Study of the reliability of the assembly of power electronic devices for aerospace applications

V. Huleux[a, b], G. Parent[a], O. Maire[a], G. Massiot[a], V. Rouet[a], C. Munier[a]

[a] *Airbus Group Innovations, 12 rue Pasteur, 92150 Suresnes, France*

[b] *Ecole Nationale Supérieure d'Ingénieurs de Caen (ENSICAEN), 6 Boulevard du Maréchal Juin, 14000 Caen, France*

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Abstract:

This study deals with reliability methods developed for power devices dedicated to aerospace industry, because reliability is a key issue for secure aerospace applications. Based on user requirements, several types of devices all made of, at least, one SiC die, are selected from the commercial marketplace for their theoretical performance. The main failure modes and mechanisms expected have been highlighted in specific environments in accordance with the literature [1].

According to standard, several reliability tests are defined in order to reproduce these main failure modes and mechanisms. In this study, only two reliability tests are undertaken: H3TRB (High Humidity, High Temperature Reverse Bias) and Power Cycling.

Currently, two types of SiC Schottky diodes are tested in several conditions of these tests. The main difference between the two diodes is the material of the die attach. One of these diodes has a lead-rich solder: content > 85 wt. % (Pb). The other present a lead-free solder as die attach material. Currently, lead-rich solder with a content superior to 85 wt. % (Pb) is still in compliance with the first RoHS (Restriction of Hazardous Substances) directive which limits the use of Pb in electronics: content > 0.1 wt. % (Pb). The lead-rich solder could be impacted by the next RoHS directive and it would be interesting to compare the two types of solder as die attach material for electronic devices [2].

Unfortunately, several components of the lead-free solder diodes have been failing only in power cycling tests with the harshest experimental conditions. Non-destructive and destructive tests have been performed on these devices with the aim of observing, analysing, and understanding the physicochemical mechanisms of failure [3]. The SAM (Scanning Acoustic Microscopy) analyses of the failed devices highlight the occurrence and the propagation of delamination or significant physicochemical changes in the die attach solders (see *figure 1*). Cross sections of failed devices have shown that both previous suppositions could be the main cause of failure. Currently, the physicochemical mechanism of aging is not correctly identified yet.

Different experimental conditions are planned in order to elaborate or to help enhancing physical models of failure under power cycling.

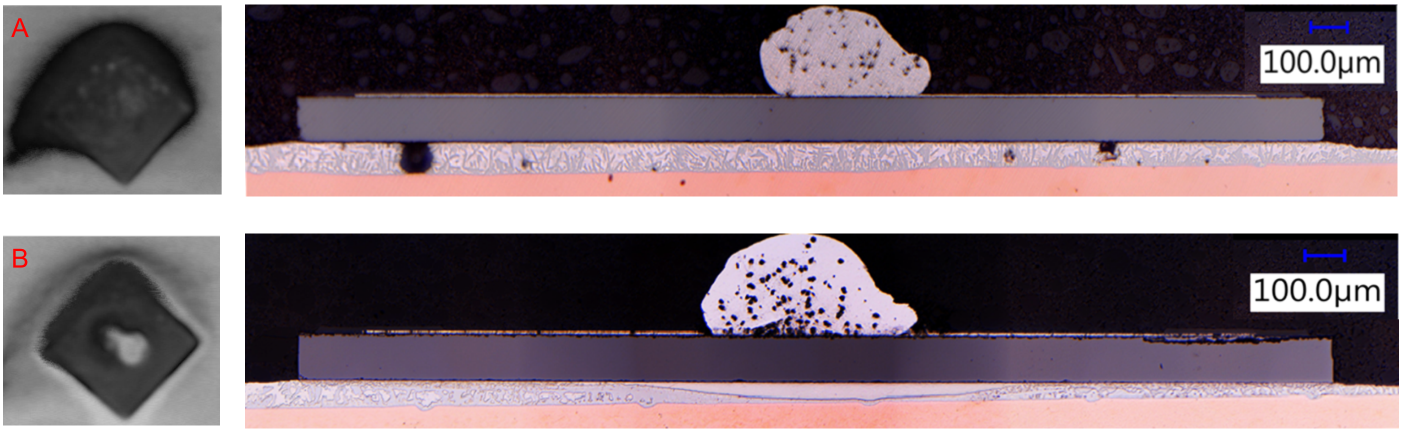

Figure 1 - Scanning acoustic microscopy pictures at the die/solder interface on the left and optical microscopy pictures on the right.   A: Before failure; B: After failure in Power Cycling

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