Tin whiskers create reliability risk in lead-free electronics manufacturing

E. Chason and K. S. Kumar, Division of Engineering, Brown University

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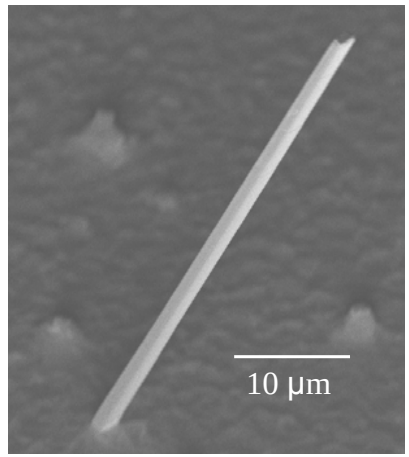
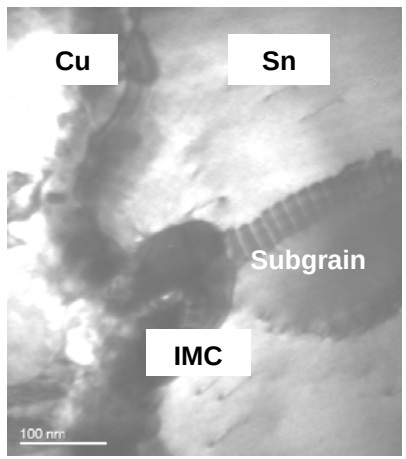
When lead is removed from the tin coatings commonly used in electronics manufacturing, long thin filaments known as whiskers are observed to form (see figure). These whiskers can grow until electrical contact between electronic components occurs, causing system failure. Such whiskers have been implicated in the loss of several satellites as well as aviation systems, pacemakers and commercial products (examples can be found on NASA website: nepp.nasa.gov/whisker/). Lead is being removed in response to legislation restricting the use of hazardous substances (RoHS), so there is a critical need to find reliable alternative coatings that do not form whiskers.

Although tin whiskers were first observed over 50 years ago, a fundamental understanding of the processes controlling their formation has eluded researchers. This is due in part to the complexity of the problem in which many different processing factors play a role. Isolating the underlying mechanisms requires well-controlled and comprehensive experiments to characterize the samples and control the experimental variables. We are using advanced thin film diagnostics to simultaneously quantify the evolution of whiskers and the parameters that control their growth. Our results are enabling us to understand how the growth of intermetallic particles in the tin film leads to stress which is the driving force for whisker formation. These measurements are supported by atomic-level studies of stress-generation and relaxation mechanisms using electron microscopy. The experimental results are being used to develop quantitative models of the processes controlling whiskering in order to predict the formation of whiskers and develop mitigation schemes.



Whisker growing from a lead-free tin coating on a copper substrate.



Electron micrograph of intermetallic particle (IMC) growing into Sn, causing dislocations to be emitted