Copper Bond Wire Reliability & Decap Challenges

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In an effort to reduce manufacturing costs, integrated circuit manufacturers have begun to use copper bond wires instead of gold bond wires. This switchover to copper bond wire devices is not always communicated by the supplier in a Part Change Notification (PCN). When a plastic encapsulated microcircuit (PEM) is purchased, there is no indication of what the bond wire material composition is until the destructive physical analysis has begun.

The DoD needs to determine process restrictions, define more stringent requirements, and create guidelines for when copper bond wire devices can and cannot be used. Currently, Raytheon addresses these copper bond wire devices by performing pre-conditioning and environmental stress tests before performing internal analysis, bond pull, and ball shear testing. Issues of concern for copper bond wire devices include:

- Higher propensity to oxidize
- Higher propensity to corrode
- Bonding performed in a forming gas to ensure good metallic bonding
- Stiffer than gold
- Work hardening
- Increased probability of Al splash
- Increased probability of cracking
- Qualification procedures have been designed around the failure mechanisms associated with gold and aluminum (Al) wire bonds. Material differences require refined manufacturing processes and create the potential for new failure mechanisms
- Increases probability of die cracking / cratering of die bond pad & breaking of ball & stich bond

Copper bond wires also present additional challenges when it comes to decapping the devices. Unlike gold bond wire devices, fuming nitric acid cannot be used to decap copper bond wire devices, since the nitric acid reacts with copper, forming copper nitrate. Microwave induced plasma etching (dry etching) protects the integrity of the bond wires, but results in a slow etch rate. Wet etching consisting of a mixture of sulfuric and nitric acid and results in a faster and more aggressive etch, but increases the risk of corrosion and damage to the bond wires.

When using a mixture of sulfuric and nitric acid to etch copper bond wire devices, the sulfuric acid creates a protective barrier around the copper bond wires, which then results in residue that needs to be removed from the bond wires. Acetone, hot DI water, liquid nitrogen, and IPA can

be used to remove the sulfuric coating from the wires, but there is also a risk of damaging the bond wires or aluminum bond pads.

The material composition of the devices plays a large role in the successful decap of copper bond wire devices, and the material composition can vary greatly between date codes of the same part number. The successful decap requires the correct combination of laser ablation (number of passes and power settings), etch time, acid mixture, temperature of acid and device, and the volume and flow rate of acid.