Tin whisker captivation by the Whisker-Tough MagnumTM conformal coating

Steve Smith Whisker-Tough Development steve@whisker-tough.us

Approved for Public Release 16-MDA-8639 (21 April 16)



Here's a side-view of about one square millimeter of a whisker-farming coupon, at a shallow angle to show the surface features.

See all those bumps?



Here's those bumps, closer. There are two distinct types. Some are irregular mounds, and some are conical tents. The tents in the coating are held up by whiskers that have not yet buckled. The irregular mounds are the coating draped over whiskers that were buckled and continued to grow to form irregular mounds.



A typical field of whiskers captivated by the Whisker-Tough Magnum coating; only fifty microns thick, it forms a containment-blister over each captivated whisker.



Closer-view of a containment-blister and its smaller companion from the previous slide.

It's really hard to see what's inside these tents. These 3- dimensional images were done with confocal laser microscopy.

Let's take a closer view, using highmagnification optical viewing:



A typical field of containment-blisters, viewed mostly-from-above



That same field, seen about 30 degrees-above-horizontal.

There's something interesting in the middle. We're going to zoom in:



Those are buckled whiskers.



Top center is a clear view, at 4000X optical magnification, of a 2.2 microndiameter whisker. It is believed to have initially grown from the center of its blister, about at the 60-micron axis, then was bent over to the left by the coating and forced to grow along its inner surface until it met the substrate. At that point further growth resulted in a series of bucklings. It is captivated and contained.



This is a top-down view of a containment-blister, the coating having been stretched to a height of a few hundred microns by apparently several whiskers, those whiskers ultimately collapsed into a wad, what is called a whisker-ball. The false-color imaging indicates height. The next slide shows the captivated whiskers more clearly.



This is a black-and-white view of the same 200-micron-diameter containmentblister as in the previous slide. These captivated whiskers all appear to be about three-to-four-microns in diameter. A multiplicity of whiskers coming from one location is called a swarm. Sometimes they grow fairly straight, as a bouquet of flowers, and sometimes very irregular, as we will see next. Whiskers sometimes occur in swarms. These are many whiskers, usually irregular in shape and numerous, not single isolated whiskers.

They are the most challenging to conformal coatings of any whiskering occurrence.



This swarm grew along a scratch in a tin-plated surface. Note the different characters of the various members of the swarm.

Swarms may also occur from a single point-source. We will see many of those on the following slides.

The next image shows a more complex scene in which a mix of small whiskers (a Whisker-Swarm) are being caught in a long blister, with a large whisker tent remaining on the left side. As that large whisker eventually starts to buckle, its tent will retract (it is under tension) and become part of the blister.

With its "controlled release", the Whisker-Tough coating peels-away-radially from the tin plating as it forms a higher-and-higher "tent" over one or more emerging-and-growing whiskers. The tented swarm here may have reached a height of several hundred microns, which would have resulted in a peel-back of the Whisker-Tough coating from the tin to about a 200-micron-diameter at the tent base. When the whiskers buckled and collapsed into a whisker-ball, the tent would flatten-out and drape over the debris, leaving only a containment-blister and a small wrinkle at the former tent periphery.

This is what you see in the next picture.



The circular wrinkle in the coating shows the extent of the controlled-release as the coating was stretched to form the containment-tent and ultimately collapsed to leave the central blister. The conformal coating conforms to the captivated whiskers.



The Whisker-Tough Magnum coating containing a buckled swarm, with two whiskers yet-to-be-buckled. These contained whiskers are estimated to be in the 4-8 micron-diameter range.



Some swarm-members already bucked in the center; two others contained and yet-tobuckle. The large whisker inside the tent on the left is estimated to be in the 6-10 microndiameter range.



Another typical whisker-swarm, members estimated in the 3-5 micron-diameter range, with buckled-and-contained whiskers wadded-up in a whisker-ball in the middle, the conformal coating outlining the whisker-ball.

Why do we see so many near-vertical whiskers and none at-an-angle?

We know very few whiskers grow perfectly vertical...



Substrate

Now we can captivate tin whiskers.

Now tin-whisker-induced failure-risk can become insignificant compared to other risks, by using the Whisker-Tough Magnum[™] conformal coating.

Why is this valuable?

Customer benefits:

It reduces reliability problems such as have occurred in recent years because of tin-plated parts getting into the production line.

Manufacturing benefits :

It replaces the costly component-level tin whisker mitigation processes, which often eliminates scheduling conflicts.

It reduces the Incoming-Receiving testing with X-Ray Fluorescence to find non-conforming (i.e., tin-plated) materials.

Engineering benefits:

The more abundant and often less-expensive lead-free (tin-plated) components can now be used in designs.

It will reduce the amount of supply-chain monitoring by Component Engineering organizations for termination finish changes.