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Experimental/numerical analysis on the thermal-induced warpage of ultra-thin chip-on-flex (UTCOF) interconnects

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Summary

For future growing applications in flexible display and wearable electronics, the need of three-dimensional stacking flexible interconnects increases rapidly. One of the core technologies is the development of ultra-thin chip-on-flex (UTCOF) interconnects owing to its high-density and flexibility as chips are thinned down and joined on a flexible substrate using anisotropic conductive adhesive (ACA) (Chen et al., 1999; Jokinen and Ristolainen, 2002 ; Lu et al., 2006; Lu and Chen, 2008). However, very little work has been devoted to the study of ACA material properties on the thermal-induced warpage for UTCOF interconnects and becomes the main aim of this work.

The ACA-P and ACA-F materials are assembled at different bonding temperatures to study the temperature effects of bonding on the warpage by out-of-plane deformation measurement via Micro Figure Measurement Instrument. Micro Au-bump and compliant-bump assemblies through the 80μm pitch dummy test are evaluated. Moreover, the assemblies with ultra-thin chips ranging from 25μm to 50μm thickness onto the polyimide flex substrates are provided to study the chip thickness effects on the thermal-induced warpage. The 85°C/85 %RH thermal humidity storage test (THST) has also been undergone for 1,000 hours for the UTCOF assembled with those process parameters. The interfaces between ultra-thin silicon chip and substrate are finally inspected through the cross-section SEM works. To validate the proposed experiments, a rigorous three-dimensional finite element analysis model which integrates both thermal and thermal-mechanical behaviors of the UTCOF is established and performed based on ANSYS program.

From both the experimental and numerical results, it is found that the averaged maximum warpage of the UTCOF interconnects is highly dependent on the bonding temperatures. The averaged maximum warpage of the ACA-P bonded samples with Au-bump using 50μm thickness chip is around 46.8μm at bonding temperature 160°C whereas the ACA-F bonded one is 64.4μm at 190°C. In addition, both the thermal expansion mismatch and thermal gradient between the ultra-thin silicon chip and substrate also strongly affect the thermal-mechanical behaviors of the UTCOF interconnects. As expected, it reveals that the warpage increases as the thickness decreases. Besides, the warpage of the micro compliant-bump assembly

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is less than that of the micro Au-bump. Good correlation between the results from the finite element analysis and experiment can be found.

Based on the results achieved, the manufacturing technology for high-density and flexible UTCOF interconnects with ACA joints is thus established.

References

1. K. Chen, R. Zenner, M. Arneson, D. Mountain, "Ultra-thin electronic device package" *IEEE ECTC*, 1999, pp. 657-662
2. E. Jokinen, E. Ristolainen, "Anisotropic conductive film flip chip joining using thin chips" *Microelectronics Reliability*, v. 42, 2002, pp. 1913-1920
3. S. T. Lu, W. C. Lo, T. H. Chen, Y. H. Chen, S. M. Chang, Y. W. Huang, Y. C. Lee, Z. Y. Kuo, Y. C. Shih, "Development and characterization of rigid-flex interface" *IEEE ECTC*, 2006, pp. 1836-1840
4. S. T. Lu and W. H. Chen, "Reliability of ultra-thin chip-on-flex (UTCOF) with anisotropic conductive adhesive (ACA) joints" *IEEE ECTC, 2008*, pp. 1287-1293