HEWLETT hp PACKARD

COMPONENTS

APPLICATION BULLETIN 3

Soldering Hewlett-Packard Silver Plated Lead Frame LED Devices

INTRODUCTION

Since the price of gold has increased several times over past years, the cost of a gold plated lead frame has increased substantially above the cost of a silver plated lead frame. The impact of this increase in cost has been industry wide.

By using silver plating, no additional manufacturing process steps are required. Silver has excellent electrical conductivity. LED die attach and wire bonding to a silver lead frame is accomplished with the same reliability as with a gold lead frame. Also, soldering to a silver lead frame provides a reliable electrical and mechanical solder joint. Soldering silver plated lead frame LED devices into a printed circuit board is not more complicated than soldering LED devices with gold plated lead frames. This application bulletin offers some suggestions on how to solder HP silver plated lead frame LED devices.

THE SILVER PLATING

The silver plating process is performed as follows: The lead frame base metal is activated (cleaned) and then plated with a copper strike, nominally 50 microinches (0.00127mm) thick. Then a minimum 150 microinch (0.00381mm) thick plating of silver is added. A "brightener" is usually added to the silver plating bath to insure an optimum surface texture to the silver plating. The term "brightener" comes from the medium bright surface reflectance of the silver plate.

Since silver is porous with respect to oxygen, the copper strike acts as an oxygen barrier for the lead frame base metal. Thus, oxide compounds of the base metal are prevented from forming underneath the silver plating. Copper readily diffuses into silver forming a solution that has a low temperature eutectic point. The interdiffusion between the copper strike and the silver overplate improves the solderability of the overall plating system. If basic soldering time and temperature limits are not exceeded, a lead frame base metal-copper-silver-solder metallurgical bonding system will be obtained.

THE EFFECT OF TARNISH

Silver reacts chemically with sulfur to form the tarnish, silver sulfide (Ag_2S). The build-up of tarnish is the primary reason for poor solderability. However, the density of the tarnish and the kind of solder flux used actually determine the solderability. As the density of the tarnish increases, the more active the flux must be to penetrate and remove the tarnish layer. Some recommended fluxes and cleaner/surface conditions are discussed in the "Solder, Flux and Cleaners" section.

STORAGE AND HANDLING

The best technique for insuring good solderability of a silver plated lead frame device is to prevent the formation of tarnish. This is easily accomplished by preventing the leads from being exposed to sulfur and sulfur compounds. The two primary sources of sulfur are free air and most paper products such as paper sacks and cardboard containers. The best defense against the formation of tarnish is to keep silver lead frame devices in protective packaging until just prior to the soldering operation. One way to accomplish this is to store the LED devices unwrapped in their original packaging as received from HP. For example, Hewlett-Packard ships its seven segment display products in plastic tubes which are sealed air tight in polyethylene. It is best to leave the polyethylene intact during storage and open just prior to soldering.

Listed below are a few suggestions for storing silver lead frame devices.

1. Store the devices in the original wrapping unopened until just prior to soldering.
2. If only a portion of the devices from a single tube are to be used, tightly re-wrap the plastic tube containing the unused devices in the original or a new polyethylene sheet to keep out free air.
3. Loose devices may be stored in zip-lock or tightly sealed polyethylene bags.
4. For long term storage of parts, place one or two petroleum napthalene mothballs inside the plastic package containing the devices. The evaporating napthalene creates a vapor pressure inside the plastic package which keeps out free air.
5. Any silver lead frame device may be wrapped in "Silver Saver" paper for positive protection against the formation of tarnish. "Silver Saver" is manufactured by:

   The Orchard Corporation
   1154 Reco Avenue
   St. Louis, Missouri 63126 (312) 822-3888

APPLICATION NOTES

6. To reduce shelf storage time, it will be worthwhile to use inventory control to insure that the devices first received will be the first devices to be used.

   One caution: The adhesives used on pressure sensitive tapes such as cellophane, electrical and masking tape can soak through silver protecting papers and may leave an adhesive film on the leads. This film reduces solderability and should be removed with freon T-P35, freon T-E35 or equivalent prior to soldering.

SOLDER, FLUX AND CLEANERS

The solder most widely used for soldering electronic components into printed circuit boards is Sn60 (60% tin and 40% lead) per federal standard QQ-S-571. Two alternates are the eutectic composition Sn63 and the 2% silver solder Sn62.

As the device leads pass through the solder wave of a flow solder process, the tin in the solder scavenges silver from the silver plating and forms one of two silver-tin intermetallics (Ag_6Sn or Ag_3Sn). This silver in the molten solder should not be considered a contaminant. As the silver content increases, the rate of scavenging decreases and the probability of obtaining the desired base metal-copper-silver-solder metallurgical system is improved. The result is that the silver content in solder, which reaches a maximum of 2-1/2% in Sn60 at 230°C, aids in producing reliable solder joints on silver plated lead frames.

Solder flux classifications per federal standard QQ-S-571, listed in order of increasing strength, are as follows:

Type R: Non-Activated Rosin Flux
Type RMA: Mildly Activated Rosin Flux
Type RA: Activated Rosin Flux
Type AC: Organic Acid Flux, Water Soluble

Suggested applications of these flux types with respect to various tarnish levels are as follows:

Silver plated lead frames that are clean, contaminant and tarnish free may be soldered using a Type R flux such as Alpha 100.

Minor Tarnish

Since some minor tarnish or other contaminant may be present on the leads, a type RMA flux such as Alpha 611 or 611 Foam, Kester 197 or equivalent is recommended. Minor tarnish may be identified by reduced reflectance of the ordinarily medium bright surface of the silver plating. Type RMA fluxes which meet MIL-F-14256 are used in the construction of telephone communication, military and aero space equipment.

Mild Tarnish

For a mild tarnish, a type RA flux such as Alpha 711-35, Alpha 809 foam, Kester 1544, Kester 1585 or equivalent should be used. A mild tarnish may be identified by a light yellow tint to the surface of the silver plating.

Moderate Tarnish

A type AC water soluable flux such as Alpha 830, Alpha 842, Kester 1429 or 1429 foam, Lonco 3355 or equivalent will give acceptable results on surface conditions up to a moderate tarnish. A moderate tarnish may be identified by a light yellow-tan color on the surface of the silver plating.

If a more severe tarnish is present, such as a heavy tarnish identified by a dark tan to black color, a cleaner/surface conditioner must be used. Some possible cleaner/surface conditioners are Alpha 140, Alpha 174, Kester 5560, and Lonco TL-1. The immersion time for each cleaner/surface conditioner will be just a few seconds and each is used at room temperature. For example, Alpha 140 will remove severe tarnish almost upon contact; therefore, the immersion time need not exceed 2 seconds. These cleaner/surface conditioners are acidic formulations. Therefore, thoroughly wash all devices which have been cleaned with a cleaner/surface conditioner in cold water. A hot water wash will cause undue etching of the surface of the silver plating. A post rinse in deionized water is advisable.

CAUTION: These cleaner/surface conditioners may etch exposed glass and may have a detrimental effect upon the glass filled encapsulating epoxies used in optoelectronic devices. Complete immersion of an optoelectronic device into a surface conditioner solution is NOT recommended. For best results, immerse only the tarnished leads and do not expose the encapsulating epoxy to the solutions.

The cleaning of printed circuit boards after soldering is important to remove ionic contaminants and increase circuit reliability. When a Type RMA or Type RA flux is used, vapor clean with an azeotrope of fluorocarbon F113 and approximately 15% alcohol by weight. Some equivalent products are Allied Chemical Genesolve DI-15/DE-15, Blaco-Tron DE-15/DI-15 and Arklone K. A Type RMA or Type RA flux is a mixture of basic Type R rosin flux and an organic acid. The fluorocarbon F113 removes the residual rosin and the alcohol removes the residual active ions. Room temperature cleaning may be accomplished by using Freon T-E35, T-P35 or equivalent. When a Type AC flux is used, wash thoroughly with water. Specific cleaning processes are suggested in the soldering process section.

SOLDERING PROCESS

Before the actual soldaring begins, the printed circuit boards and components to be soldered should be free of dirt, oil, grease, finger prints and other contaminants. Fluorinated cleaners such as Freon T-P35 may be used to preclean both the printed circuit boards and LED devices. Operators may wear cotton gloves to prevent finger prints when loading components into the printed circuit boards.

If the silver lead frames have acquired an unacceptable layer of tarnish, remove this tarnish layer with a cleaner/surface conditioner just prior to soldering. Since a cleaner/surface conditioner does slightly etch the surface of the silver plating, the silver leads are now more susceptible to tarnish formation. Therefore, use a cleaner/surface conditioner only on those silver lead frame devices which will be soldered within a four hour time period. The effect of various tarnish levels on the choice of flux is discussed in the previous section.

Many of Hewlett-Packard's LED Lamps and Display products have a soldering specification of 230°C (446°F) for a maximum time period of 5 seconds. Therefore, in a flow solder operation adjust the solder temperature and belt speed to conform to this specification, or as is specified on the device data sheet. The flow solder operation may now proceed in a normal fashion. For best results, any one single lead should be immersed in molten solder for as short a time period as possible. At a solder temperature of 230°C (446°F), Sn60 solder will dissolve silver at the rate of 60 microinches per second. Therefore, with an initial silver plating thickness of 150 microinches, an immersion time of 2 seconds will provide the desired lead base metal-copper-silver-solder metallurgical system. At a solder temperature of 260°C (500°F), Sn60 solder will dissolve silver at the rate of 80 microinches per second. These dissolving rates decrease as the silver content increases in the molten solder bath.

Post cleaning of soldered assemblies when a type RMA or Type RA flux has been used may be accomplished via a vapor cleaning process in a degreasing tank, using an azeotrope of fluorocarbon F113 and alcohol as the cleaning agent. A recommended method is a 15 second suspension in vapors, a 15 to 30 second spray wash in liquid cleaner, and finally a one minute suspension in the vapors. When a water soluable Type AC flux such as Alpha 830 or Kester 1429/1429F is used, the following post cleaning process is suggested: thoroughly wash with water, neutralize using Alpha 2441 or Kester 5760 or Kester 5761 foaming, then thoroughly wash with water and air dry.

CAUTION: The use of tatrachloro-di-fluoroethane (F112), acetone, trichloroethylene, MEK, carbon tetrachloride and similar solvents as cleaning agents is NOT recommended, as these cleaners will attack or dissolve the epoxies used in optoelectronic devices.

A WORD ABOUT PRINTED CIRCUIT BOARDS

Printed circuit boards, either single sided, double sided or multilayer, may be manufactured with plated through holes with a metal trace pad surrounding the hole on both sides of the printed circuit board. The plated through hole is desirable to provide a sufficient surface for the solder to wet, and thereby be pulled up by capillary attraction along the lead through the hole to the top of the printed circuit board. This provides the best possible solder connection between the printed circuit board and the leads of the LED device.

SOLDERED LEADS

Figure 1 illustrates an ideally soldered lead. The amount of solder which has flowed to the top of the printed circuit board is not critical. A sound electrical and machanical joint is formed.

Figure 2 illustrates a soldered lead which is undesirable.

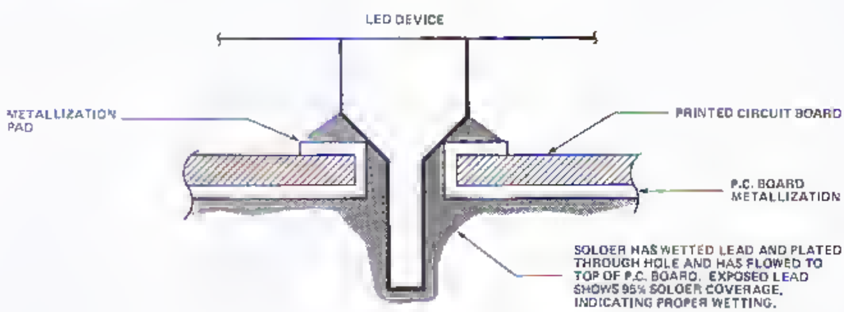

Figure 1. Ideally Soldered Lead

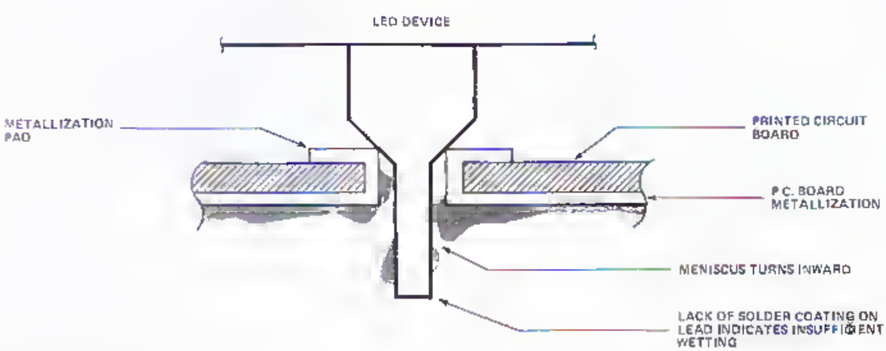

Figure 2. Undesirable Soldered Lead

APPLICATION NOTES

LIST OF MANUFACTURERS

Alpha Metals, Inc.
56 G Water Street
Jersey City, New Jersey 07304
(302) 434-6778

London Chemical Co. (Lonco®)
240 G Foster
Bensenville, Illinois 60106
(312) 287-9477

E.I. DuPonte De Nemours & Co.
Freon Products Division
Wilminton, Delaware 19898
(302) 774-8341

Frank Curren Co. (Petroleum Napthalene Mothballs)
8101 South Lemont Road
Downers Grove, Illinois 60515
(312) 969-2200

Kester Solder Co.
4201 G Wrightwood Avenue
Chicago, Illinois 60639
(312) 235-1600

Allied Chemical Corporation
Specialty Chemicals Division
P.O. Box 1087R
Morristown, New Jersey 07960
(201) 455-5083

Baron-Blakeslee (Bleco-Tron)®
1620 S. Laramie Avenue
Chicago, Illinois 60650
(312) 656-7300

Imperial Chemical Industries, Ltd. (Arklone)®
Imperial Chemical House, Millbank
London SW1P3JF, England

REFERENCES

Manko, Howard H. *Solders and Soldering*. New York: McGraw-Hill, 1964.

Coombs, Clyde F. *Printed Circuits Handbook. New York: McGraw-Hill, 1964.*

Flaskerud, Paul and Rick Mann, "Silver Plated Lead Frames for Large Molded Packages," IEEE Catalog No. 74CH0839-1PHY (1974), pp. 211-222.