EVOLUTION OF DEFORMATION PROPERTIES IN SnAgCu SOLDER JOINTS IN ACCELERATED TESTING

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ABSTRACT

Assessments of the fatigue life of solder joints are only meaningful to the extent that they reflect the absolute or relative life, or at least the ranking of alternative designs, materials or processes, under realistic service conditions. This is complicated by interactions between loading modes and even just effects of, for example, varying cycling amplitudes. For now, the industry would be delighted by estimates of life under simpler 'worst case' conditions such as a fixed cycling amplitude or temperature range low enough that the joints may survive for the many years often of interest. In fact, even if we cannot predict the actual life the industry would be well served by the ability to compare alternatives, allowing for optimizations and protecting from 'surprises'. Given the ongoing evolution of materials even such predictions can however not be validated empirically in time, i.e. they would have to be based on an understanding of the important mechanisms and take evolving microstructures into account. One approach to life assessment is based on mechanical modeling, usually FEM. However, this requires the knowledge of deformation properties as well as, ideally, a damage function. As we shall see, the ongoing evolution of the microstructure in cycling leads to changing deformation properties. Others have pointed to the effects of precipitate coarsening on dislocation motion and thus stress relaxation, but we shall see that coarsening only has secondary effects on relaxation. The effects of evolving dislocation structures are, however, too complex to be accounted for in quantitative modeling. Future research may eventually allow for such modeling of isothermal cycling, but as we shall see

the behavior in thermal cycling is much more challenging. Meanwhile, as we shall see FEM still offers a powerful tool for the interpretation of accelerated test results when combined with a mechanistic understanding. Accelerated testing, most commonly employed by industry as so-called ‘engineering tests’ focused on qualitative comparisons of alternatives such as materials, design or process parameters, does offer significant advantages, but previous work has shown how it may easily be misleading. In simple terms, ‘best in test’ may not equate to ‘best in use’. In fact, the alternative that performs best in one accelerated test may not perform best in a similar one with a different test vehicle or slightly different cycling parameters. Mechanical cycling, notably in shear, offers the direct measurement of loads and displacement. The challenge is that these vary with the loading mode and parameters, test vehicle and joint deformation properties, requiring modeling to compare alternatives. Thermal cycling, in contrast, simulates the loading mode of actual concern, but loads and displacements (stresses and strains) can only be calculated. One recently submitted paper and one currently being finalized illustrate the general comparisons of two solder alloy variations in terms of isothermal and thermal fatigue life by combinations of accelerated testing and FEM.