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A Better Package For Rad Hard MOSFETs: PCBs Meet Their (CTE) Match

IR HiRel, an Infineon Technologies company, has introduced fourteen newly QPL-qualified radiation-hardened (rad hard) MOSFETs housed in an innovative direct-to-PCB mounting package called the SupIR-SMD. This new proprietary package overcomes the challenge of reliably attaching surface-mount hermetic power packages to PCBs in space applications, where different thermal coefficients lead to an expansion mismatch of different materials (Fig. 1). With its ability to improve the thermal performance of rad hard power MOSFETs, the SupIR-SMD enables higher-performing space power systems such as satellite bus power distribution systems, payload power supplies, space-grade dc-dc converters, and other high-switching designs.

Capable of attaching directly to the PCB, the SupIR-SMD design is optimized for surface-mount attach and proven to meet the most stringent reliability testing in this configuration, according to the vendor, as detailed in IR HiRel's application note #1222. Compared to the typical packaging solution used in space applications, the SupIR-SMD is said to deliver a 37% smaller footprint, 34% lighter mass and 33% higher current density, while offering a more-direct thermal path for heat transfer.

"The SupIR-SMD package is testament to IR HiRel's commitment to deliver innovation that exceeds the specific requirements of the space market," says Eric Toulouse, vice president and general manager of IR HiRel.

Traditionally, designers resort to a "dead bug" and lead configuration, where the packages are flipped upside down and soldered to the PCB via leads. Dead bug soldering dissipates heat sub-optimally and decreases MOSFET power capacity (Fig. 2). But with the SupIR-SMD, system designers can optimize power system efficiency through direct mounting of the package to the PCB, enabling the shortest thermal conduction path without compromise in system reliability.

According to Andrew Popp, director, marketing—space products at IR HiRel, there were two factors that drove development of the SupIR-SMD package. First, IR HiRel is not only a supplier of rad hard MOSFETs, it is also a user of these devices as it also produces pc-board based, rad hard dc-dc converters. As Popp observes, "Our internal dc-dc converter group was driving us to develop this package."

The second factor was the low $R_{DS(ON)}$ of its R9 superjunction MOSFET technology—the first products produced in this process were released in 2017. Because the on-resistance of the R9 MOSFETs was so low, the resistance of the package's interconnects became a factor. "So we were looking at the package to see what we could do to improve it," says Popp. "SupIR-SMD can fit more wires into the package and die, so we can reduce the inherent packaging resistance, so it's not greater than the die $R_{DS(ON)}$."

R9 is one of several rad hard MOSFET processes offered by IR HiRel. The chart in Fig 3 shows which voltage ratings and die sizes are offered with the R9 process technology versus the company's other rad hard MOSFET processes. The SupIR-SMD accommodates the largest die size (#4) and is essentially an enhanced version of the SMD-2. A smaller version of that package is the SMD-0.5, which accommodates the next largest die size (#3). IR HiRel also plans to offer an enhanced version of the SMD-0.5 that will be similar to the SupIR-SMD. (For more on these packages, see the website.)

The SupIR-SMD package is JANS-qualified to MIL-PRF-19500. JANS is the most rigorous level of screening and acceptance requirements available to assure the performance, quality and reliability of discrete semiconductors intended for space. The new rad hard MOSFETs are also QPL-qualified in accordance with the Qualified Products List (QPL) for space applications.

The SupIR-SMD QPL-qualified rad hard MOSFETs can be ordered now with the MIL-PRF-19500 package identifier U2A. For more information, see the SupIR-SMD application note AN-1222 or see the SupIR-SMD web page.

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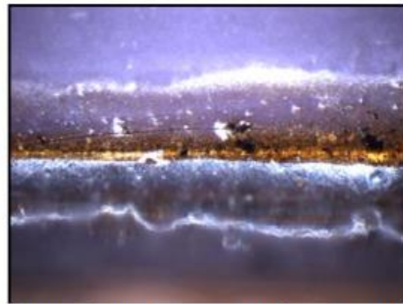

Stress fracture in a surface mount device on a circuit board

Surface mount device stress fracture

Fig. 1. CTE mismatch is a recurring problem in space power electronics where the CTE mismatch—between a hermetically packaged power MOSFET and the pc-board on which it's mounted—creates two challenges. One is maintaining reliable solder joints at the interface. Another is preserving the sealed integrity of the hermetically packaged power MOSFET. Even small CTE mismatches can produce thermally induced stress fractures at the interface as illustrated here.

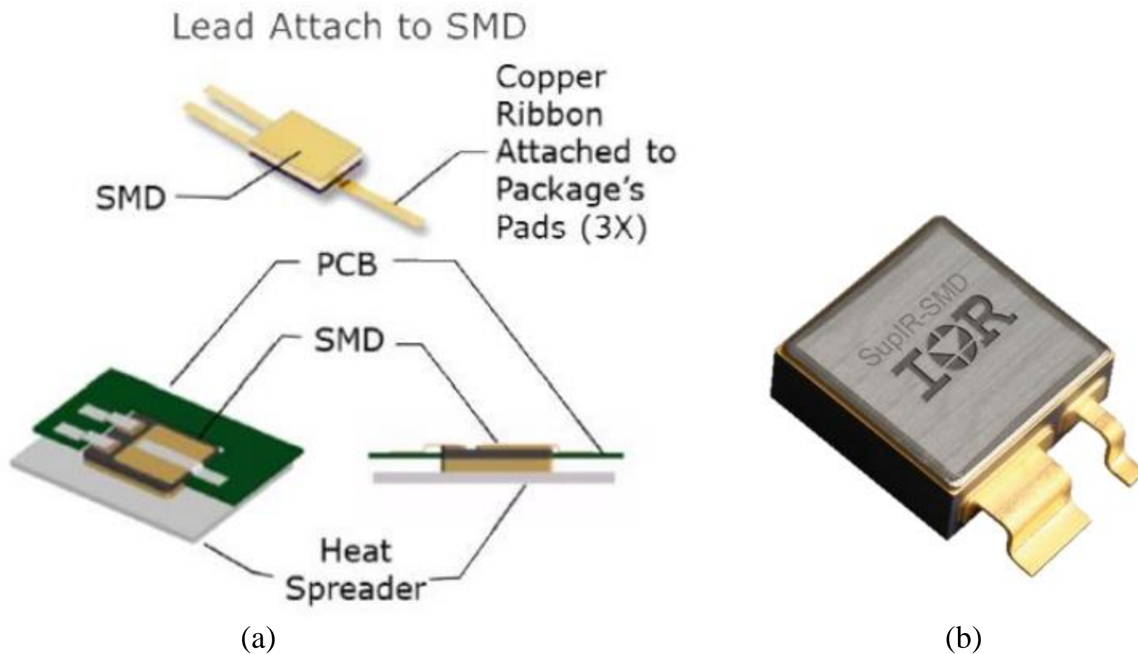

Fig. 2. A common space industry practice to address the CTE mismatch problem is to add package leads or carrier options. For example, in "dead bug" and lead configuration (shown in (a)), the package is turned upside down and soldered to the PCB via leads. This overcomes the fracturing issue, but dissipates heat sub-optimally, which reduces the power that can be dissipated by the MOSFET, essentially derating the part. Optimized for surface-mount attach and capable of direct-to-PCB mounting, the SupIR SMD (b) relieves thermally-induced stress in the solder joint between the PCB and device package, while also minimizing thermal and electrical resistance.

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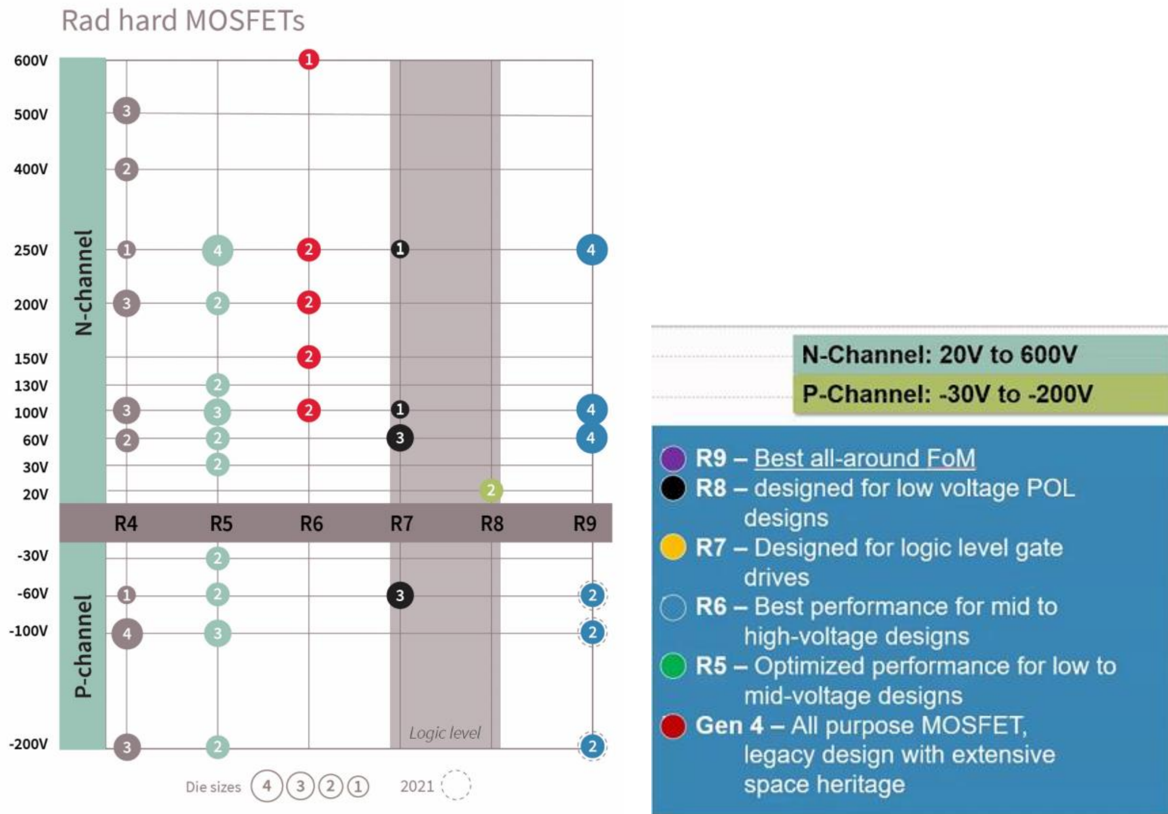

Fig. 3. IR HiRel's rad hard MOSFET portfolio.

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