Soldering and Rework of UnitedSiC THT Devices

Jonathan Dodge, P.E.
Soldering and rework

1 Scope

This document provides recommendations for soldering and rework of UnitedSiC through-hole technology (THT) devices, including (but not limited to) TO-247 with three or four leads, and TO-220. Included are recommendations for production assembly soldering as well as rework.

2 UnitedSiC THT Construction

UnitedSiC THT devices are constructed on a 100 % matte tin plated copper lead-frame, as shown in a cross-section drawing of a TO-247 below in Figure 1. The TO-220 and other THT device construction are similar.

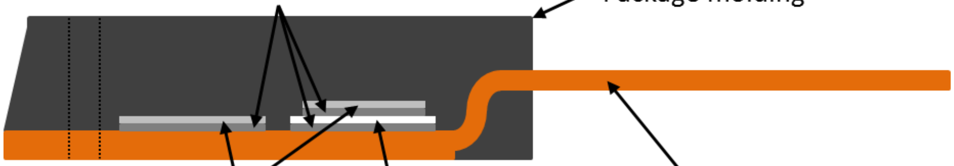

Figure 1 Cross section of TO-247 (bond wires excluded and some proportions exaggerated for clarity)

In the case of SiC JFET and SiC junction-barrier Schottky diode, the chips are attached directly to the lead-frame with either high-temperature solder or silver sintering. The low-voltage MOSFET used in cascode devices is mounted on a ceramic substrate. The ceramic substrate is often referred to as DBC, which stands for the direct bonded copper, with the top-side copper forming a printed circuit pattern.

All Generation 3 (part number begins with UJ3 or UF3) and newer JFETs and cascodes use silver sintering. UnitedSiC diodes except some rated at 50 A or higher are silver sintered. Silver sintered connections maintain integrity at temperatures of several hundred degrees C, and therefore there is no concern of re-melting sintered connections during PCB assembly or rework processes. A further advantage of silver sintering versus solder is significantly reduced thermal resistance between the chip and the copper lead-frame, which results in a lower junction-case thermal resistance listed in datasheets. All cascodes prior Generation 3 use high-lead content, high-temperature solder that melts at 380 °C.

All UnitedSiC products are RoHS compliant, even those that use solder instead of sintering. Use of lead in high melting temperature solder is allowed by the RoHS initiative.

3 Reflow Soldering

The major process steps in reflow soldering include application of solder paste to pads on the circuit board, placement of components onto the solder paste, preheating, solder melting, and cooldown. Although reflow soldering is typically used for surface-mount technology (SMT) devices, UnitedSiC THT devices are compatible with reflow soldering providing the maximum temperature reached is less than 300 °C. It is recommended to limit the time duration at temperatures above 250 °C to 10 seconds or less.

4 Wave Soldering

The major process steps in wave soldering include fixing the THT components to the circuit board and/or heat sink on the board, preheat, passing the circuit board assembly across one or more waves of molten solder, and cooldown. The process may also include application of flux before the soldering process, and washing afterward.

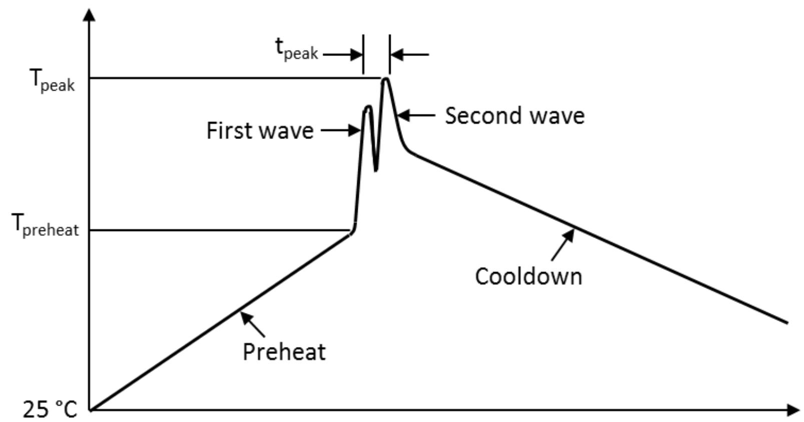

Figure 2 Typical dual-wave solder profile

All UnitedSiC THT devices are compatible with wave soldering processes providing the maximum temperature of the solder is less than 300 °C. It is recommended to limit the time duration of leads exposed to solder at temperatures above 250 °C to 10 seconds or less. In the recommended dual-wave solder profile of Figure 2, T_{peak} is 235 or 260 °C for tin-lead or lead-free solder respectively, and the maximum duration at both peaks combined is 10 seconds. The preheat temperature $T_{preheat}$ is typically 100 to 130 °C.

Bond wires are not shown in Figure 1, but wire bond connection integrity is an important factor relating to rapid, extreme temperature cycling. A THT device should not be immersed into molten solder. Only the leads should be exposed to the molten solder, preferably after preheating.

5 Manual Solder and Rework

Solder iron tip temperatures commonly far exceed 300 °C, which is necessary to preheat the device lead and the PCB pad, and to melt the solder so that it flows and adheres to make a good solder joint. Using the minimum solder iron tip temperature to make a good solder joint is recommended. However, minimizing the soldering time is more important than minimizing iron tip temperature. Substantial heat is drawn away from the joint by the circuit board and the device lead, especially if a JFET/cascode drain lead or diode cathode lead is being soldered. This requires the iron tip temperature to far exceed the melting temperature of the solder being applied in order to quickly make the solder connection. The lead-frame temperature near a semiconductor chip is much lower than the iron tip temperature, unless the iron tip is left in direct contact with the device lead for an excessive duration. Therefore, the maximum lead temperature for soldering in UnitedSiC datasheets is not to be interpreted as the maximum solder iron tip temperature. The following practices generally ensure safe solder and rework of THT devices.

- Use thermal relief patterns on circuit board pads, which are “spokes” that connect from the plated through-hole to copper pour and internal plane areas. See Figure 3 for an example. Connections to power planes are very common for THT power devices. Eliminating thermal relief patterns in an effort to improve electrical performance makes circuit board assembly impractical and unreliable because too much heat is drawn away during the solder process, forcing far excessive solder time.

- Use an appropriate solder iron tip. Tips that are too small or too pointed have insufficient mass to quickly transfer heat, thus increasing the solder time unnecessarily. A chisel tip is generally a good choice for soldering THT leads.
- Wait until the solder iron tip temperature has reached its operating temperature before attempting to solder. Most quality solder irons reach their operating temperature within a several seconds of being powered on.
- Apply flux if needed.
- Wet the solder tip with solder.
- Preheat the circuit board pad and the THT device lead by contacting them both with the wetted solder iron tip.
- Apply more solder as needed to get a good fillet between the circuit board pad and the THT device lead, and then immediately remove the iron tip from the solder joint area.

For removing THT devices for rework, if at all possible, remove or thermally separate the THT device from its heatsink first. Use a desoldering tip with a vacuum system and filter to remove the molten solder. A desoldering tip is hollow, allowing it to fit over the THT device lead, thus quickly and uniformly melting the entire solder joint. It is preferable not to use a hot air gun for rework because the heat may degrade adjacent solder joints.

Following these guidelines, solder joints can be consistently made or removed in less than 5 seconds. It should never take longer than 10 seconds; otherwise something should be corrected in the circuit board design, soldering or rework process, and/or soldering equipment.

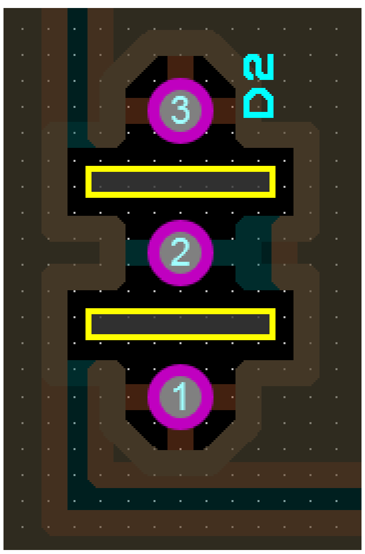

Figure 3 Example of thermal relief "spokes" to TO-247 leads, with slots between leads to increase creapage distance