MATERION

TECH BRIEFS

Soldering Copper Alloy Strip

As with most copper alloys, copper beryllium can be easily soldered using readily available materials. Soldering provides a reliable, electrically conductive bond when high strength is not essential and when high process temperatures may damage components. Soldering is the most common joining technique for copper beryllium in electronic applications and is usually limited to components less than 0.012 inch (0.3 mm) thick. Proper techniques in surface preparation, materials selection, the soldering process, and post solder cleaning are required to insure a sound, reliable solder joint. Soldering will normally not affect copper beryllium's properties.

SURFACE PREPARATION

Surface impurities such as oil, grease, dust, stain inhibitors, tarnish, and oxide account for the major share of soldering problems. Flux is not a substitute for adequate surface preparation and will not reliably remove all surface contamination. Conventional cleaning methods, such as organic solvents, vapor decreasing, and alkaline cleaners are usually adequate for removing dirt, oil, and grease. Ultrasonic agitation enhances these cleaning agents. Cleaning solutions must be thoroughly rinsed from all surfaces after use.

Surface oxides are formed during the heat treatment of copper beryllium or copper nickel tin. The composition, thickness, and appearance of the oxide is influenced by heat treating conditions such as temperature and furnace atmosphere. Inert and reducing atmospheres (dew point less than -40°F or -40°C) as well as a hard vacuum inhibit copper oxidation, but are not sufficiently oxygen free to prevent beryllium oxide formation on copper beryllium.

When present, the black or reddish oxides of copper are easily removed using conventional techniques. Transparent, tenacious, and refractory, beryllium oxide, as thin as 500 angstroms, can lead to soldering difficulty. Oxides formed during heat treating copper beryllium can be removed by acid pickling. Information on pickling procedures for copper beryllium is discussed in Materion Brush Performance Alloys TechBrief, "Cleaning Copper Beryllium".

The copper nickel tin alloys do not form beryllium oxide, but the copper, nickel, and tin oxides can be removed by the same cleaning methods used for the copper beryllium.

Any heating during part stamping and fabrication should be considered as a potential source of oxide contamination. Mill hardened copper beryllium or copper nickel tin products, which are heat treated by the material supplier, are cleaned after heat treating and are free of detrimental oxide contamination. Copper alloys stored for extended periods or under unprotected conditions may discolor or tarnish. Light pickling will remove the tarnish.

Copper alloy parts should be soldered as soon as possible after cleaning. If delays are unavoidable, the parts should be stored in a clean, dry, protected area away from shop dust, acid, and sulfurous or ammonia fumes

TIN-LEAD (SnPb) SOLDERS

Copper beryllium and copper nickel tin alloys are solderable with all common solder compositions, but historically tin/lead solders have been most frequently used. (Although Sn-Pb solders are no longer used as widely as they once were, they are well-understood and have a simple binary phase diagram that is useful for illustration.) Their melting temperatures vary from 361°F (183°C) at the eutectic composition of 63% Sn 37% Pb (63/37) to 621°F (327°C) for pure lead and 450°F (232°C) for pure tin, as shown in Figure 1.

Solders with lower tin (5/95 and 10/90) are less expensive, but since only tin provides wetting action on copper, low tin solders will require longer contact times and higher temperatures. Because of their high tin content, low melting temperatures and low solidification ranges, 60/40 or 63/37 solders are usually used in high volume electronic work. The 63/37 composition offers higher shear and impact strengths, better electrical and thermal conductivity's, and a lower thermal expansion coefficient. The relatively high tin content of 63/37 solder means that heating times and temperatures must be controlled to avoid excessive intermetallic compound formation in the solder joint.

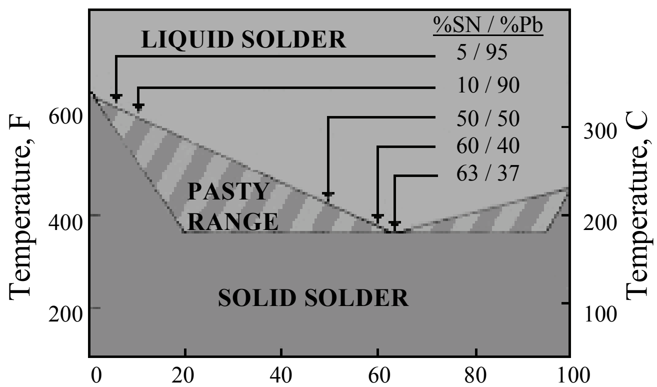

Figure 1. Melting Ranges of Tin/Lead Solders

Greater latitude in solder selection is permissible for hand soldering since this technique is less demanding. An all purpose 50/50 solder or special alloys may be used. These include silver or indium containing compositions for higher strength and ductility. Tin/lead solders rapidly dissolve silver coatings used on many electronic components, but silver solders (e.g. 62% Sn 36% Pb-2% Ag) reduce this tendency.

The solderability of bare copper beryllium is adequate for manual or moderate speed automated operation. However, the wetting speed requirements of high volume soldering may require a precoating process. This is particularly true when a long time elapses between cleaning and soldering processes. Common precoat compositions include 60/40 solder and pure tin, applied to copper beryllium at least 0.0003 inch (0.007 mm) thick. The precoat can be applied by hot dipping or electroplating. Thin electroplated coatings are often porous and require a subsequent reflow heating operation to seal porosity. The reflow also provides the same sound metallurgical bond between the precoat and base metal, as is produced in hot dip precoating. A slightly tarnished precoat will present no problems in subsequent soldering.

Solder preforms, pastes, and pellets are often used with copper beryllium to reduce assembly time, eliminate waste, and improve product quality.

Pb-FREE SOLDERS

The RoHS (Restriction of Hazardous Substances) regulations in Europe have mandated the use of Pb-free solders in most electronic applications. Most of these solders are alloys with various combinations of tin (Sn), copper (Cu), silver (Ag), indium (IN), bismuth (Bi) or antimony (Sb). The tin silver copper (SAC) alloys are widely used as alternatives to SnPb solders. These alloys melt around 217-128°C (422-424°F).

CHALLENGES WITH Pb-FREE SOLDERS

Eutectic and near-eutectic SnPb solders have very low melting points (183-188°C / 361-370°F) and most automated soldering processes were designed around those temperatures. The higher melting temperatures associated with Pb-free solders can lead to manufacturing difficulties. Unless accounted for in processing, the additional thermal stresses of the higher temperatures can lead to warpage or cracking of components on circuit boards. Depending on the duration of the reflow process, stress relaxation of components may occur, resulting in decreased performance.

Higher temperatures also lead to the increased formation of the Cu_6Sn_5 intermetallic compound at the intersection of the copper base metal and the solder coat. This compound is very brittle and can lead to cracking problems during service. A nickel underplate below the solder coat can prevent this phase from forming. It should be noted that the copper nickel tin alloys do not tend to form this intermetallic compound.

FLUXES

Soldering of copper beryllium or copper nickel tin presents no special flux selection problems. Fluxes are classified as corrosive, intermediate, or non corrosive. Generally, use the mildest flux that will work.

Corrosive (inorganic acid) fluxes, containing zinc chloride, are generally considered too aggressive for electronic applications. They should not be used for closed assemblies such as bellows, tubes, or capsules. Acid fluxes should only be used where rapid, highly activated fluxing is required and a thorough, hot water cleaning can be done after soldering.

Intermediate (organic) fluxes contain organic compounds that decompose and evaporate at soldering temperatures. The active period of intermediate fluxes is limited, and they leave an inert residue which should be removed with hot water.

Non corrosive (rosin) fluxes are classified as nonactivated (R), mildly activated (RMA), and fully activated (RA). The main advantage of rosin based fluxes is that they become active only with heating. RMA and RA fluxes are most frequently used in soldering copper beryllium alloys. Hot or warm water rinsing will remove any flux residue.

Gas fluxes, containing hydrazine in argon or nitrogen, can also be used when soldering copper beryllium. Since all reaction products are gaseous, corrosive, or electrically conducting, residues are not a problem.

SOLDERING PROCESSES

Selection of the best soldering process depends on the number, type, and complexity of the joints. In all cases, rapid heating and cooling are recommended because:

•High temperatures can cause oxidation of the copper beryllium substrate.

•Fluxes degrade during prolonged heating. Over-heating may cause metallurgical changes in copper beryllium.

•Excessive heating causes intermetallic compound formation at the solder/substrate interface, leading to a loss in bond strength.

Hand soldering is used in low volume operations where rapid heating rates are critical. Dip soldering of prefluxed assemblies requires immersion in a solder pot from a few seconds to several minutes.

Large volume soldering of electronic components to circuit boards is done by wave soldering, where elevated temperature exposure times are limited to a few seconds.

Vapor phase soldering offers advantages for selective or inaccessible joining operations, since it provides precise temperature control in a contamination free environment. Solder is applied as a paste or preform, and the elevated temperature exposure time varies from 10 to 180 seconds.

Other commonly used heat sources, such as induction coils, infrared, and resistance heating can be used when soldering copper beryllium. When soldering copper beryllium to other metals, it is often the other metal that establishes the soldering parameters. The high thermal conductivity of copper beryllium must be considered when soldering to lower conductivity metals. Heat sinks may be required to concentrate heat at the joint. Soldering copper beryllium to itself presents no unusual problems.

SILVER SOLDERING

Refer to Materion Brush Performance Alloys' TechBrief, "Brazing Copper Beryllium". .

EFFECT OF SOLDERING ON THE PROPERTIES OF COPPER BERYLLIUM OR COPPER NICKEL TIN

The strength of copper beryllium and copper nickel tin alloys comes from thermal treatments performed before the soldering operations. Since the age hardening (heat treating) temperature for copper beryllium alloys is above typical soldering temperatures, no appreciable change in properties will occur. This is true even at the higher temperatures associated with Pb-free solders. Normal soldering operations will not affect the physical properties of copper beryllium, such as thermal conductivity, thermal expansion coefficient, grain size, density, etc.

SAFE HANDLING OF COPPER BERYLLIUM

Please refer to the Materion Corporation publication "Safety Facts 105 - Processing Copper Beryllium Alloys."

Handling copper beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on copper beryllium, contact Materion Brush Performance Alloys, Technical Service Department at 1-800-375-4205.

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