Recommended Attachment Techniques for ATC Multilayer Chip Capacitors

Bulletin No. 201

THE ENGINEERS' CHOICE™

AMERICAN TECHNICAL CERAMICS

COMPONENT AND CUSTOM INTEGRATED PACKAGING SOLUTIONS
FOR RF, MICROWAVE AND TELECOMMUNICATIONS

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1.0: SCOPE. This document describes the attachment techniques recommended by ATC for ceramic chip capacitors. The document is non-exhaustive and customers with specific attachment requirements or attachment scenarios that are not covered by this document are directed to ATC for consultation.

2.0: HANDLING. Handling of both the capacitor and substrate should be minimized. Assembly operators should wear gloves or finger cots. Whenever precise orientation of the capacitor is required prior to heating, it is recommended that plastic tweezers be employed.

3.0: AUTOMATED CHIP PLACEMENT. The industry has adopted two distinct approaches to automated chip placement and the use of pick and place equipment. The most common technique, Non-contact Alignment, is accomplished through the use of a vision assist to allow for correction of placement angles after pickup.

The second type is Mechanical Pickup and Centering. In this method, the user is advised to apply centering jaw pressure of no greater than 300 grams to the sides of the chips. Excessive "centering" pressure may result in cracking the chip. The user is also advised not to exceed 300 grams of placement pressure (Z axis pressure) with any of the automated systems for the same reason.

4.0: CHIP MOUNTING PAD DIMENSIONS. The metallized pad or land area on the end user's substrate must be properly designed. Improper dimensioning or spacing of the land areas may result in poor solder fillets or tombstoning. Good land design will depend on the end user's application. Recommended mounting pad dimensions for ATC components are referenced in ATC Technical Bulletin ATC # 001-820. Other useful information on assembly practice may be found in IPC-A-610. See the references at the end of this document.

5.0: FLUX. Flux removes tarnish films, maintains surface cleanliness, and facilitates solder spread during attachment operations. Non-activated rosin fluxes decrease the surface tension of solder, facilitating the spreading activity of the solder during attachment operations. Activated fluxes cleans surfaces by reducing oxides in addition to decreasing the surface tension of the solder. The flux must be compatible with the soldering temperature and soldering times required in the customer's application. Types R and RMA fluxes, per IPC-J-STD-004 are recommended. Soldering attachment methods employed should permit the flux to attain its activation temperature (100-200° C) just prior to achieving the working temperature of the alloy. The end user should avoid prolonged exposure of rosin fluxes to temperatures above the char point of the rosin (285° C) since char will be difficult to clean from the parts.

6.0 SOLDER. A variety of solder compositions is available to suit specific application requirements. For silver bearing substrate conductor patterns or silver bearing component metallizations, Sn62 is recommended. For non-noble components or conductors, Sn63 (or equivalent) is recommended. For chip attachment to gold conductors, the indium alloy 50% Pb, 50% In is suggested in order to avoid gold scavenging and/or embrittlement. The Sn95.5 alloy shown below is an example of a commonly used lead-free solder. Typical composition and melting ranges are shown in Table 1.

The end user may be required to perform sequential attachment operations for which ATC recommends a step soldering approach. A full range of alloys is available. The user should refer to IPC-J-STD-006A or specific vendor literature for more information.

Solder pastes or creams are frequently used. RMA based materials are suggested since they ensure adequate application characteristics even when the solder alloy components have become oxidized. The use of a solder paste will afford the user many advantages when used with various reflow technologies, such as Vapor Phase, Infrared Radiation (IR), or Hot Air Convection methods. The solder paste should be screen printed onto the substrate, applying solder to selected land areas. The chips should then be placed on top of the solder paste by means of automatic pick-and-place or by manual placement (see Sections 3.0 and 4.0).

7.0 CHIP AND SUBSTRATE PREPARATION. It is recommended that substrates be pre-tinned by some means prior to reflow attachment. The substrate may be tinned using any of the methods described in Sections 8.0 or 9.0. Alternatively, organic coatings can be useful for preventing the passivation of circuit traces. The user should clean the substrate per Section 11.0 prior to chip attachment.

TABLE 1: RECOMMENDED SOFT SOLDERS

ALLOY	COMPOSITION	SOLIDUS	LIQUIDUS	COMMENT
In 52	52 In, 48 Sn	118°C	118°C	Eutectic
Sn 62	62.5 Sn, 36.1 Pb, 1.4 Ag	179°C	179°C	Eutectic
Sn 63	63 Sn, 37 Pb	183°C	183°C	Eutectic
In 50	50 In, 50 Pb	180°C	209°C	
No-lead	95.5 Sn, 3.8 Ag, 0.7 Cu	217°C	217°C	Eutectic
Hi-Temp	5 Sn, 93.5 Pb, 1.5 Ag	296°C	301°C	
Sn5	5 Sn, 95 Pb	308°C	312°C	

8.0 REFLOW ATTACHMENT. ATC recommends three methods of reflow attachment: Convection Reflow, Vapor Phase Reflow and IR Reflow. All are best accomplished in conveyorized ovens. The most critical assembly issue for ceramic chip capacitors is the heating and cooling rate, Refer to Figure 1. In the preheat portion of the process, ideal profiles for any of these methods will exhibit a ramp-up rate that is equal to 2° C/second. The user is advised never to exceed a maximum rise rate of 4° C/second. Careful attention should be paid to the ramp down rate. After exiting from a soldering operation, the board or substrate should be allowed to cool at their own natural rate, without heat sinking. The user is advised to cool the product to well below 60° C before attempting any cleaning operations and to never withdraw parts from the oven at temperatures above 100° C.

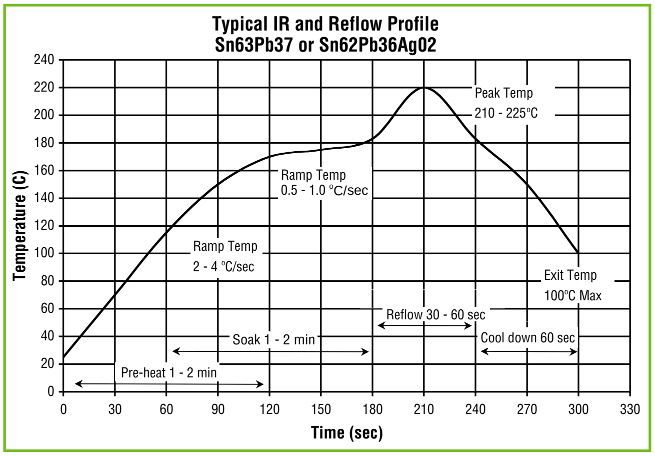

Figure 1. Typical Reflow Profile Using Sn63/Pb37 or Sn62/Pb 36/Ag02 Alloy

TABLE 2: RECOMMENDED PARAMETERS FOR VARIOUS REFLOW SOLDERING PROCESSES

Reflow Method	Solder Type	Preheat Section		Soak Section		Reflow Section		Cooling Section	
		Max (°C/s)	Duration (s)	Max (°C/s)	Duration (s)	Peak (°C)	Duration (s)	Max (°C/s)	Duration (s)
Convection Oven	Sn 63	2	60-120	4	60-120	210-225	30-60	4	60-120
	No-lead	2	60-120	4	60-120	250-260	30-60	4	60-120
	Hi-Temp	2	60-120	4	60-120	330-340	60-90	4	60-120
Vapor Phase	Sn 63	2	60-120	N/A	N/A	215	Varies	4	60-120
	No-lead	2	60-120	N/A	N/A	230	Varies	4	60-120
	Hi-Temp	Not possible with vapor phase method							
Infra Red	Sn 63	2	60-120	4	60-120	210-225	30-60	4	60-120
	No-lead	2	60-120	4	60-120	250-260	30-60	4	60-120
	Hi-Temp	2	60-120	4	60-120	330-340	60-90	4	60-120

8.1 Convection Reflow. Perhaps the most basic reflow process, this technique uses a conveyor to transport boards through an oven with several controlled heating zones. In this case, energy is supplied to resistance heating elements and heat transfer is accomplished by convection. Peak temperature and soak time may be important for components with organic or polymeric constituents but, from a ceramic component standpoint, heating and cooling rates are the most critical variables in the process. Good soldering practice will limit Reflow time to a maximum of 60 seconds above the solidus point of the alloy (Refer to Table 2).

8.2 Vapor Phase Reflow: Heating is accomplished by the condensation of perflorinated solvent vapors. Heating rates of all exposed surfaces is very uniform and repeatable from assembly to assembly. Both in-line conveyor and batch systems are in use. The immersion time required for reflow varies from about ten seconds to one minute. It is possible to achieve very rapid heating with this process, especially in the batch version. Care must be taken to accommodate the maximum permitted heating rates for ceramic components.

8.3 IR Reflow: Infrared radiation is a popular method for solder reflow. The IR energy is provided by lamps or specially muffled panel-type heat sources. Both the board top and bottom can be heated, sometimes with different temperature profiles. Heating tends to be a function of the emissivity of the materials and their inherent thermal conductivity. Solder pastes absorb IR radiation and heat quicker than the chip metallization. Because IR is line-of-sight, large or tall components may cause "shadowing" of some board areas. This requires special attention be paid to pad dimensions, component size, and component placement. Refer to Table 2.

9.0 Wave Soldering. Wave soldering contrasts with reflow soldering in two aspects:

a) The chips must be attached to the assembly before soldering by means of a gluing operation.

b) The attachment process will add the solder used in joining and forming the fillet.

Wave soldering is accomplished by passing the assembly through a standing wave or dual waves of molten solder. Because of the high potential for thermal shock in this process, ATC does not recommend wave soldering for the attachment of its products. Larger sizes are at greater risk for internal dielectric fracture, resulting in insulation resistance failures. In particular, parts larger than EIA-1210 size or larger than ATC B Case may be especially prone to thermal shock in wave soldering processes. It is also generally accepted that X7R and BX dielectrics are more sensitive than C0G ceramics. Therefore, special care should be taken to avoid the use of wave soldering for the attachment of ATC 200 and 900 Series products. When there is no other process choice, the guidelines in Figure 2 should be followed. For additional information please consult ATC.

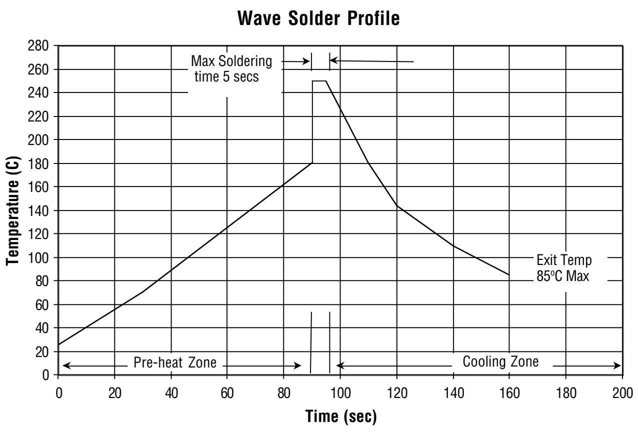

Figure 2. Wave Solder Profile

Wave Soldering Recommendations

1. Adjust the belt speed per the manufacturer's recommendations in order to insure a dwell time in the solder wave of 2 to 3 seconds.
2. Adjust the solder pot temperature to a range of 240°C to 250°C.
3. The flux station (foam or wave) preheat temperature should range from 80°C to 105°C
4. The preheat temperature must not exceed a level of 100°C below the solder wave temperature and the preheat rate of 1.5 to 2.5°C/sec.
5. The underside PC board temperature at last preheat zone should be approximately 150°C.
6. Check that the difference between the solder temperature and the board is 100°C or less at the point in time when the PC board leaves the last preheat zone.
7. Permit the board to air-cool at ambient conditions; do not force cool the board.
8. It is not recommended to wave solder chips with case sizes greater than the 1210 case size due to the risk of thermal shock. This can result in the formation of micro cracks that may cause insulation resistance (IR) failures.

10.0 HAND SOLDERING. Hand soldering with a soldering iron is a manual process. Unlike solder reflow where all variables are under tight machine control, this process is subject to the variability of individual operators and training programs. Each solder connection can see different temperatures, different stresses and varying amounts of solder. The most important aspect of hand soldering is operator skill. The operator must fully understand the operation being performed. Care should be taken not only in soldering, but in handling. Never touch electronic components with bare hands. Never allow the tip of the soldering iron to come in contact with a ceramic component, even at its terminal. The following hand soldering technique is recommended for proper installation of a chip capacitor across two lands of a substrate.

a) As outlined in Section 7.0, chip and substrate will be properly prepared for a solder assembly.

b) The soldering iron should be of a size appropriate to the component and should have a temperature controlled tip not exceeding 600° F or 315° C.

c) Care must be exercised to avoid damaging the component. The capacitor can be picked up with a pair of tweezers or with a vacuum pickup.

d) Flux will be placed at the joint area of each terminal. (see Section 5.0).

e) The capacitor will be placed across the two land areas on the substrate. For best results and to preclude the possibility of thermal shock, it is recommended that the board or substrate be pre-heated to and held at a temperature 50-100°C below the working temperature of the solder.

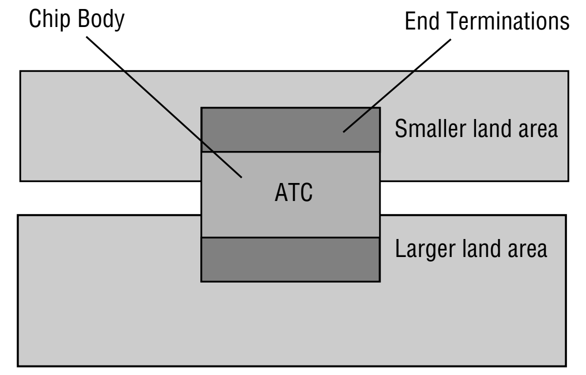

Figure 3. Solder smaller land area first.

f) If lands are of different size the smaller land area will be soldered first while holding the chip in place with tweezers or vacuum pickup.

g) Make sure that the capacitor is flat on the substrate and place the solder iron on the land near the chip termination/land interface. When the solder starts to flow, the tip of the iron will be moved slowly towards the chip and quickly removed once a fillet has formed.

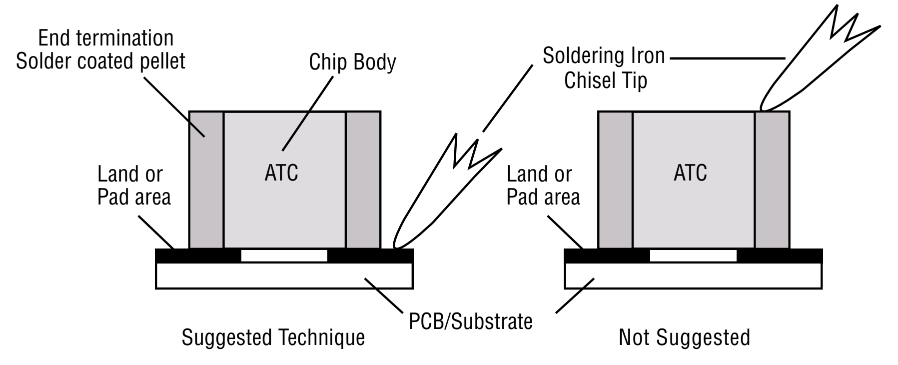

Figure 4. Recommended soldering techniques

h) Fillets should have sufficient solder to join the land at least 50% of component height and exhibit a concave profile. Excess solder can cause mechanical stress on components, thereby, diminishing reliability.

i) After examining the chip capacitor to make sure it is still flat on the board, repeat step "g" for the opposite land connection.

j) The fillet should show even flow of solder and should be free of solder peaks and voids.

k) The assembly is now complete. Flux residues should be removed with a solvent cleaner as described in Section 11.0 or by equivalent methods.

11.0 POST ATTACHMENT CLEANING. Solvent or aqueous cleaning can remove most contaminants generated after soldering operations. Cleaning is most often performed in ultrasonic tanks, vapor degreasers or ultrasonic vapor degreasers. Typical cleaning cycles may employ more than one step in order to effectively remove contaminants. Care must be taken to insure that residues are removed from beneath the component in order to insure long-term reliability.

12.0 CONDUCTIVE EPOXY BONDING. Epoxy connection is a technically demanding technique. It requires the user to be familiar with the material requirements and reliability considerations of the conductor system chosen. ATC typically recommends either its gold over nickel barrier termination (termination style "CA") or its Ag/Pd alloy termination for compatibility with these applications.

13.0 REFERENCES. ATC recommends the following references for further information on component assembly:

1. IPC-A-610: Acceptability of Electronic Assemblies, available from IPC, 2215 Sandus Road, Northbrook, IL 60062.
2. IPC/EIA-J-STD-006A: Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications, available from EIA, 2500 Wilson Blvd, Arlington, VA 22201
3. IPC/EIA-J-STD-004: Requirements for Soldering Fluxes, available from EIA, 2500 Wilson Blvd, Arlington, VA 22201
4. ATC-001-820: Suggested Mounting Pad Dimensions for ATC Multilayer Chip Capacitors, ATC Applications Engineering Department, 17 Stepar Place, Huntington Station, NY 11746

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