Creep Dominated High Cycle Fatigue of Freestanding Gold Thin Films at Room and Elevated Temperatures

Benoit Merle*[1], Anna Krapf[2], Christoph Gammer[3], David Gebhart[3], and Megan Cordill[3]

[1]University of Kassel, Institute of Materials Engineering, 34125 Kassel, Hessen, Germany – Germany
[2]Friedrich-Alexander-Universität Erlangen-Nürnberg – Germany
[3]Erich-Schmid-Institute of Materials Science Leoben – Austria

Abstract

Freestanding metallic thin films experience cyclic loading conditions when they are used in flexible electronic devices, e.g. as interconnects. While supported thin films have been extensively studied, comparatively little is known about the fatigue behavior of freestanding films, largely due to experimental challenges. In addition to sharing with supported films a unique PVD-resulting microstructure, freestanding films stand out due to the ubiquitous presence of a free surface, which likely further alters the classical fatigue mechanisms known from their bulk counterparts. Using bulge testing, we conducted a comprehensive investigation of the high cycle fatigue behavior of gold thin films over a temperature range of 20 to 100∘C, closely reflecting operational conditions in microelectronic devices. Interrupted testing, coupled with transmission electron microscopy, was used to monitor the microstructural evolution. Through analysis of activation parameters and comparisons to reference creep bulge tests, we demonstrated that the cyclic behavior is dominated by creep mechanisms. A transition from dislocation to diffusion controlled deformation was observed as temperature and microstructures were varied. The distinct behaviors of columnar ultrafine-grained and nanocrystalline samples will be discussed in detail during the presentation.

*Speaker