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Hygro-Thermal Behaviors of an ACF-typed Ultra-thin Chip-on-Flex Interconnect Technology

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Summary

Due to the strong demand of electronic products with light-weight, flexibility and portability and rollability from consumers, the development of flexible electronics with flexible interconnects is presently underway. Flexible electronics is a technology that extends electronics devices beyond the rigid form factor. It is highly recognized that it can bring a very vigorous drive toward the new flourish of economic growth in the electronics industry.

In the study, a flexible interconnect technology based on an ultra thin chip and a very thin flexible polyimide (PI) circuited substrate is developed, as shown in Fig. 1. The electrical interconnects and also thermal-mechanical connections of the technology are formed through a piece of anisotropic conductive film (ACF). It is thus termed ACF-typed ultra-thin chip-on-flex (UTCOF) interconnect technology (i.e., ACF-UTCOF in abbreviation) throughout the study. The technology is promising and potential for a variety of flexible electronics applications, such as flexible display, paper-thin smart labels, particularly the RFID labels, miniaturized medical electronic systems, E-paper, E-label and memory chip stacking etc. Before the full and successful realization and implementation of the ACF-UTCOF technology, many technical challenges need to be resolved, including reliability and bendability.

Thus, the study aims at the investigation of the hygro-thermal behaviors of the advanced ACF-UTCOF technology during high temperature and humidity condition through transient moisture content model analysis of the Fick law using finite element (FE) modeling and experimental validation. The considered hygro-thermal behaviors include moisture saturation time, moisture diffusion rate, moisture concentration, moisture diffusion coefficient, saturated moisture concentration. To achieve the goal, an ACF-UTCOF test vehicle is first constructed for subsequent testing and characterization, and the humidity property of the PI substrate is determined by measuring the weight gain during moisture absorption, shown in Fig. 2. Next, the dependences of the relative humidity and saturated moisture concentration and also the moisture diffusion rate of the ACF applied on temperature are characterized through moisture absorption experiments, as shown in Fig. 3. In addition, strains/stresses induced from hygro-thermal effects are examined through three-dimensional (3D) transient moisture analysis of the Fick law. Finally, the influences of the hygro-thermal stress relaxation of the ACF on the hygro-thermal-induced mechanical behaviors.

FE simulation results reveal that most of moisture diffuses into the ACF layer directly through the substrate side rather than the periphery of the ACF. As shown in Fig. 4, the ACF-UTCOF test vehicle is saturated after about twenty hours under an 85C/85% relative humidity condition test. Most importantly, from the experimental results, it is found that the moisture effect would play a much more significant role in reliability than the thermal effect.