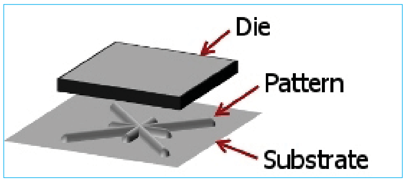

Figure 1: Schematic of the die attachment process

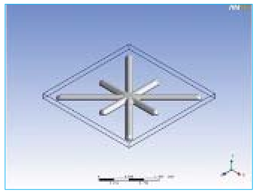

Figure 2: Analysis of a Large Die Attachment with an Epoxy Adhesive

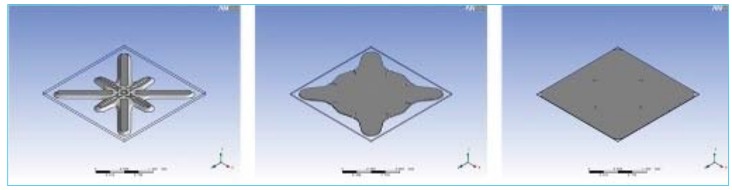

Figure 3: Three snapshots during attachment using a viscoelastic epoxy.

Analysis of a Large Die Attachment with an Epoxy Adhesive

Die attachment is an important process in the packaging of silicon components and will have ramifications on a wide range of electronic products, from mobile phones to digital televisions. The quality of the bond between the die and substrate will be critical to the longevity and operation of an electronic device. If the bond quality is poor, thermal and/or mechanical stresses will cause the die to lift or crack when it is put into use. In the fast paced market of consumer electronics, frequent product failures or recalls will be damaging to a manufacturer's good reputation and ability to stay competitive. It is imperative to the development of reliable package assembly processes that an accurate and efficient means to predict bond quality be available.

In a typical application, such as large die attachment using either conductive or non-conductive epoxy adhesives with pattern writing (see figure 1 above), bond quality is sensitive to several factors and cannot be easily predicted a priori. Factors affecting bond quality include the initial pattern, attachment speed, bond-line thickness, and the properties of the epoxy. Epoxies exhibit complex reactions to even simple shear conditions due to their shear thinning and viscoelastic characteristics; therefore, standard Newtonian models of material properties commonly available in CFD codes are not robust enough to accurately predict the quality of a bond.

The customizable features of the ANSYS-CFX software allow the engineer to expand upon the solution set by solving standard transport or Laplacian equations for additional variables. CFX users can employ this capability to implement material models that will account for the more complex

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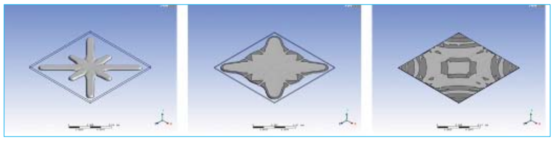

Figure 4: Three snapshots during attachment using a Newtonian epoxy.

characteristics of epoxies. Shear -dependent viscosities can be easily and quickly introduced into CFX through CEL (CFX Expression Language) expressions.

For the case of die attachment, CAE Associates has implemented a Carreau-type viscosity model to represent the shear thinning characteristics of the epoxy. The total stress response of a viscoelastic material is a combination of its Newtonian and viscoelastic components. The evolution of the viscoelastic stress tensor is tracked via the White-Metzner differential model and is incorporated into the momentum equations as a source term. The resultant material model includes six additional transport equations for the six components of the symmetric viscoelastic stress tensor.

A comparison of the attachment process and the resultant bond demonstrates the importance of the viscoelastic properties of the epoxy. Figure 2 shows the initial pattern of epoxy and figures 3a and 3b show the epoxy at 3 different times during the attachment process for a 20 mm × 20 mm die using viscoelastic and Newtonian epoxies, respectively. In both cases the volume and shape of the initial pattern are the same and the bondline thickness after attachment is 0.1 mm.

The black outlines demarcate regions of complete adhesion (indicated in dark gray) from voids (indicated in light gray). Notice that the Newtonian model of the epoxy incorrectly predicts large voids. As the die is lowered, a pressure front spreads out the Newtonian epoxy so that air becomes trapped at the center of the die. The more realistic viscoelastic material model correctly predicts an evenly distributed adhesion of the die. The elastic forces in the viscoelastic epoxy maintain the shape of the pattern until contact with the die so that only few very small voids are formed.
The dramatic difference between the two results shows the importance of using correct material models in these types of analyses. In this case, the ability of ANSYS-CFX to easily incorporate complex material models means the difference between obtaining a true solution to the problem and meaningless computational results. ANSYS-CFX provides an efficient and accurate means to refine the die attachment process.

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