220 Alloy is a versatile, ductile bonding alloy that can wet and bond any of the materials and/or any materials combinations, now being considered for golf clubs.

- Stainless Steel to Titanium / Beryllium
- Tungsten to Titanium
- Carbides to Steel and / or Titanium
- Diamonds . . . . and more

Its characteristics make S-Bond joining suited for economic processing since the joining can be done in air and without the use of flux. Low temperature processing reduces discoloration and distortion. This minimizes post braze working and clean up operations, which are typically time consuming manual operations. Short heating cycle times, especially using MRi's induction heating systems, make the S-Bond joining process fast. Long furnace brazing or curing times can be eliminated. Additionally, S-Bond is an environmentally friendly manufacturing method.

S-Bond is a metallic joining compound, hence, the performance of the joint is superior to epoxy and mechanical fastened joints. The ultraviolet from sun, heat damage and stresses from rough handling and cold club storage can degrade epoxies. These circumstances won't degrade S-Bond since it is a metallic alloy. Alternatively, mechanical joints can loosen and fracture with use. The metallic S-Bond joint assures the toughness needed to withstand the high striking forces imposed on clubs.

Results

- Many difficult combinations of materials joined.
- Reliable, durable ,metallic joints.
- Economic and flexible joining process.
- Environmentally friendly processing.
- Reduces post-joining operations.

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Ceramic/Carbide Wear Surfaces

The Opportunity

Many times moving components in abrasive or erosive environments need to be protected. Examples include slideways, mixers, dies, mandrels, molds, knife blades, conveyor components, etc. The materials that are known to protect these metal components are either carbides (e.g cemented tungsten carbides) or ceramics (e.g. alumina, silicon nitride, even diamond). These materials are typically molded then brazed to the metal surfaces. The current metal / ceramic joining techniques are multi-step, expose the base component to high temperature and require vacuum. Thus, the processes to apply such wear surfaces can be too expensive and/or cannot be easily used in the field.

Tools / Carbides

Similar to the problem stated above, the abrasive cutting action seen by many cutting tools against wood, cloth, plastic and metals require very hard cemented carbides and/or engineered ceramics to be on the leading, cutting edge of steel tools. Brazing inserts into blade edges normally exposes the rest of the cutting tools and blades to high temperatures. This can distort the tool and thus create considerable rework or, in the worst case, render the tool unusable. Additionally, the current vacuum braze processes are expensive and not easy to do in house.

Solution

S-Bond alloys are low temperature brazing materials, which can be heated in air and by their design are active and thus readily bond ceramics to metals. These characteristics greatly simplify the joining process for metals to ceramics, enabling any tool or machine shop to join carbides to metals in the shop or in the field. Components can be heated by flame, air furnaces and/or induction heating. This flexibility lowers the processing costs and enables most shops to join previously difficult to join materials. The lower processing temperatures reduce tool discoloration and distortion, thus reducing post-joining operations. Provided the cutting interfaces will not exceed 400°C (750°F), S-Bond can be a solution for many cutting tool and wear surface applications

Results

- Low temperature, low distortion processing
- Bonds ceramics and carbides to steel
- Simple heating and processing steps
- Lowers post joining rework
- Low cost processing

Applications

- rock drilling
- chipper blades
- shears
- mixers blades
- pump parts
- wood saws
- slideways
- dies / mandrels
- knives
- conveyors
- shaft seals

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C:C to Metals

Refractory Composite Joining

The Opportunity

NASA was looking to take advantage carbon fiber / carbon (C:C) matrix materials for electronic and heat transfer components in avionics, space station, and satellite components. However, the joining of materials has presented a major challenge. Wetting the carbon with active brazes while not melting the base metals, typically aluminum, has prevented components from being fabricated. Additionally, C:C materials with high inherent porosity has easily wicked (pulled) any conventional braze materials with high capillarity away from the joint.

The Solution

S-Bond alloys have been found to be VERY effective in joining C:C to aluminum and a variety of other metals and ceramics. First, S-Bond alloys easily wet and bond carbon, metals and ceramics. Second, the alloy, being active requires no flux which could infiltrate the porous C:C structures. Third, the low joining temperatures 250-450°C (480 - 840°F) limits thermal expansion mismatch that occurs between the low expansion C:C and the much higher expansion metals. Fourth, S-Bond has low capillarity which keeps this filler alloy at the joint and reduces "wicking" into the porous C:C materials. Finally, S-Bond joining is conducted in air, eliminating vacuum processing which imposes costs and problems due to air entrapment in the C:C pores. These same attributes make S-Bond a good candidate for bonding other porous metals or ceramics

Housewares

The Opportunity

Aluminum, stainless steel and copper are used in the fabrication of pots and pans due to their thermal conductivity and /or their corrosion-stain resistance. However, aluminum and stainless steel are VERY difficult to braze due to their tenacious oxide films that protect the alloys. During brazing corrosive chemical fluxes must be used and generally high temperature and/or protective atmospheres may be required which increase processing costs and processing times. Additionally, composite / dissimilar material joints impose more difficult, tighter braze joining process windows.

The Solution

S-Bond 400 alloys are available as foils and wire and can be economically applied to bond these metals and their combinations. Air joining without flux and at lower temperature greatly reduces the demands of the joining process and opens up process tolerances, a large advantage for large volume, high rate production processes. The lower brazing temperatures also reduce distortion and discoloration, thus reducing post braze rework. S-Bond Alloy 400 is thus a significant cost reduction over current commercial practice for both stainless steel and aluminum brazing as it eliminate the need for corrosive fluxes, controlled braze atmospheres and higher braze temperatures.