Technical Note

Recommended Soldering Parameters

Introduction

The semiconductor industry is moving toward the elimination of Pb from packages in accordance with new international regulations. This concerns both solder paste, for the board mounting process, and semiconductor packages themselves.

The solder reflow process step is affected by this change because most Pb-free solder pastes melt at temperatures that are 30°C to 40°C higher than Pb-based materials.

Currently, Pb-based and Pb-free technologies coexist, by having Pb-based packages mounted with Pb-free paste or by having eutectic Sn/Pb paste used with Pb-free components. It's likely this will continue for quite some time.

This technical note defines the recommended soldering techniques and parameters for Micron's products. Using these techniques and parameters will help prevent damage to the semiconductor package through the soldering processes and help ensure product quality and reliability.

Definitions and Common Terms

Symbols used from the periodic table of elements, used in this document:
- Sn = tin, Pb = lead, Ag = silver, Cu = copper, Bi = bismuth, Ni = nickel

Common Pb-based solder ball compositions:
- 63Sn, 37% Pb
- 60Sn, 40% Pb
- 62Sn, 36% Pb, 2% Ag

Pb-free solder ball and paste alloys (Micron uses an assortment of SAC alloys to meet customer requirements):
- SAC405 = 95.5% Sn, 4%Ag, 0.5% Cu
- SAC305 = 96.5% Sn, 3% Ag, 0.5% Cu
- SAC302 = 96.8% Sn, 3Ag, 0.2% Cu
- SAC387 = 95.5% Sn, 3.8Ag, 0.7% Cu
- LF35 = 98.25% Sn, 1.2% Ag, 0.5% Cu, 0.05% Ni
- SAC105 = 98.5% Sn, 1% Ag, 0.5% Cu
- SACN=98.27 Sn, 1.2 Ag, 0.5 Cu, 0.003 Ni

Pb-free lead-frame finishing materials:
- Matte Sn
- Hot dipped Sn
- NiPdAu, SnBi

Maximum Soldering Parameters

Below are the maximum ratings for Micron packages to ensure package integrity through the surface mount process. These maximum ratings apply for all types of soldering processes, including mass assembly, rework, and component removal. The common types of reflow processes are described and discussed in the following section.

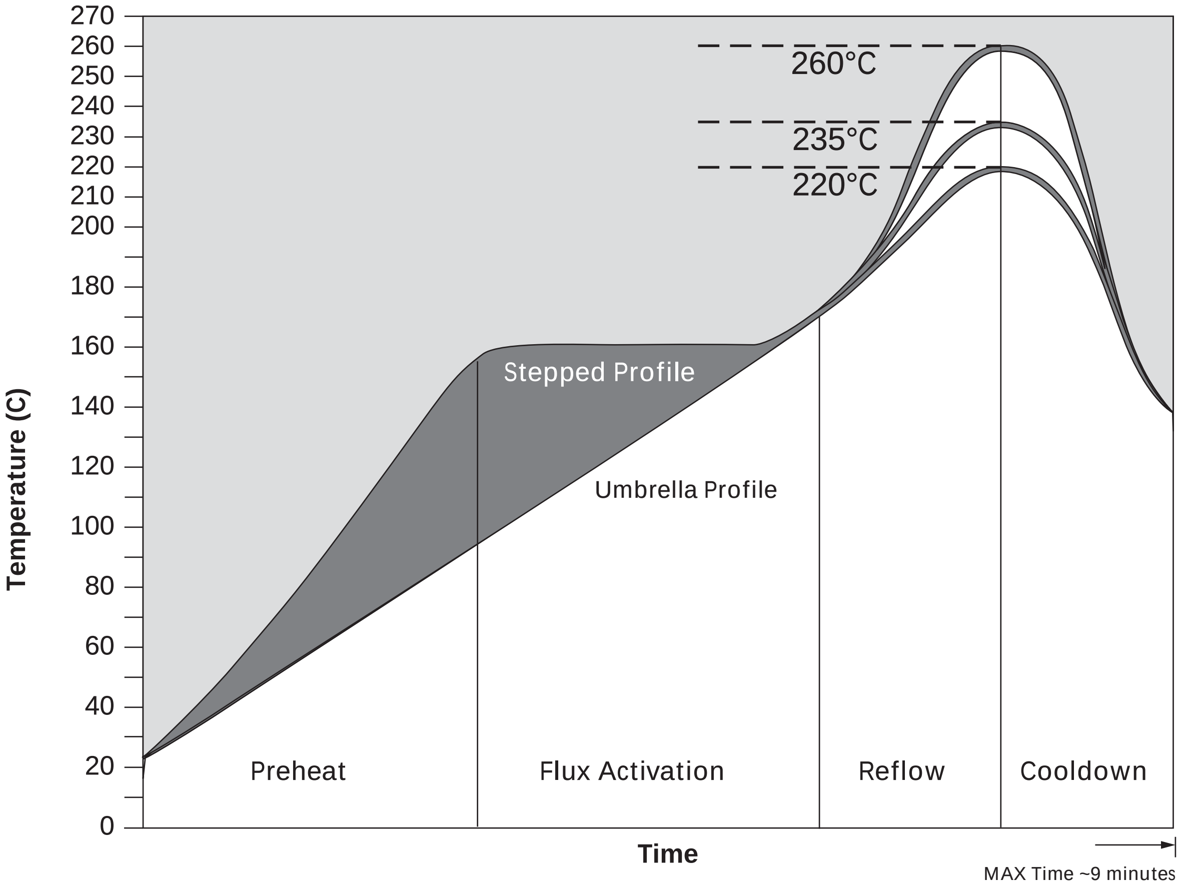
Reflow parameters are primarily a function of solder paste chemistry and board technology. Therefore, Micron's first recommendation is to follow the solder paste supplier's soldering parameters, while not violating the maximum parameters that are listed in the table below.

Table 1: Maximum Soldering Parameters for Typical Surface Mount Technology (SMT) Processes

Process	Max Peak Temperature (°C)	Max Dwell Time at Peak (s)	Max Heating Rate (°C/s)	Max Cooling Rate (°C/s)	Total Time in Chamber (Minutes)	Number of Reflow Cycles
Pb-based	235	30	3	6	9	3
Pb-free	260	30	3	6	9	3

Note: Preprogrammed NAND or PCM devices have lower temperature limits due to data retention. See data sheets or contact your Micron representative for additional requirements.

Figure 1: General Reflow Profiles for Various Maximum-Peak Temperatures



Note: For specific profile recommendations, contact your solder paste supplier.

Convection Reflow Soldering

Convection reflow uses hot air or nitrogen to heat the assembly to reflow temperature. This is the most common reflow process used today, because of its low operational cost, easy and continuous operation, and ability to accurately control the heating and cooling profile. Because the convection reflow process typically has multiple heating stages, the assembly can be slowly and uniformly heated to the appropriate temperature. Convection reflow is also compatible with double sided assembly and can be used in conjunction with IR.

Wave Soldering

Wave soldering uses a wave of molten solder to create the solder connections between the board and components. After the components are attached to the board, the assembly is then passed through the wave and solder sticks to areas of the board and component that have exposed metal. Wave soldering is a technique that works well for continuous production, through-hole technology, and products with a large variation of board sizes. To wave solder a surface mount package, the part must be glued to the board, so that it doesn't fall off in the wave. This means the part must be immersed directly in the molten solder, and that the package will see extreme temperature ramp rates and a peak temperature that can lead to package or PCB damage. As a result, wave soldering is not recommended for Micron products. Wave soldering could be used if the parameters in Table 1 are maintained. Heating and cooling rates, as well as peak temperature will be the critical parameters to monitor.

Infrared Reflow

The infrared reflow (IR) process uses IR lights to heat the assembly to reflow temperatures. Because the process uses light, the resulting component and board temperatures are dependent on their color and thermal mass, so this should be considered during the product design stage. This process is not recommended because of the large variation in temperature that can occur on the board. The heating rate and temperature variation will depend on many assembly attributes. If the product can be held to Table 1 parameters, the process may be acceptable. IR reflow is commonly used for rework when a single component needs to be replaced or removed, because it's easy to shield areas of a board from the IR light to minimize heating while other areas are being reworked.

Vapor Phase Reflow

Vapor phase reflow uses the vaporized form of an inert fluid to bring the assembly to reflow temperatures. The advantage of this methods is the very tight temperature control it has over the assembly, because the peak temperature is limited by the boiling point of the liquid. As a result, component-to-component temperature variation is low. This is a limitation as well, because changing the peak temperature requires changing the liquid, so an assembly process that needs to handle different peak temperatures may not be suited for vapor phase reflow. Also, while the presence of the inert vapor means that nitrogen isn't needed, wet-ability tends to be better, and voiding is less than with other processes, the liquid used for heating is very expensive, resulting in higher operational costs compared to other processes. Vapor phase reflow can have extreme temperature ramp rates, but can be acceptable if the maximum rating conditions listed in Table 1 are met.

Hand Soldering

Typically, hand soldering is used only on leaded devices to touch-up leads with incomplete or poorly formed solder joints. The recommended hand soldering parameters are shown in Table 2. These are considered to be a starting point for lead touch-up process development. It is recommended that the current version of IPC-A-610 be consulted for solder-joint formation requirements. The parameters in Table 2 were developed with an assortment of Micron leaded packages. PCB copper loading or iron tip and heat capacity could have a significant effect on the parameters, so great care should be used to develop a process for specific system design parameters.

Table 2: Hand Soldering Parameters Starting Point

Process	Max Solder Iron Tip Temperature (°C)	Max Contact Time with Component Lead (s)	Number of Heat Cycles
Pb-based	300	20	3
Pb-free	350	20	3

Note: Preprogrammed NAND or phase change memory (PCM) devices have lower temperature limits than those listed in the table above. See the relevant Micron data sheet for specific product temperature limits.

Mixed Alloy Considerations

In the context of this document, a mixed alloy refers to mixing Pb-based and Pb-free solder, where the component termination is of different composition than the paste. Mixing between the various SAC alloys is typically not a concern in terms of surface mount. There are long term reliability implications that need to be considered when choosing alloys, but that is beyond the scope of this technical note.

In terms of time zero surface mount quality, SAC305 and SAC405 are common paste alloys used by the industry and are, generally, compatible with other SAC compositions. These materials are readily available, have a low melting temperature, and provide good head-in-pillow (HIP) performance.

Table 3: Compatibility Matrix of Mixed Alloy Systems

Product	Component	Solder paste	Process	Moisture Sensitivity	Reliability
Lead-frame-based	Pb-based	Pb-free	Pb-free	Good	Good
	Pb-free	Pb-based	Pb or Pb-free	Good	Good
BGA	Pb-based	Pb-free	Pb-free	Concerns	Good
	Pb-free	Pb-based	Pb-based	Good	Concerns
			Pb-free	Good	Good

Notes:
1. This table assumes that the paste has been formulated for the given process. Contact your paste supplier to confirm.
2. Most Micron Pb components are rated for Pb-free temperatures. Each product should be considered on a case-by-case basis. See the appropriate Micron data sheet for details.
3. When a ball grid array (BGA) Pb-free part is used in a Pb process, it is recommended that the peak temperature be chosen to ensure full mixing of the solder ball and paste.
4. Preprogrammed NAND and PCM products have a limited temperature in terms of data retention, regardless of whether the package is reliable and adequate solder-joints are formed.

Qualification and Moisture Sensitivity

Most of Micron's NAND and DRAM products are qualified at Pb-free reflow temperatures regardless of whether they are in a Pb rated package. This makes most Micron products compatible with Pb and Pb-free SMT processes. Since 2003 all commodity DRAM and networking DRAM have been qualified with 3 x 2 60°C preconditioning to ensure forward and backward compatibility.

Micron NOR and MCP packages have a few exceptions to this rule, so the product data sheet should be consulted to make sure the any given product is capable of the required ratings.

Micron floor-life recommendations, based on the moisture sensitivity level of the component, are designed to prevent component damage during reflow processing. The component packaging label notes the rated floor life for each type of component. The moisture sensitivity level is determined in accordance with the current version of J-STD-020, "Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices."

Reliability Considerations

Lead-Frame-Based Packages

With lead-frame-based packages, Sn, SnPb, or NiPdAu plating finishes form reliable solder joints with or without full mixing as long as the solder joints is formed according to IPC requirements. The coating on the lead-frame contributes about 10% to 20% to the total solder-joint volume and, therefore, isn't overly influential. See the latest edition of IPC-A-610 for the requirements to form a proper solder joint.

BGA Packages

BGA products have different requirements than their leaded counterparts. The solder ball contributes about 70% to 80% of the total solder-joint volume. For BGA packages, full mixing of the solder-joint and solder paste is recommended.[1, 2, 3, 4, 5, 6]

Mixed Alloy Conclusions

Mixed alloy systems have been studied extensively by the industry and are considered as reliable as homogeneous systems when a uniform solder-joint is formed during surface mount. However, temperatures that provide partial mixing when the SAC alloy is in the liquid phase can lead to solder-joint reliability issues.[1, 2, 3, 4, 5, 6]

Additional Soldering Parameter Considerations

- Oxidation rates are higher at elevated temperatures, so the flux activity should be considered relative to the reflow temperature
- Voiding also increases with increased oxidation
- Flux residue can be harder to remove with higher reflow temperatures
- The glass transition temperature (T_G) of the PCB and what affect will it have on process and long term reliability of the product
- Nitrogen gas can be used in the reflow atmosphere to improve the process margin, wet ability, appearance of the solder-joints, and reduce oxidation
- The peak temperature of the product should be ~30°C higher than the melting point of the solder

References

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Revision History

Rev. F 12/12

- Updated all sections

Rev. E 7/06

- Corrected typos, suppplier on page 1, note 1 punctuation on page 2

Rev. E 5/06

- Updated Tables 1, 2, and 3

Rev. D 4/06

- Changed J-STD-020 to "the most recent version of J-STD-020"
- In Tables 1 and 2: changed MAX Dwell Time to 30s
- In Tables 1 and 2: changed the MAX Heating/Cooling Rate to MAX Heating Rate of 3°C/s
- In Tables 1 and 2: Added MAX Cooling Rate column, with of 6°C/s value

Rev. C 12/04

- Added note 3 to Tables 1 and 2

Rev. C 6/04

- Changed Table 1 Max. Heating/Cooling Rate to 4°C

Rev. B 10/03

- Reworded some text, added CMOS image sensors to all tables

Rev. B 2/03

- Changed MAX solder iron tip temp in table 3: SnPb from 235 to 300C, Pb-free from 260 to 350C

Rev. A 12/02

- New technical note