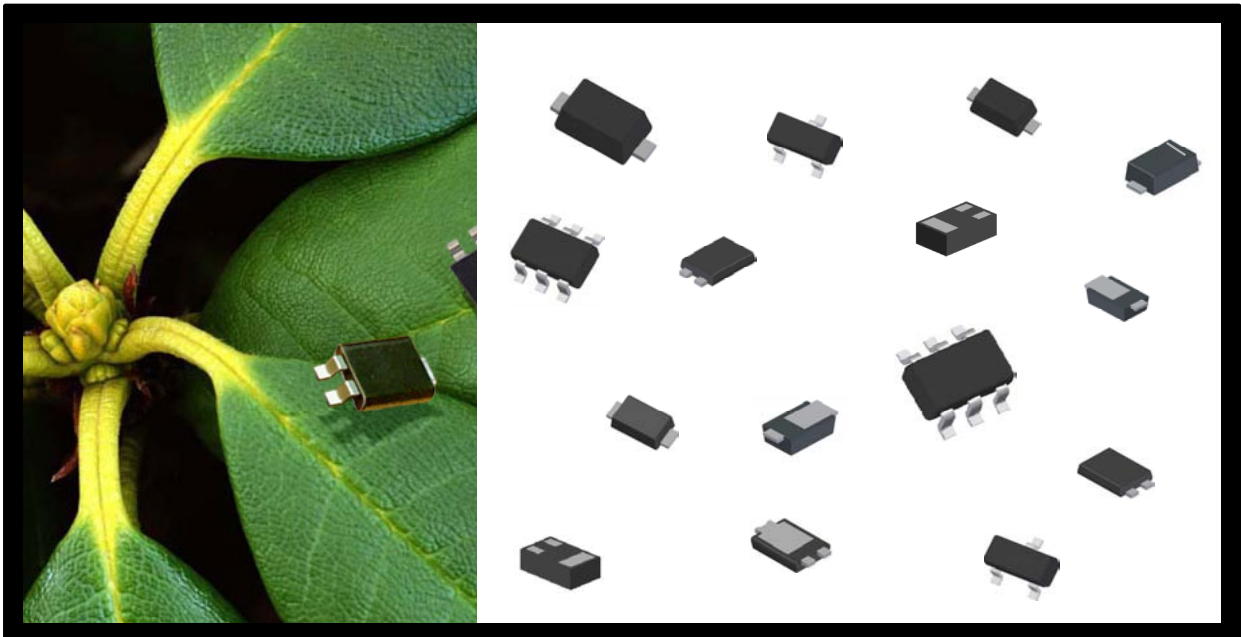




## Green Products



Information provided is necessarily general in nature. For information about specific Lead Free and Green devices, please contact your local Diodes, Inc. Sales Representatives.

## Diodes Incorporated Is Committed to a Global Green Environment



Diodes Incorporated is dedicated to preserving our environment for future generations and is working proactively with customers and suppliers to comply with the increasing demands and requirements to provide Green products.

### How Does Diodes, Inc. Define “Green” Products?

Diodes defines "Green" products as those which are RoHS compliant and contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br+Cl) and <1000ppm antimony compounds.

### Why Is Diodes, Inc. Going Green?

- The electronics industry has been working to provide Green products in response to concerns about the impact of those compounds that are unfriendly to the environment.
- Diodes, Inc. now offers virtually all products in Lead Free or Lead Free Finish formats. Versions containing Lead or Lead Plating Finish are being discontinued. In addition, many of our packages are halogen- and antimony-free as well.

This online brochure is designed to help you learn more about Diodes, Inc.'s Green Implementation and the issues and concerns surrounding the industry's efforts to comply with a growing global demand for Green products.

### Diodes Incorporated's Lead Free / Green Policy

- Company-Wide Policy is to eliminate Lead and other hazardous compounds wherever possible.
- Lead Free and Green products are clearly identified on package labeling so they will not be confused with non-Green products.

### Current Status

- Steady increase in the number of Green products shipped.
- Diodes, Inc. is currently limiting production of non-Green products.

## Lead Free (Pb-Free) / Green Information at a Glance



### 1. **Diodes, Inc.'s definition of "Lead Free."**

Diodes, Inc.'s products defined as "Lead Free" will contain no purposefully added Lead either internally or externally. Only trace elements may remain.

### 2. **Diodes, Inc.'s definition of products with a "Lead Free Finish."**

These products will have no external Lead, but will still contain internal Lead in the form of high temperature die / lead bonding solder. Remaining Lead percentage by weight will vary by product package and type. Lead in this type of solder is RoHS Exempt as of this date.

### 3. **Diodes, Inc.'s definition of "Green".**

Diodes defines "Green" products as those which are RoHS compliant and contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br+Cl) and <1000ppm antimony compounds.

### 4. **Diodes, Inc. is committed to environmental friendliness.**

Eliminating Pb from Lead plating is just one step towards a "Green Product." Diodes, Inc. is taking additional steps to remove halogens and antimony compounds and will announce each change with the appropriate mechanism: i.e., New Product Announcement or Product Change Notice (PCN). We strive to continuously improve the environmental friendliness of our products and meet the demands of our Customers for such. A Material Content List is available for most products. Please request this report through your Sales Representative or email [compliance@diodes.com](mailto:compliance@diodes.com).

Note: For many products, you may find the Material Content Lists for Lead Free information helpful, at <http://www.diodes.com/RoHS/index.php>.

### 5. **Diodes, Inc.'s Road Map for Green and where products are manufactured.**

In 2006, Diodes, Inc. eliminated most SnPb plated versions of products. In addition, more and more products were introduced in a "Green" format. Diodes, Inc.'s Green products will not contain Lead, Halogens or Sb compounds. Small outline packages (SOD, SOT, SC-59) will be converted first. Larger packages are expected to be converted in 2008.

Over time, as demand warrants, the traditional non-green products will be discontinued. This will be announced by a Product Change Notice (PCN). Demand will affect which packages are discontinued first.

Finished products are built in the Republic of China, Peoples Republic of China and Hungary.

### 6. **Lead Free or Green options may not be offered for 100% of Diodes, Inc.'s products.**

This depends on demand. Major customers who continue to require SnPb Finish may be accommodated for a period determined by individual agreements.



## Lead Free (Pb-Free) / Green Information at a Glance (Continued)

### 7. **Products with the new lead free finishes can be used with Pb containing solders.**

The Finish will be backward compatible with Pb containing solders. Conversely, the current product with SnPb Lead Finish can be used with Pb Free solders. A slight Pb contamination of the solder joint from Pb migration out of the Lead plating may result but should not harm the joint. Soldering profiles may need to be adjusted slightly depending on the many design and usage variables.

### 8. **Removal of halogens and antimony compounds.**

Removal of halogens and antimony compounds is brought about by a change of molding compounds only. No electrical or performance changes are made for this conversion. All these ratings remain the same.

### 9. **There will be no specification changes other than to reflect the Lead Finish and Molding Compound.**

Products will continue to be qualified to 260°C solder re-flow profiles. Moisture Sensitivity Level (MSL) will remain 1 unless specifically announced otherwise on an individual product. Reliability and Qualification Testing will remain as is before with the exception of additional Solderability Testing using Pb Free solders. No major changes should be necessary in customer's processes except for solder profile adjustments.

### 10. **Details on product availability.**

Availability of Small Outline packages in an SnPb Plated version will be limited and most will be phased out. Lead Free Finish on many larger package products is also available now. Many Axial and power packaged products (TO-220, etc.) have traditionally been manufactured with pure Sn plated leads and have been available in production quantities for many years. Please contact your Sales Representative for more information, to request samples or to request a Qualification Package for a specific product.

### 11. **Prices may change.**

There are many variables that impact pricing. While we have experienced a slight manufacturing cost increase for Green product versions, we do not anticipate any immediate change of pricing because of these changes.

### 12. **Part Numbers changes.**

Over the last few years there have been some changes to part numbers to distinguish RoHS and "green" versions of our products. Please refer to the data sheets for specific product ordering information and to determine the green conversion status.



## Lead Free (Pb-Free) / Green Information at a Glance (Continued)

### 13. **Buying product with the old SnPb Lead Finish after the conversion date.**

Customers may continue to buy products that have not been “converted” subject to availability in either format, with SnPb Lead Finish or Lead Free. If other products are converted, advanced notification will be given. Should a major customer require product with SnPb plating after a general product conversion, a Customer Special Part Number may have to be generated. The length of time the old product will remain available to you will be by special agreement. (Pricing may then be reviewed.) A Lifetime buy may be offered on a package / Customer basis.

Green molding compound changes are by date code. Once stock is exhausted, the device will not be available in the old compound even if SnPb finish.

### 14. **How to distinguish between Finishes on the product.**

Product package labeling clearly states the status of the parts. Please see Document AP02006.pdf for complete labeling information. This document is available on [www.diodes.com](http://www.diodes.com) under Products > Product Packaging > Product Label Specification.

Product labels on reels and packaging will contain the full part number including the “-F” (if needed) where the product is Lead Free or Lead Free Finish. After the product is removed from the packaging, the product leads would have to be visibly inspected. The sheen of Matte Tin vs. SnPb Finish is visibly different. It is not possible to tell Green from non-Green products once put into use.

### 15. **Testing done to qualify Lead Free Finishes for use in standard SMT/Through-hole assembly processes.**

Each product family where the Lead Finish is being converted to Pb Free has been or will be re-qualified by subjecting a family sample to the following tests (typical):

Preconditioning (PC) followed by:

Highly Accelerated Stress Testing (HAST)

Autoclave (AC)

Temperature Cycling (TC)

Solderability

With SnCuAg Solder

With SnPb Solder

Resistance to Solder Heat (RSH)

### 16. **Please refer to Data Sheets for change indications.**

Most Data Sheets will contain ordering information for each version of a component where more than one version is available. Also, the Features Section will indicate when a Lead Free Version of a product is available or if a product is Lead Free by design, and it is Green.

The Mechanical Data Section will have a notation regarding the type of Lead Finish plating.



## Lead Free Product Specification

Diodes Incorporated is dedicated to preserving our environment for future generations and, therefore, the Company offers most small packaged discrete products in a Lead Free version. These include SC-59, SC-74R, SOD-123, SOD-323, SOD-523, SOT-23, SOT-25/-26, SOT-143, SOT-323, SOT-363, SOT-523, and SOT-563.

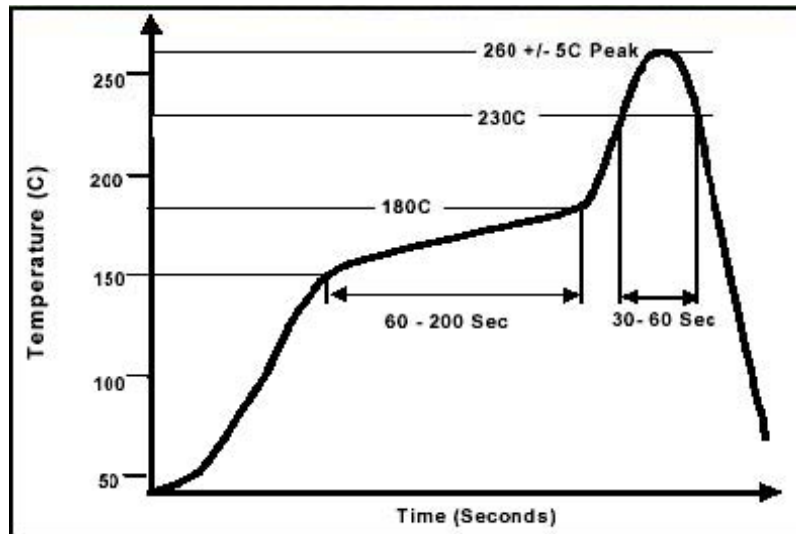
Diodes, Inc. offers most other products in an external Lead Free Finish version. These include packages SMA, SMB, SMC, DF-S, DPAK, TO-3P, TO-220, POWERDI®5, POWERDI®123 and others. Please enquire about specific product availability.

Please see the product's Data Sheet for specific Ordering Instructions. The above products are now generally available only in the Lead Free format. The plating is 100% Tin. Standard SnPb plated products as released remain available by special arrangements. New products will only be released with Lead Free plating. Contact your Sales Representative regarding continuing availability of the older versions.

Lead Free Finished products are compatible with most Lead Free soldering alloys, including such combinations as SnAg, SnCu and SnAgCu. The Lead Free Finish remains backward compatible with Lead containing soldering alloys.

All products will withstand a peak reflow temperature of 260°C for 10 ~ 30 sec. in a 230°C 60 sec. reflow zone with a preheat of 150°C to 180°C for 60 to 200 seconds. Flow soldering heat resistance is specified at 260 + 5/-0 °C for 10 ~ 30 sec.

## Standard Soldering Profile



Members of each product/package family have been tested in the Lead Free Finish Green versions. Test conditions results are as follows.

Test Item	Industry Standard	Conditions	Result
1 Plating Surface Finish	Visual	N/A	Passed
2 MSL Certification	Modified J-STD-020C	260°C Reflow Profile	Passed
3 Autoclave	JESD22-A 102	121°C, 100% RH, 96 hr	Passed
4 Temperature Recycling	JESD22-A 104	-55°C to 150°C, 1000 cyc	Passed
5 Biased Humidity	JESD22-A 101	85°C, 85% RH, 1000 hr	Passed
	JESD22-A 110	130°C, 85% RH, 96 hr	Passed
6 Solderability	JESD22-A 102	245°C, 5 sec SnPb & Sn solder	Passed
7 Medium Temp Storage Bake	N/A	50°C, 1344 hr (whisker test)	Passed
8 Plating Polymer Material Test	National Testing Center	N/A	Passed

Note: Whisker growth is controlled by precise process and material control. Material grain size is controlled to 7 ~ 8µm with no organic foreign material. Plating thickness is 5 ~ 13µm. Plating current density is controlled to < 40A.

## Experiments (1)

### 1) Purpose

To evaluate Lead Free whisker growth

### 2) Machine

Kaihong Plating Line #1

### 3) Process Flow (Applicable for Copper or Alloy 42 lead frame)

- |                 |                                     |         |
|-----------------|-------------------------------------|---------|
| • De-scale      | JQ-7                                | 40~60°C |
| • Rinse         |                                     |         |
| • De-rust       | H <sub>2</sub> SO <sub>4</sub> (8%) | 30~40°C |
| • DI rinse      |                                     |         |
| • Activation    | Sulfonic Acid                       |         |
| • Plating       | Tin concentrate                     | 1~2ASD  |
|                 | Sulfonic Acid                       |         |
|                 | Additive (XinYang)                  |         |
| • Neutralizer   | Alkalescent                         | 60~80°C |
| • DI cold rinse |                                     |         |
| • DI hot rinse  |                                     | 60~70°C |
| • Air blow      |                                     |         |
| • Dryer         |                                     | 65~90°C |

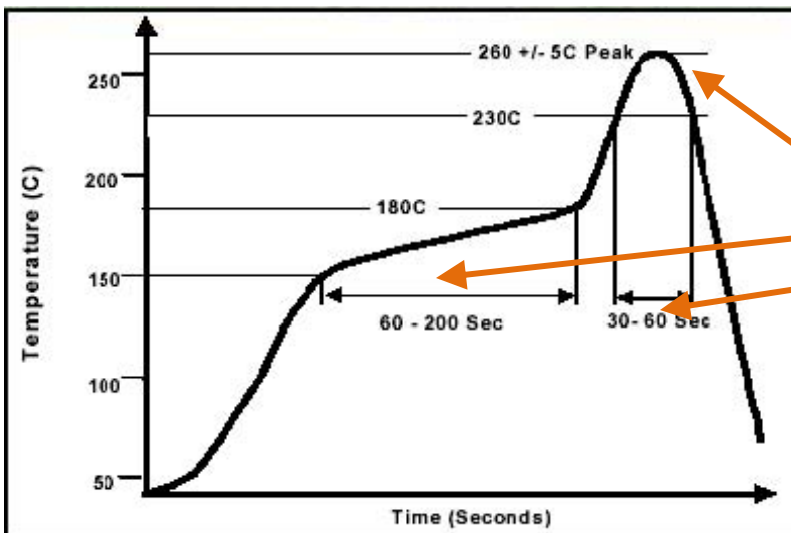
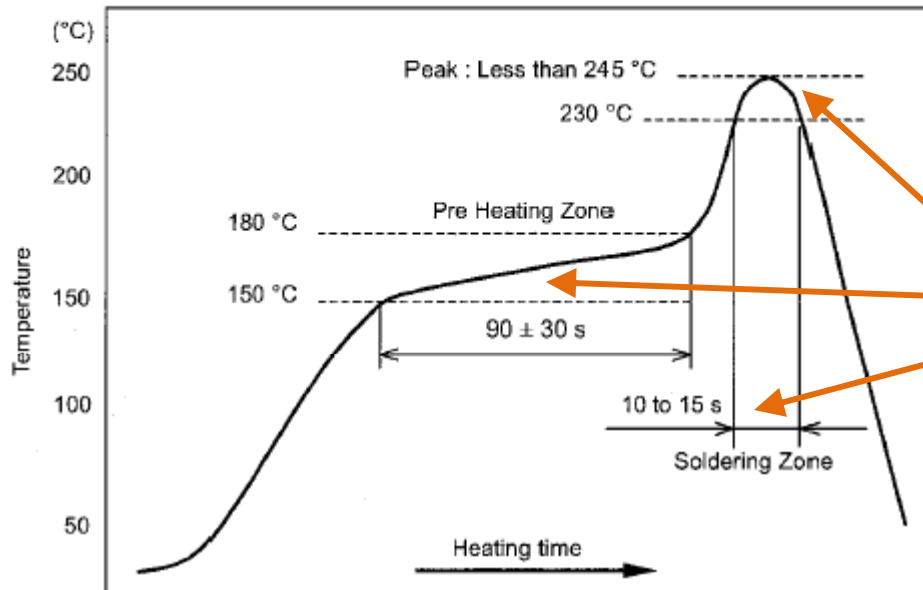
### 4) Process Control (Applicable for Copper or Alloy 42 lead frame)

- **Material Control**  
Control material grain size 7~8µm  
Control Organic foreign material
- **Process control**  
Control plating thickness: 7.5~15.5µm  
Control plating current density: <40 A

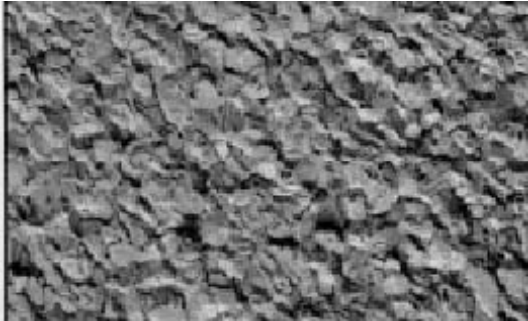


## Standard vs. Lead Free Solder Reflow Profile

Note: No changes for Green versions of the products.



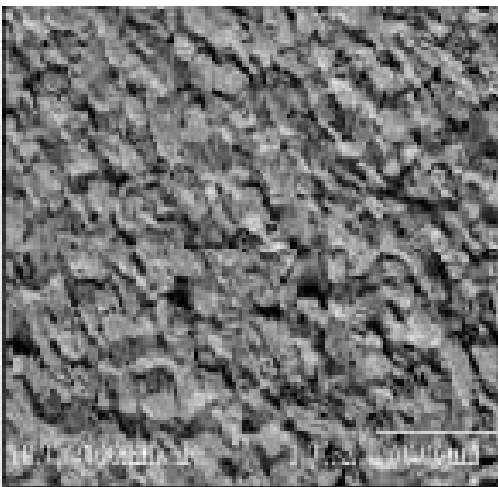
## Results of Whisker Growth Test



After 1344 hours, samples were stored at 85°C, 85%RH for 52 weeks.  
At 52 weeks, samples were inspected under 10,000X magnification.  
Maximum whisker growth on samples was observed to be 10µm.

## Whisker Growth Result (1)

### Lead Free Sample Whisker Growth Simulation / Characterization



Chemical Supplier A's Sample – 1,000X



Chemical Supplier B's Sample – 3,000X

- No whisker after 6 weeks of storage at 55°C oven bake

## Whisker Growth Result (2)

Storage Condition: 85°C and 85%RH



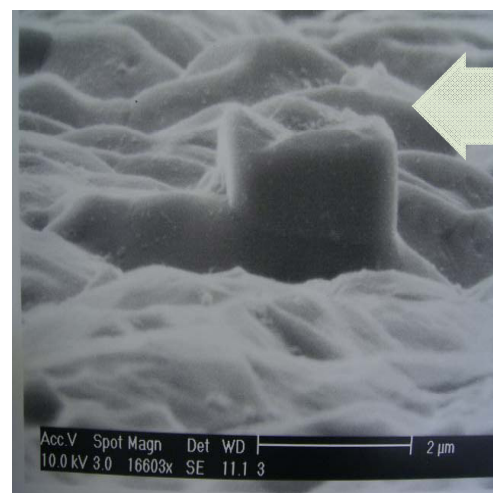
**0 weeks X2,500**



**8 weeks later X2,500**



**16 weeks X5,000**



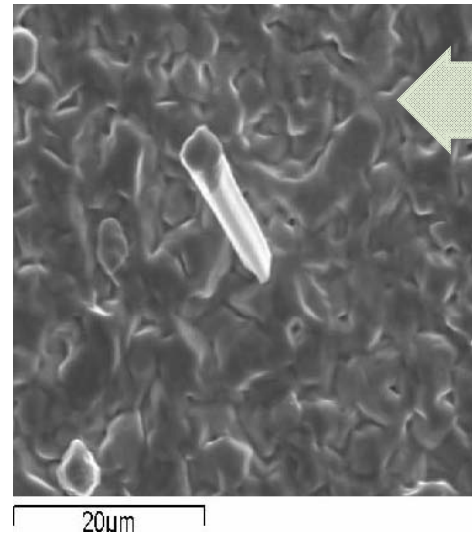
**24 weeks X16,600**

### Whisker Growth Result (3)

Storage Condition: 85°C and 85%RH



**32 weeks X10,000**



**52 weeks later X10,000**

Conclusion:

- 10 µm whisker growth after 52 weeks storage;  
Growth rate = 0.2 µm/wk
- Equal to or Better than Industry Standard