Identification method of the resin shrinkage: Application to woven composite used in Power Electronics

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Abstract

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Printed circuit boards (PCB) are a fundamental part of any electronical device. PCBs are essentially made of copper (conductive material) and woven glass fibers embedded in a polymeric resin (structural and dielectric material). One of the PCB manufacturing step is hot pressing to ensure the adhesion between the copper and pre-impregnated composite by curing the resin within the composite (leading to a shrinkage). Unfortunately, the resin and its thermo-mechanical properties are not available which make difficult the development of a predictive FE model (1,2).

Therefore, a two step method was developed to determine the effective shrinkage associated to the woven composite (3,4). First, hot pressing and curing composite layers on top of already cured layers result in a bent plate due to difference in strain history. Second, identification is carried out based on the plate curvatures acquired by Digital Image Correlation. Note that effective shrinkage is a homogenized property, resulting from the real chemical shrinkage of the resin, interacting with the glass fibers (which do not shrink).

Clearly, the effective shrinkage depends on the thickness (or more precisely on the local volume of constituents), whereas the plate thickness was assumed uniform in previous studies (3,4). Therefore in this work, thickness measurement and cross-sectional optical observations were carried out and actually revealed a difference in the thickness distribution and fiber/resin volume fraction. Thermo-mechanical properties are significantly different between the center and borders of the plate due to a heterogeneous resin flow during the hot pressing stage.

From the thickness and volume content measurements, a numerical model has been developed using Abaqus™ FEM Software (5). In the present simulation, the bent plate is modeled using shell elements. The local thermo-mechanical properties are obtained following the work of Girard et al. (6). A better restitution of the experimental measurements is given by the model, demonstrating the added value to the existing method. Finally, a precise value of the

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chemical shrinkage of the resin is given.

Key-words: Resin shrinkage, Woven Composite, Numerical identification method, Multiscale homogenization, Printed Circuit Board.

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