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RE: ENIG vs Lead Free HASL   October 29, 2012

The choice between whether or not to use ENIG or Lead Free **H**ot **A**ir **S**older **L**eveling (**HASL**) should depend upon several factors. The positives and negatives of both surface finishes should be weighed against one another.

ENIG Positives:

1. Flat co-planar surface.
2. Nickel layer prevents copper diffusion.
3. Nickel layer strengthens the barrel of a plated through hole.
4. Moderate dry bake times.

ENIG Negatives:

1. Cost (highest compared to all other finishes)
2. Potential for solderability issues.
    a. Black Pad
    b. Hyper Corrosion
    c. High Phosphorus
3. Surface is sensitive to handling.
4. The thicker the immersion gold the weaker the solder joint.
5. Does not provide a solder shock at the bare board level.
6. Surface finish cannot be re-worked at the bare board level.
7. The immersion gold surface is porous. Storage conditions are a concern.

ENIG Information:

1. Solder forms an inter-metallic alloy of nickel-tin.
2. The immersion gold is absorbed into the solder joint as an impurity.
3. The immersion gold layer only protects the electroless nickel until the electroless nickel is soldered to. What comes into contact with the immersion gold ultimately comes into contact with the electroless nickel.

Lead Free HASL Positives:

1. Cost (low compared to other finishes)
2. Provides a solder shock at the bare board level.
3. Robust solderable surface.
4. Not sensitive to handling issues like other lead free surface finishes.
5. Increased dry bake times.

Lead Free HASL Negatives:

1. Requires higher soldering temperatures at assembly.
2. Susceptible to copper diffusion.
3. Not a flat surface.
4. May be reworked at the bare board level.

Lead Free HASL Information:

1. Solder forms an inter-metallic alloy of copper –tin.

Once the positive and negatives are understood a practical choice may be made. The main benefits to ENIG are a flat surface and the addition of a nickel layer/barrier. The flat surface provided by ENIG make the surface finish ideal for fine pitch surface mount devices and ball grid arrays. The nickel layer

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strengthens the barrel of the plated through hole. The nickel also acts as a barrier protecting the copper underneath. The copper is protected from copper diffusion that occurs in the soldering process. Every time a board is exposed to soldering temperatures the copper diffuses into the solder. The nickel layer/barrier eliminates this as a concern. Lead Free soldering on the other hand is susceptible to copper diffusion. This is actually true for all of the other lead free surface finishes. All but ENIG form a copper-tin inter-metallic alloy through the soldering process. However, Lead Free HASL results in the most aggressive amount of copper diffusion as compared to the other lead free surface finishes.

ENIG has the stigma of black pad and other solderability issues. Black pad and high phosphorous occurs as a result of an ENIG process operating out of the control range. An ENIG process that is monitored and controlled shall not be prone to these non-conformances. Hyper corrosion may form as a result of the ENIG process operating out of the control range or is the ENIG surface comes into contact with a cleaner that is not compatible with electroless nickel. ENIG is also sensitive to handling concerns. Something as simple as a finger print on a SMD pad is cause for concern since skin oils and hand creams leave behind residue.

Lead Free HASL is generally acceptable for through-hole technology and boards without fine pitch surface mount devices. Solder puddling on the surface is to be expected as a result of the application process. An extra added benefit is that all boards coated with Lead Free HASL are exposed to a high temperature solder shock at the time they are processed through the HASL process. This provides a level of insurance since the solder shock applied may bring to light any unexpected manufacturing non-conformances. The other lead free surface finishes do not provide this high temperature shock. The other finishes are applied at relatively low temperatures through chemical deposition. There is no thermal shock applied to the printed circuit board until the boards are assembled.

Traditional FR4 is hygroscopic. The Lead Free assembly compliant grades of FR4 are even more hygroscopic. Hygroscopic refers to the property of a material to absorb moisture to the point of equilibrium. Exposure to available moisture over periods of time should be a concern. Many assembly operations are conducted in a moisture rich environment in order to cut down on the level of static electricity. Moisture absorbed by a printed circuit board needs to be baked out of the FR4 prior to the board being exposed to soldering temperatures. Dry baking should be conducted in accordance with IPC-1601. Printed circuit boards coated with ENIG and Lead Free HASL may be dry baked prior to exposure to soldering temperatures. Over extending the dry baking process may result in oxidation of the electroless nickel. Remember, the immersion gold surface is porous. With regards to Lead Free HASL, dry baking shall adversely affect solderability in the case of very thin solder below 30 micro inches.

Regards,
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