Heterogeneous Stress Relaxation in Thin Films: Whiskers, Hillocks, and Beyond

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Abstract

Synchrotron micro-diffraction plays a critical role in identifying the local conditions that control the stress relaxation mechanisms that are operating in thin films, and thus, in designing microstructures to control the film response to stresses. A particularly important example of this is in mitigating the risk of tin whisker formation in microelectronic devices and systems. When tin thin films are stressed, the thin film microstructures are destabilized, leading to the formation of long single crystal whiskers that can create short circuits between adjacent leads and components and destroy MEMS devices in electronic assemblies. The conditions for whisker formation are inherently local as indicted by their frequency: there will be typically 1 whisker for every 10^9 -10^10 film grains. What makes synchrotron micro-diffraction an essential tool for studying tin whisker formation is that whiskers grow from the bottom, i.e., at the buried interface between the whisker grain that grows out of the film and its neighboring grains in the film. No other technique provides the ability to characterize the strains adjacent to buried interfaces and with the 0.5-1.0 µm spatial resolution required to understand how strains are evolving locally for different types of films under different conditions. As with most other scientific problems, micro-diffraction by itself is not enough. By combining synchrotron micro-diffraction with surface characterization techniques, such as scanning electron microscopy, electron backscattered diffraction, focused-ion beam imaging, and atomic force microscopy, a clear picture has begun to emerge of the interplay between microstructure, imposed and thermal expansion on whisker formation in beta-Sn thin films.

Keywords - stress relaxation, whisker, hillock, microelectronics, thin films

References