SMCC Microelectronic History and Handling Considerations

Application Bulletin 237

General Discussion

In recent years, major strides have been made in LED technology. The most significant has been the increase in output power. The technology innovations have been such that LEDs can now accept higher drive currents and, as a result, create higher output power. Being able to dissipate the heat generated by this power conversion has become a challenge. In applications where the LED die is mounted directly to a metallic substrate, such as a TO header, heat sinking has proven to be successful in handling this challenge. However, as designers turn to smaller and smaller packages, bulky substrates and headers are not a practical solution. Increasingly, new designs are using hybrid microelectronics. This application bulletin addresses the history of these products as well as some of the precautions necessary in handling the hybrid devices developed by TT Electronics / OPTEK Technology.

History

The first hybrid devices were made using traditional PC board materials and hard, optically clear epoxies. The major advantage was that these materials had been used for decades in other applications and other package styles. Being well known made acceptance of the new package styles quite easy. Another significant advantage was that hard epoxies easily protect the contents of the hybrid while being very smooth and fairly resistant to contamination – or at least easy to clean. For many years, this construction was very successful and led to many useful products; however, in recent years LED technology has caught up with some of the limitations of this packaging method.

The Problem

Put simply, the problem is that every material expands due to increases in temperature. As the required power dissipation of newer LEDs has increased, so has the heat generated. At the same time, the materials used in creating higher power LEDs have become increasingly fragile. So, the situation is that as heat is generated, the hard epoxies begin to expand; and, because they are rigid, they begin to exert stresses on the surfaces of the die. As a result, stress fractures can be induced in the die. Not only can these fractures lead to occasional product failures, they can often lead to latent failures – which is an absolute catastrophe for any design.

The Solution

The solution is to use a less rigid material in place of the epoxies. The material of choice is now silicone based rather than epoxy based. There are several advantages to using a silicone based material. First, silicone compounds are more readily available as single part rather than two part compounds. This means that the working life is usually months, rather than hours. Second, silicone compounds usually have a higher upper operating temperature limit. This means that the list of environments in which these devices can operate has broadened. Third, and most important to this discussion, is that silicone compounds are flexible after curing.

It is true that the silicone compounds expand as the temperature increases – just as their epoxy counterparts. However, since they are flexible, they exert proportionally less stress on the surface of the die. As a result, the high reliability that these devices have enjoyed for years can still be enjoyed without have to fabricate the packages from more costly materials or attached to bulky heatsinks.

As might be imagined, as with any other technological advances, along with the benefits of using silicone based compounds come some precautions which must be addressed. Bear in mind that using epoxy compounds in hybrids means that they <u>should not</u> be used with newer, higher power LEDs. Using silicone compounds in hybrids means that they <u>can</u> be used with newer, higher power LEDs as long as care is taken in the handling of them.

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Mechanical Handling

The rigid parts of the hybrid, namely the frame and substrate (top and bottom) layers, are just as resilient as they always have been. However, the flexibility of the silicone potting compound requires new considerations. Most manual handling of microelectronics means the use of tweezers. Even the dullest pair of tweezers can cause damage to the silicone. The creation of a hole in the silicone can mean a change to the optical properties of the silicone. If a silicon-to-air interface is created in the silicone, light entering or leaving the package may become refracted or reflected, and this can lead to undesirable nuances in the behavior of the part. Second, being able to insert any object into the silicone means that die surfaces can be contacted, and therefore, damaged. Third, the flexibility of the material means that it can be compressed or temporarily shifted. This can lead to die being sheared or irreparable damage being caused to delicate contents such as wirebonds.

A good general rule-of-thumb is that care should be taken to completely avoid touching the silicone. When grasping a hybrid, grasp it by the sides rather than the top and bottom.

Contamination

The nature of silicone is that it is more ionized than epoxy. This means that loose particulates that come in contact with the silicone are more likely to adhere to its surface than with epoxy. In addition, the surface of silicone is not nearly as smooth as that of an epoxy. So, loose particulates which do come to rest on the surface of the silicone usually cannot be removed as easily as being swiped with a lint free swab or paper. A liquid is often required in addition to the lint free material for cleaning as well as some mildly aggressive abrasion.

It is recommended that hybrid devices be left in their original packaging or at least in their shipping tubes until ready for use. Alternatively, units which must be removed from their tubes can be stored in a clean environment, such as a dry box, prior to use.

Soldering

Hybrid devices lend themselves very well to industry standard solder reflow processes. This is true of leaded and lead-free processes. While proper care is taken, hand soldering is acceptable – but not encouraged. Oftentimes, because hybrid packages have many more contacts than discrete components, more heat is applied to the device than the operator is aware of. This can lead to many of the other problems discussed in this note. Special attention should be given to the absolute maximum soldering conditions shown on each product's datasheet.

The following diagram shows a commonly used temperature profile for lead-free solders. The process engineer should evaluate the solder being used to ensure that the temperatures required for that solder do not violate the maximum solder profile shown. It should be noted that using a solder that requires a lower solder profile is perfectly acceptable provided it meets the requirements of the application.

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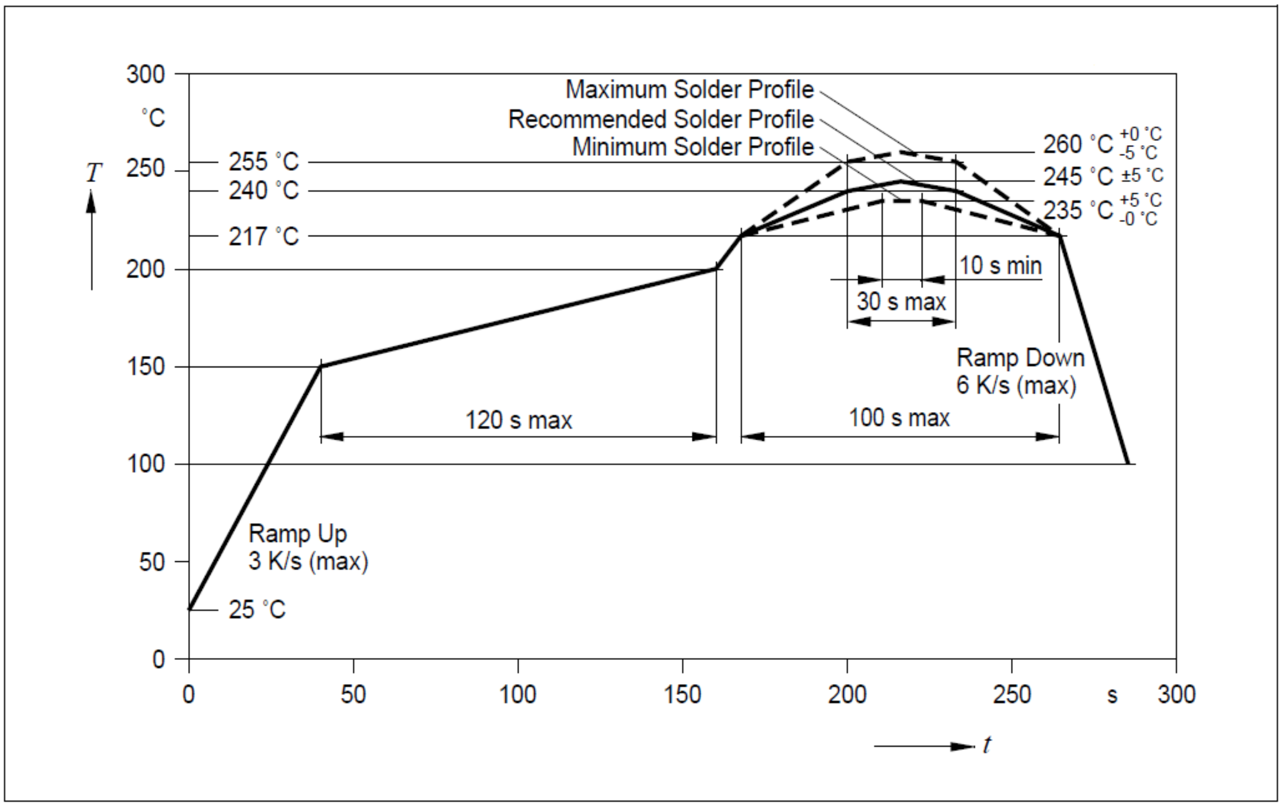
Soldering Conditions, Typical Lead-Free



Humidity (and Soldering)

It is common sense that microelectronics, as a general rule, should not be exposed to moisture. Hybrid devices with silicone potting are no exception. The structural material of the hybrid devices can absorb moisture, provided they are left in a humid environment. So can the silicone – and to a much greater degree than epoxies. As heat is applied during the soldering process (temperatures during soldering exceed the vaporization point of the water), small pockets of steam can be created. This steam creates pressure inside the package. Because the silicone is flexible, it gives; and, while this movement will not damage the surface of the die, it can be strong enough to shear the die or tear wirebonds. In addition, since it is possible for the corners of the die to have small air gaps below them (usually only 75% die coverage of die mount epoxy is required for qualified die mount processes), moisture turning to steam in these gaps can push directly on the die causing it to shear.

To establish a means of handling this situation, the JEDEC standards committee has developed guidelines for determining the moisture sensitivity level of these devices as well as how to manufacture, label, ship, and process these devices. Those guidelines are outlined in J-STD-033 and J-STD-020, respectively. In accordance with these standards, Optek has tested its SMCC family of products and classified them as Level 3. This classification means that the devices may be exposed to standard factory conditions (less than 30°C and less than 60% relative humidity) for a total of 168 hours before needing to be re-baked prior to any soldering operations. Given that Optek requires some time to test, inspect, and package devices, it has reserved 72 hours for internal operations. As such, the devices ship to the customer as a Level 4 device, which means their maximum exposure time is 72 hours. Also, in accordance to the standards, all Optek SMCC devices are shipped in dry pack and appropriately labeled.

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What does this mean for the customer? As long as the dry pack is unopened, the parts will stay dry for a minimum of 12 months (the actual calculated time appears on the warning label). However, in a lower volume manufacturing operation, prototype line, or engineering environment, it is natural to assume the dry pack will need to be opened and closed several times. The amount of open time is considered cumulative against the 72 hour maximum exposure time. So, the dry pack can be opened, closed, and re-opened and re-closed as many times as necessary as long as the total time does not exceed the maximum exposure time. This provides the customer flexibility on how and when to use the devices. As soon as a device is removed from the dry pack, its exposure time starts up again. Note that storing devices out of the dry pack but in a < 5% RH dry box is not considered part of the cumulative exposure time.

What do you do if parts exceed the maximum exposure time? The parts must be re-baked, and the following apply:
If it is acceptable for the customer to remove the parts from the dry pack and inner packaging (shipping tube, waffle pack, or tape and reel), the customer may bake the parts at 125°C for 17 hours. If there is any concern about this temperature, the customer may alternatively bake the parts at 90°C and less than 5% RH for 2 days.
Otherwise, the parts may bake the parts in the inner packaging (but out of the dry pack) at 40°C and less than 5% RH for 23 days.
Once the parts are baked, they may be repackaged (in the case of (a)) and placed in a dry pack with fresh desiccant and new moisture indicator card. At this point, the cumulative exposure time is reset.
Once baked, the parts are now classified as Level 3, increasing the maximum exposure time to 168 hours.

It is important to note that even once the devices are soldered, the cumulative exposure time does not pause or reset. If the devices are expected to undergo reflow conditions in the future, they must still be handled the same as bare devices, observing the conditions already established herein. It is acceptable to bake the parts multiple times if there are multiple soldering operations and a dry environment cannot be maintained. Once all soldering operations are completed, exposing the parts to humidity is acceptable.

A note about storage temperature: Optek defines storage temperature (as it is shown on the datasheets) as the maximum allowable ambient temperature a device may be exposed to when not in operation. However, the storage temperature that is acceptable for the dry packs is different given that the inner packaging materials cannot take as much heat. The acceptable temperature range for Optek dry packs is –25 °C to +70 °C.

NOTE: The information in this section is taken from J-STD-020 and J-STD-033 as it pertains to Optek SMCC devices. The customer is strongly encouraged to review these documents, especially J-STD-033, and handle the devices accordingly. In the event where this application bulletin conflicts with any information in these two standards, the standards take precedence.

Summary

Given the need for smaller and smaller devices, designing with hybrid microelectronics will become more necessary going forward. And, with brighter and brighter LEDs requiring more and more power and heat dissipation, flexible compounds such as silicone, which can absorb the heat without detrimental effects, will also become more common. Learning how to deal with the limitations of these materials with process controls and operator training will be key to their success.

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