Contribution submitted by Don Ballard, Coherent regarding Nickel Sulphate

Even if there is a relatively simple replacement, proving reliability is always hard.

And we may not have to do it. If a “Homogeneous material” consists of a combination of materials, that cannot be separated into different materials using grinding or abrasive processes, then our tabs and risers and posts are not “Homogeneous materials”. The easy examples are tabs like 1308680, which is a flat part with only one side plated. Simply lapping the part (clearly an abrasive process) will remove all the sulfamate nickel from the plated side. A more complicated part with curved surfaces, like tab 0170-725-00 might require sanding and bead blasting, but the plating could all be removed. Both of these processes are much easier than the example they give of separating the solder from a solder joint, so they seem legitimate. If the total weight of nickel is used, rather than the weight of the plated parts, we should be well below the 1000ppm limit.

That said, if we were proposing to add sulfamate nickel to our process now, there would be a couple reasons to reject it out of hand. First, the plating solution contains sulfur, some of which is incorporated into the plating, as per the attached Nickel Plating Handbook. We carefully avoid these sorts of potential contaminants in other places, why not here? Second, the plating tends to build up on corners and can cause dimensional problems, which is another inconvenience we would ordinarily try to avoid. As described in the Handbook, the usual advantage of sulfamate plating is that it can support thick, low stress layers. This critical for things like electroforming, but hardly matters for the 1.3-2.5um thick nickel layers we usually specify. Other forms of nickel plating may be equally usable.

Our use of sulfamate nickel is essentially copied from electronic applications, where it is used on copper substrates as a barrier layer to prevent copper from diffusing into the gold plating and affecting conductivity, wire bonding and soldering. A nickel layer thickness of 3.8um seems to be the industry standard (Nickel Barrier Thickness Requirement), so our specification is actually a bit thinner than recommended for use on copper. The advantage of doing it this way is that sulfamate nickel is a high volume process that is actually supported by plating shops. In the future, this may change, as electroless nickel appears to be replacing sulfamate nickel in electronics applications (apparently the reliability data finally exists). This may be what prompted the ROHS proposal, and it may eventually make sulfamate nickel plating vendors harder to find.

The issues with plating Invar and stainless steel substrates are different from those with copper. Iron, chromium and nickel do not easily inter-diffuse with gold and have tenacious oxides. The main issue is not the barrier but rather adhesion. An adhesion layer (in plater’s jargon, a strike layer) must be used to provide an oxide-free layer for subsequent plating to bond to. This is usually achieved by plating a thin layer of nickel out of a strongly acidic chloride bath (“Wood’s strike”, Nickel plating / striking of stainless steel). Chloride plating solutions are not widely used because they give highly stressed layers (Nickel electroplating [SubsTech]), but they work well in thin (1-2um) layers. It is quite possible that the nickel layers we currently use on Invar consist of sulfamate nickel over a similar thicknesses of chloride nickel. I recently asked a plater for advice on how to avoid nickel buildup in a small Invar vee groove. His suggestion was to forget about the sulfamate layer and just plate the gold directly over the Wood’s strike that would be there anyway. I had the parts made that way and they had no dimensional issues and they soldered without a problem. His specification “Gold Plate MIL-G-45204C Ty III, Gr A 0.25-0.38um thick over Wood Nickel Strike 1-2 um” would probably be suitable for use on Invar/Stainless substrates if sulfamate nickel becomes unavailable. Something similar might also work on copper.

One other related question is the thickness of the gold layer. The plating note that Wayne attached is unusual in that the gold layer is specified as being 1.3-2.5um thick. The more common thickness range is 0.25-0.38um, found on tabs made from Invar (0170-725-00, Verdi 1996), Super Invar (1236144, Monaco 2013) and 410 stainless (1308680, Monaco 2016). The attached Design Rules for Fluxless Solder (page 113) mentions that that with BiSn solder a thick layer (more than 1um for a 250um solder thickness) risks embrittlement of the solder with intermetallic phases, while a thin a layer (less than 2um) allows oxygen to diffuse through to oxidize the nickel. To avoid this conflict, they suggest adding a thick (5um) layer of silver between the nickel and the gold, since silver oxidizes much more slowly than nickel. We have been using a thin gold layer and ignoring whatever oxidation occurs at the nickel surface. This has worked so far, but moving our process to a hot, humid climate (e.g. Singapore) might accelerate the oxidation, and if we start having soldering problems, this might need to be revisited.

Additional comments……

I think changing the material here could be a substantial amount of effort. We would have to prove that the change does not affect our process parameters and long term stability which will be very hard to do…