

OBJECTIVE

The objective of this application note is to provide the customer with a general understanding of ANADIGICS' product's high temperature capabilities associated with 2nd level lead-free assembly. It also provides general information on the moisture sensitivity level (MSL) tests as required by JEDEC for sensitivity rating of products to be used in lead-free assembly environments. Finally, a brief look at the various tests used to qualify ANADIGICS' products is also presented.

INTRODUCTION

The world-wide lead-free initiative for microelectronics has caused the industry to revamp the design, material selection, and manufacturing processes of its products. Japan and Europe have launched industry wide programs banning lead from electronics products in 2005 and 2006, respectively. These programs are backed by OEMs in Japan and by the Parliament in Europe. Although the United States does not have any legislation for the removal of lead from electronic components, in order to remain competitive in this global market, the United States must follow suit or face exclusion from markets requiring the elimination of lead.

Lead based solders are now being replaced by lead-free solders for 2nd level interconnects. The most common replacements for 63Sn37Pb (eutectic point 187 °C) are the 96.5Sn3Ag0.5Cu (SAC305) and 95.5Sn4Ag0.5Cu (SAC405) solders, which have a eutectic point of 217 °C. Due to the non-uniformity of heat distribution on boards during 2nd level interconnection reflow, the SAC solders reflow profiles contain a peak temperature of 250 °C. This peak temperature could potentially be as high as 260 °C depending on the assembler's equipment and process capabilities. Subjecting components to such high temperatures can cause a multitude of problems such as delamination at any of the various interfaces, solder extrusion, external cracking, and cracks on any of the internal features and I/Os.

In order to overcome these problems, ANADIGICS uses innovative designs, processes and materials

in the manufacture of its products. Products using these techniques exceed the standards set by JEDEC for exposure to high temperature reflows.

LEAD-FREE SOLDERS

The following table provides a few lead-free solders being used in industry. Although no standard replacement has been identified by the microelectronics industry, research organizations specializing in lead-free solders have recommended several replacements for the standard Sn37Pb solder.

Table 1: Common Lead-free Solders [1, 2, 4]

Alloy	Melting Point (°C)	Industry
Sn3.5Ag	221 - 226	Automotive
Sn3.5Ag3Bi	208 - 217	Military/Aero-space
Sn3.5Ag1Bi4In	208 - 213	Consumer
Sn3.0Ag0.5Cu	217	Automotive Telecom.
Sn57Bi	138	Consumer
Sn0.7Cu	227	Consumer Telecom.
Sn9Zn	199	Consumer

PROPERTIES OF LEAD-FREE SOLDERS [1]

Some of the properties common to lead-free solders are given below:

- Typically have much higher melting points than traditional Sn63Pb37
- Are stronger and less ductile than lead or indium-bearing alloys
- Typically exhibit poor wetting when compared to Sn37Pb

High Temperature Report

SAC305 and SAC405 provide certain advantages over other lead-free compounds due to the presence of copper.

- Copper in solder retards the dissolution rate of copper from boards.
- Copper can improve the wettability of the solder during reflow.
- Copper can improve the thermo-mechanical properties of solder joints.
- Copper reduces the melting point slightly. 96.5Sn3.5Ag has a melting point of 221 °C.

Table 2: SAC305/SAC403 Data [2, 4]

Category	Property
Melting point	217 °C
Tack Force	2.63g/mm ²
Density	7.44
Elec. Resistivity	13 μΩ-cm
CTE	~14
Ultimate Tensile Strength	42 Mpa
Yield Strength	45 MPa
Shear Strength	27 MPa
Creep	27 MPa (100 h to failure)
Wetting time	~0.27 sec

BACKGROUND ON MSL LEVELS

MSL levels are used to classify the sensitivity of a microelectronic package to moisture. Packages can be classified from level 1 (hermetic package) to level 6 (very sensitive). Knowledge of the MSL level of a package is crucial during 2nd level solder reflow for proper assembly of the product as these levels dictate the duration that the package can be exposed to the atmosphere before being exposed to solder reflow temperatures. Once this time limit expires, the package is at risk for catastrophic damage during reflow. Table 1 summarizes the different MSL levels as defined by JEDEC Standards J-STD-020B and J-STD-020C [3, 5].

Table 3: Moisture Sensitivity Levels by JEDEC

Level	Floor Life
1	Unlimited
2	1 year
2a	4 weeks
3	168 hours
4	72 hours
5	48 hours
5a	24 hours
6	Time on Label

HIGH TEMPERATURE REFLOW PROFILES

In order to qualify the products at the desired MSL level, it needs to be subjected to, and pass, the environmental conditions and stress tests as specified in J-STD-020C. While, this standard specifies a peak reflow temperature of 260 °C, the actual peak temperature subjected to the parts during qualification will be dependent on the particular products' high temperature tolerating capabilities.

The following flowchart shows the flow of the tests for an MSL test.

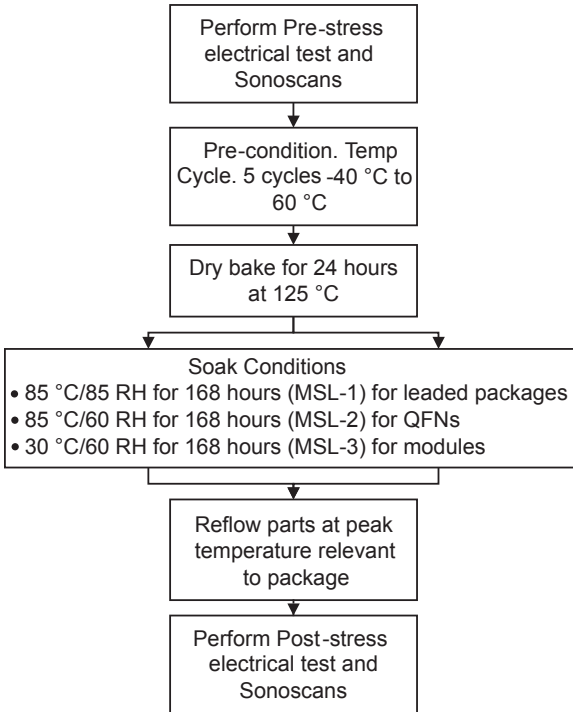


Table 4 provides a breakdown of the reflow conditions [5].

Table 4: Lead-free MSL Reflow Profile Breakdown

Profile Feature	JEDEC Specifications
Avg. Ramp-up (T_L to T_P) ^{(1), (2)}	3 °C/second max
Dwell Time (175 ± 25 °C)	60-180 seconds
Ramp-up 200 °C to 217 °C	3 °C/second max
Time above 217 °C	60-150 seconds
Time within 5 °C of peak	20-40 seconds max
Peak Temperature ⁽³⁾	260 -5/+0 °C
Average Ramp-down	6 °C/second max

Notes:

- (1) T_L is the solder Eutectic temperature
- (2) T_P is the peak temperature
- (3) Actual peak temperature will be product dependent

After soaking in the moisture chamber for the required time, the parts are subjected to the reflow conditions specified in J-STD-020C. Three successive profile passes, within 4 hours of being removed from the moisture chamber, are required according to JEDEC specifications. Figure 1 compares the standard (non-RoHS) and high temperature (RoHS) reflow profiles.

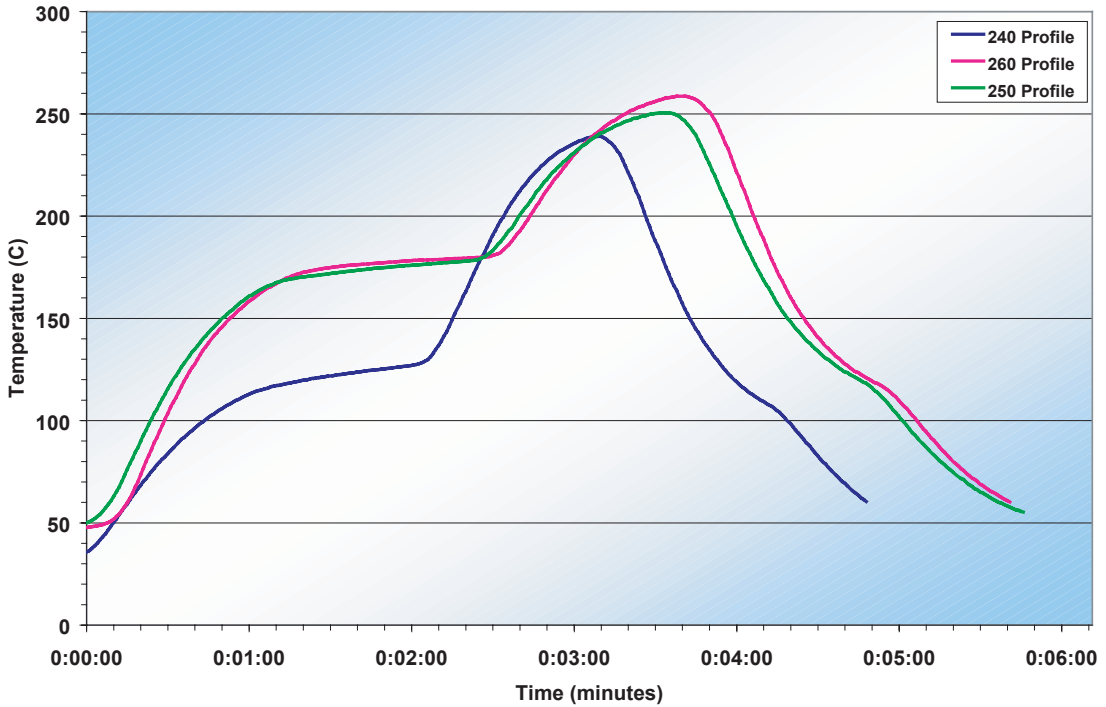


Figure 1: Comparison of Product Reflow Temperature Profiles

QUALIFICATION TESTS

Apart from MSL, the qualification of packages, that are reliable in lead-free assembly conditions, also requires a number of additional tests. According to ANADIGICS' internal specification, such packages were successfully submitted to reliability/environmental stresses in accordance to JEDEC standards, as applicable. Qualification testing results are available upon request.

LEAD-FREE ORGANIZATIONS

The following are some of the organizations that are actively pursuing lead-free activities.

- JEDEC www.jedec.org
- IPC www.ipc.org; www.lead-free.org
- NEMI www.nemi.org
- NCMS lead-free.ncms.org
- JEIDA www.jeida.or.jp
- ITRI www.itri.co.uk

REFERENCES

- [1] http://www.kester.com/lead-free_alloys.htm
- [2] John H. Lau, *Electronic Manufacturing with lead-free, halogen-free & conductive-Adhesive Materials*. McGraw Hill Publishing. 2003.
- [3] JEDEC Standard J-STD-020B. *Moisture/Reflow Sensitivity Classification for non-hermetic Solid State Surface Mount Devices*. July 2002.
- [4] Jennie Hwang, *Environment-Friendly Electronics: Lead-free Technology*. Electrochemical Publications Ltd. Isle of Man, 2001.
- [5] JEDEC Standard J-STD-020C. *Moisture/Reflow Sensitivity Classification for non-hermetic Solid State Surface Mount Devices*. July 2004.

NOTES

NOTES



ANADIGICS, Inc.

141 Mount Bethel Road
Warren, New Jersey 07059, U.S.A.
Tel: +1 (908) 668-5000
Fax: +1 (908) 668-5132

URL: <http://www.anadigics.com>
E-mail: Mktg@anadigics.com

IMPORTANT NOTICE

ANADIGICS, Inc. reserves the right to make changes to its products or to discontinue any product at any time without notice. The product specifications contained in Advanced Product Information sheets and Preliminary Data Sheets are subject to change prior to a product's formal introduction. Information in Data Sheets have been carefully checked and are assumed to be reliable; however, ANADIGICS assumes no responsibilities for inaccuracies. ANADIGICS strongly urges customers to verify that the information they are using is current before placing orders.

WARNING

ANADIGICS products are not intended for use in life support appliances, devices or systems. Use of an ANADIGICS product in any such application without written consent is prohibited.