International agreements now require lead-free surface finishes for most electronic components. Pure tin finishes have been shown to form whiskers and hillocks. Tin whiskers can grow rapidly to long lengths that can cause faults in electronic devices and circuits. Long whiskers have been shown to be largely single crystals with specific crystallographic growth directions. Hillocks are smaller bump-like growths that can be made up of single grains or many grains and are less likely to cause electrical faults. Both whiskers and hillocks have been shown to grow from their bases.

The actual growth mechanisms for these features still remain elusive, although tin whiskers and hillocks are generally thought to grow as a response to stress in the plated tin films. In order to provide more information about the growth mechanism it is important to have a complete understanding of the crystallography of the growth substrate and the whiskers or hillocks that form. In this work we will apply the technique of 3D EBSD using the dual platform FIB/SEM to provide a more complete picture of whisker crystallography.

Shown in Figure 1 is a long thin whisker that contains low-angle grain boundaries. In this case, the whisker formed first followed by the formation of a hillock grain at the base, which caused subsequent whisker growth to stop. Note that the growth directions of the whisker segments are <001> and are aligned with the <001> direction in the hillock grain. The 3D crystallographic reconstruction shown in Figure 1 allows all of the grains at the base of the whisker to be visualized which is not possible with single 2D sections as are normally used for EBSD orientation maps.

Figure 2 is a 3D EBSD reconstruction of a hillock on the same Sn-film as the whisker in Figure 1. This reconstruction demonstrates that the hillock is polycrystalline with a grain size that is substantially larger than that of the electrodeposited Sn-film. When the area under the hillock is examined there is considerable grain growth associated with the film grains that continue into the hillock, indicating that grain growth and recrystallization may be contributing to hillock growth.

The capability to visualize whiskers and hillocks and the underlying grains in the plated films with 3D EBSD provides new insights into possible growth mechanisms and therefore may enable strategies to eliminate their occurrence on tin plated Cu surfaces.

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Fig. 1: 3D reconstruction of a straight tin whisker that has grown from a pure tin-plated surface on Cu.

Fig. 2: 3D reconstruction of a large tin hillock that grew on a pure tin-plated surface on Cu. Note that the hillock is polycrystalline as compared to the single crystal whisker in Figure 1.