Effects of Aging on the Reliability of Electronic Products

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Abstract:

Environmental concerns and legislation adopted in Europe and Asia has led to a nearly universal world-wide transition to lead free solders (so-called SAC alloys) in electronic products over the past 15 years. One of the greatest challenges has been that lead free solders are highly susceptible to aging effects, where their mechanical behavior and failure properties degrade with time when exposed to isothermal or variable temperature environments. Such degradations are caused by the unstable microstructures present at very low temperatures, and they can lead to a significant reduction in the reliability of electronic products with time.

In this talk, an overview of our research on the effects of aging on the mechanical behavior of lead free solders is presented. This work as involved a combination of experimental material characterization and measurements of microstructural evolution, as well as constitutive model development and finite element predictions of reliability. Stress-strain and creep tests have been performed using miniature tensile samples, and the degradations in the effective elastic modulus, yield stress, ultimate tensile strength, and creep strain rate have been characterized and modeled as a function of aging temperature, aging time, and alloy composition. Analogous results have also been obtained using nanoindentation testing of small solder joints from lead free electronic assemblies. Finally, cyclic stress-strain testing has been utilized to understand the aging induced degradations in the hysteresis loop and fatigue life. The results of the experimental mechanical testing have been correlated with observations of microstructural evolution occurring in lead free solders during aging to develop a fundamental understanding of the causes of the material property degradations. In addition, they have been used to build aging effects into the Anand viscoplastic constitutive model as well as a modified Morrow model for fatigue life, and then implemented in finite element simulations to make reliability predictions for electronic products subjected to aging.

Speaker's Biography:

Jeffrey C. Suhling received his Ph.D. degree in Engineering Mechanics in 1985 from the

University of Wisconsin. He then joined the Department of Mechanical Engineering at Auburn University, where he currently holds the rank of Quina Distinguished Professor and Department Chair. Prior to becoming Department Chair, he served as Center Director for the NSF Center for Advance Vehicle Electronics (CAVE). His research interests include applications of solid mechanics to electronics packaging, including emphasis on lead free solders and silicon sensors. In IEEE, Dr. Suhling has been a member of the Electronics Packaging Society for the past 30 years. He has served in several EPS leadership roles including Vice President, Education (2019-2022), Vice President, Finance (2023-2004), and President Elect (2025).