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Instrumentation for Simulation

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APPLICATION NOTE

High Magnification 2D Optical Analysis of Solder Joints

Abstract

Modeling thermomechanical lifetime response of lead free solder joints is an area of growing concern. Armed with only a single high powered optical lens, high resolution strain and load data can be obtained. Utilizing digital image correlation (DIC), a miniature universal load frame and special optical distortion calibration techniques, a user can easily validate micromechanics models on length scales down to 25 nanometers. The technique was applied to copper dogbone samples with a solder joint across the width (Figure 1).

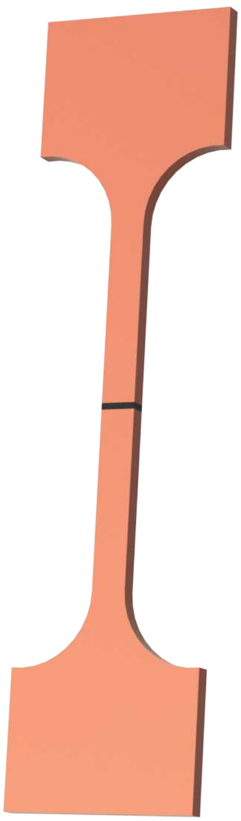

Figure 1: Copper Dogbone Sample

Samples

Three different copper tensile dogbone samples were created. Each had a different thickness solder (178µm, 477µm and 560µm) joint that joined the dogbone together at the middle of the longitudinal axis. The samples measured 3.15mm wide x 1.86mm thick with a gauge length of 47.10mm. A black base coat of spray paint was laid down before a white speckle pattern was introduced using a TEM grid stencil. Bright field lighting under a 10x objective offered the best combination of DIC efficacy and field of view.

Miniature Universal Load Frame

Psylotech's meso-scale universal load frame (Figure 2) joined to Correlated Solutions' DIC techniques allowed a novel testing procedure. Simultaneously gathering macro-scale data with Psylotech's high resolution sensors and micro-scale data with high magnification optics, models can be validated on the same hardware and software platform. Psylotech's dedicated effort to reduce out of plane motion required on-axis loading

Figure 2: Psylotech's µTS

and precision machined parts. Optical focus on the specimen was maintained while eliminating inconsistencies that can be introduced by using multiple test setups to gather the same data.

Results

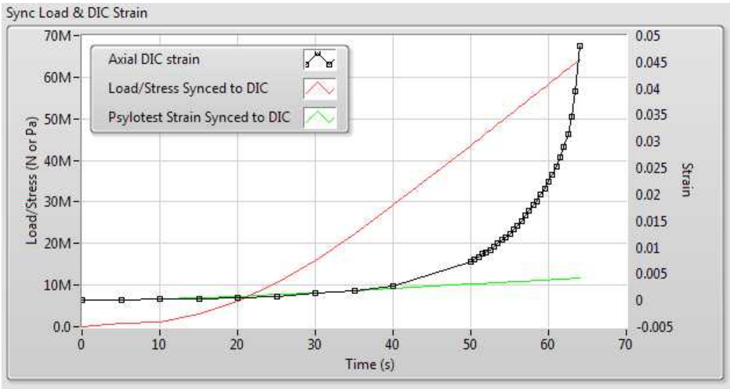

Figure 3: Synced Psylotech Load and Correlated Solutions' DIC Data

Dogbone samples were pulled at a crosshead controlled displacement rate of 4.3 microns/sec until failure, which occurred at roughly 400N. Load data was recorded and synced to the DIC displacement fields, which were analyzed in Vic-2D™ software (Figure 3). Visual interpretation of the strain fields leads to insight regarding structural behavior, which can inspire FEA models such as the one in ABAQUS™ below (Figure 4).

Conclusion

Highlighting small scale phenomena, non-contact surface strain analysis allows for rapid FEA model development. Combining DIC with a miniature universal load frame and high magnification optical microscopy enables experimental techniques to **quickly inspire and verify meso-scale micromechanics models**.

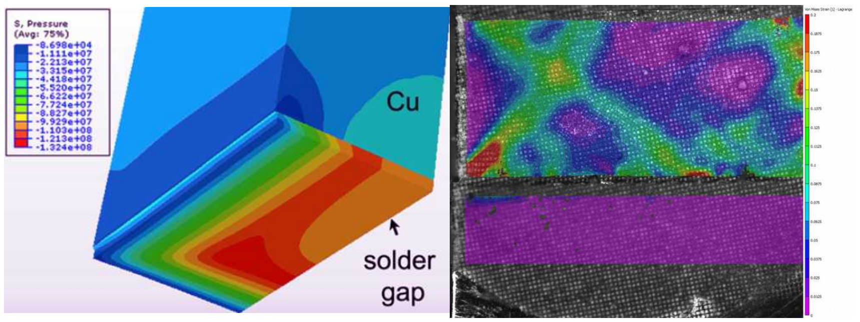

Figure 4: ABAQUS™ Model (left) and 2D DIC Strain Field on 477µm Sample (right)

Visit www.psylotech.com today to learn more about how Correlated Solutions' Vic-2D DIC software combined with Psylotech's universal load frame can accurately validate multiscale models.

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References

Khatibi, G., M. Lederer, E. Byrne, A. Betzwar Kotas, B. Weiss, and H. Ipser. "Characterization of Stress–Strain Response of Lead-Free Solder Joints Using a Digital Image Correlation Technique and Finite-Element Modeling." *Journal of Electronic Materials* 42.2 (2012): 294-303. Web.

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