Mechanical Activation of Active Solders

Solder bonding has long been used for the joining of metal components and is a requirement in manufacturing processes across many industries. Today solder filler metals are available in a variety of forms and compositions to facilitate the production of a wide range of assembled components. From electronics packages to solar panels to radiation sensors, solder bonding makes possible the devices that keep our public and private worlds running.

Inherent in the soldering process is the need for clean joining surfaces. Whether joining components of the same metal or of dissimilar materials, naturally occurring oxides and surface impurities can contaminate solder joints and prevent viable bonds from forming. Additionally, solder filler metals and processes must be compatible with the base materials being joined, able to wet and adhere to components via processing methods that preserve the integrity of the components themselves as well as the completed assemblies. Surface cleanliness requirements can make it difficult to achieve the robust thermal and electrical connections necessary for today's high performance devices.

Chemical Fluxing

The most commonly employed method for preparing joining surfaces is chemical fluxing. Flux is derived from the Latin word *fluxus* meaning "flow." In conventional soldering, the fluxes used are chemical-based cleaning agents that remove oxidation layers from the metals that are being joined. If not removed, these oxides would interrupt the reaction between the molten solder metal and the underlying metal joining surfaces, and thereby impede bonding. Tin-lead solder, for example, attaches very well to copper, but poorly to the various oxides of copper, which form quickly at soldering temperatures. Additionally, flux allows solder to flow smoothly and easily on the working piece rather than forming beads as it would otherwise.

Chemical fluxing agents are nearly inert at room temperature, but become strongly reducing at the elevated temperatures at which they are used. Common fluxes for soldering tin are ammonium chloride or rosin. Hydrochloric acid and zinc chloride are used for soldering galvanized iron and other zinc surfaces, and borax is used for brazing or braze-welding ferrous metals. For aluminum bonding, ammonium fluoborate, aminoethylethanolamine (AEEA) and zinc oxide are common flux constituents. These chemicals are quite corrosive and must be removed or neutralized before a soldered assembly is put in service. Residual or trapped flux may contaminate solder joints, causing voids and gaps and impacting final joint properties. Additionally, the post-bonding flux clean-up operation can result in increased joint stresses. Added cost and processing time are also considerations in a chemical flux clean-up process. Until recently, viable alternatives to chemical fluxing have not been available.

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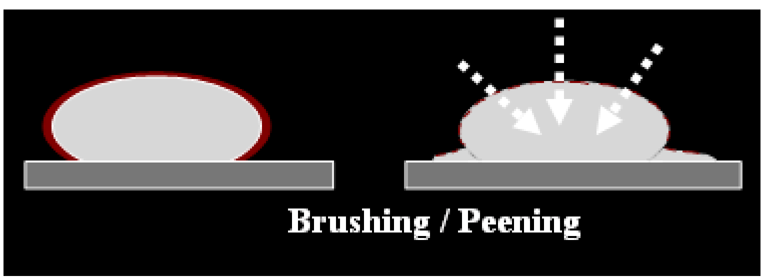
Mechanical Fluxing

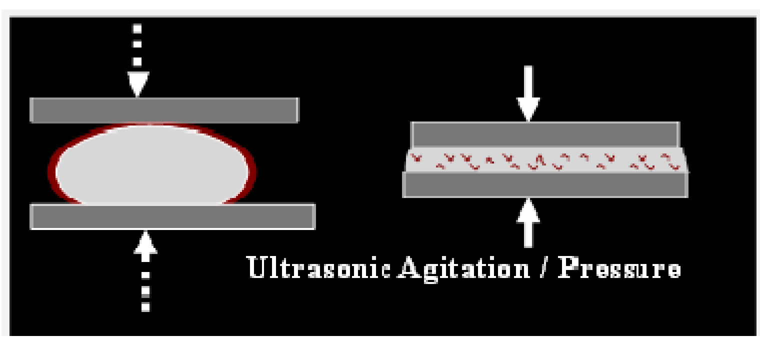
Today, solder filler metals developed by engineers at S-Bond Technologies provide a different solution. S-Bond solders bond without chemical fluxing in the bonding process. These solder alloys contain additions of reactive elements such as Titanium and rare earths, and are termed *active solders*. Reactions between the active solder and base materials eliminate the need for a chemical fluxing agent to remove oxides from metals.

As the S-Bond active solder melts, oxides naturally form on the molten surface. To enable the active elements in the S-Bond solder to come in contact with the underlying base materials, these oxides need to be disrupted. Applied mechanical agitation is all that is necessary to achieve this disruption and activate the solder bonding. A variety of methods can be used to introduce mechanical activation into the bonding process, including mechanical rubbing, brushing and the use of ultrasonic tools. Once mechanically activated "fluxing" is employed, S-Bond active solders will wet and flow over metal, ceramic and carbide materials, setting up the first physical step of solder joining — wetting.

The figures below demonstrate the disruption of the rare earth oxide films that form on melting S-Bond.



These stable oxide films are transparent and incredibly thin, measuring only 20-30 angstroms in thickness.



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S-Bond active solders can be made to wet and spread on most metals, glasses and ceramic materials via mechanically activated processes like those seen in the images below. Once the S-Bond solder is heated to its molten temperature, these methods of agitation will initiate the disruption of the thin oxide surface films and activate the solder for wetting and bonding without the use of a chemical fluxing agent. The images below show mechanical rubbing using a spatula, brushing with heated metal bristles, and ultrasonically activated tools which disrupt oxides through cavitation.

Mechanical Rubbing

Mechanical Brushing

Ultrasonic Soldering Iron

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Ultrasonic Pressing

The mechanical activation process requires a pre-placement of S-Bond solder on the heated base material faying surfaces prior to assembly. This is applied via mechanical or ultrasonic spreading. Joining of these S-Bond pre-tinned surfaces is then accomplished by sliding or rotating the two faying surfaces against one another, or by firing focused ultrasonic energy through the molten solder interface in order to disrupt the thin oxide layer on the free S-Bond surfaces.

The S-Bond active solder bonding process provides an alternative to conventional soldering methods that use chemical fluxing for activation. In fact S-Bond materials and processes are 'fluxless' and should not be used in combination with chemical fluxing agents.

Ultrasonic Solder Spreading

Consequently, the S-Bond mechanically-activated process differs from a conventional solder reflow process. The mechanical activation requirement precludes it as a replacement for commercial "reflow" processes that used preplaced solder paste or preforms with integrated chemical fluxes. For high volume production, process changes are required in order to integrate active soldering into the production plan. In many cases, the implementation of active, fluxless S-Bond joining offers superior process advantages, such as:

- Elimination of post-solder cleaning. In blind enclosures, this is a major benefit since trapped flux can contaminate optics and electronics.

- Containment of solder filler metal. S-Bond solders do not flow until activated, so solders stay where they are placed and will not flow extensively to adjacent areas.

- Ease of correction. S-Bond solders only adhere to surfaces when mechanically activated. Any inadvertent flow and contact of excess S-Bond solder can easily be removed after bonding is completed.

To Learn More

S-Bond Technologies has been developing breakthrough materials and joining solutions for more than two decades. To learn more about S-Bond fluxless bonding solutions, go to www.S-Bond.com and explore our comprehensive knowledge base of application notes, white papers and videos prepared by

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