Study of packaging reliability of two SiC Schottky diodes of power electronic

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Abstract

This study deals with reliability methods developed for power electronic devices dedicated to the aerospace industry, because the reliability is a key issue for safe aerospace applications. Based on end-user requirements, eight different types of non-hermetic power electronic components in standard plastic package have been selected from the commercial marketplace, in particular Si and SiC power electronic devices. These devices are COTS (Component Off The Shelf). The main failure modes and mechanisms expected have been highlighted in specific environments in accordance with the literature. They will be presented in the final paper.

According to IEC standards, six reliability tests are defined in order to reproduce these main failure modes and mechanisms. The experimental conditions of IEC standards have been modified and adapted to test these power electronic devices. These six reliability tests are H3TRB (High Humidity, High Temperature Reverse Bias), HTRB (High Temperature Reverse Bias), HPET (Humidity Popcorn Effect Test), RCT (Rapid Change of Temperature), power cycling and HTFB (High Temperature Forward Bias). Currently, the behavior of two types of SiC Schottky diodes is studied implementing the tests.

The technologies of these diodes have been investigated and will be described in details in the final paper. It is pointed out that the main difference between both diodes is the die attach material. One of these diodes has a lead-rich solder (PbSnAg) with a content > 85 wt. % (Pb) and the other has a lead-free solder (SnAgSb). It would be interesting to compare these die attach materials for COTS devices. Several components of both diodes have finally failed in power cycling tests with the harshest experimental conditions: junction temperature delta $\Delta T_J = 90°C$ and maximal junction temperature $T_{J\,Max} = 175°C$. The SAM (Scanning Acoustic Microscopy) analyses of the failed devices highlight the occurrence and the propagation of delaminations or significant physicochemical changes in the die attach solders. Cross sections of the first six failed devices have shown that both previous suppositions are the cause of the failure. For the devices with lead-rich solder, the formation of dendrites of Pb near the die and the propagation of cracks in the solder has been observed, with Scanning Electron Microscopy (SEM). For the others, an important diffusion of Intermetallic Compounds (IMCs) and the occurrence of voids under the die at the level of wire bondings have been highlighted. Currently, the physicochemical mechanism of ageing is under investigation and it will be described in the final paper. The failure of these devices appears before 11,000 cycles which corresponds to less than 13 days of power cycling test. Therefore, more results on the power cycling test will be presented in the final paper.

The final aim of this study is to use the failure results according to different experimental conditions to elaborate or help to improve existing physical models of failure.

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