BOWMAN
Coating Measurement Instruments

Compliance with **New IPC-4552** Requirements for Measurement of Thin Au Plating Thickness in ENIG Coatings on Printed Circuit Boards

As electronic devices have become more prevalent and important to almost everything we do, PCB manufacturers are constantly working to improve the quality and reliability of their products. Devices are becoming smaller, so the PCBs must follow suit. High speed data transfer is now the norm and no longer a luxury. Computers control basically everything around us, and reliability is paramount. PCB manufacturers must adhere to strict guidelines when carrying out quality assurance practices to ensure the electronics will not prematurely fail.

Surface finishes on PCBs are critical to prevent oxidation of the conductive copper layer as well as provide a solderable finish to allow components to be mounted to the board. One of the most popular surface finish involves a process referred to as ENIG. ENIG is a two-layer metallic coating of thin Au over electroless Ni. The IPC Association, which provides guidelines for the electronics industry, has set specific thickness ranges for Au and electroless Ni to achieve peak performance for ENIG coatings. A recent amendment (A) to the ENIG spec IPC-4552 states that the coating layers for rigid PCBs must fall within the following ranges:

- Au: 0.04-0.1um (1.58-3.94uin) with a +/- 3 sigma standard deviation applied
- Ni: 3-6um (118.1-236.2uin)

This recently published amendment, which applies an upper limit to the Au thickness, presents a new challenge for testing methods. XRF is the approved method of testing for ENIG coating thickness, so every company working with ENIG coatings likely already has an XRF instrument in their lab for quality assurance. Many older instruments have technology that simply cannot achieve the measurement precision required to guarantee that the Au layer falls within specification. In those cases where the instrument is incapable of performing, it must be either serviced or replaced.

The IPC has defined a measurement method for determining whether an XRF instrument has the capability of meeting the new specification limits. The method involves performing a Type 1 Gage R&R study using a reference standard that falls within the specified thickness ranges for Au and Ni. Below is an excerpt from the new IPC-4552 publication:

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The purpose of performing this study is a test of Gage Capability with respect to repeatability and mean of measurement values for a given tolerance. It is preferred that this study is performed with a calibrated reference standard, with its reference value approximately in the middle of the tolerance field. Without a calibrated reference standard, the Type 1 Gage study only measures repeatability. Bias, a measure of accuracy, becomes invalid.

At defined measurement points the reference standard is to be measured with $n \geq 0$ times under repeatability conditions.

- *For measurement criteria with Upper and Lower Specification Limits (USL and LSL); T = USL-LSL.*
- *For measurement criteria with only a one-sided specification limit (USL or LSL); T is non-existent.*

In this case the allowable measurement value lies below USL -4s or above LSL +4s. The value of the reference standard should be within ± 10 % of the USL or LSL.

If Gage Capability Indexes are to be calculated, use the following formulas:

The instrument capability is checked thru the C_g and C_{gk} values which are defined as Gage Capability:

- $C_g = \frac{0.2 \cdot T}{6 \cdot s}$
- $C_{gk} = \frac{0.1 \cdot T - |\bar{x} - x_m|}{3 \cdot s}$

T = tolerance, s = standard deviation), x_m = mean of standard, x = mean value measurement A gage index is considered capable if $C_g \geq 1.33$ and $C_{gk} \geq 1.33$.

For the IPC-4552 Specification: Au_{min} 1.6 µin – max 3.94 µin (0.040-0.100 µm)

T= 0.060 µm

s needs to be = 1.5 nm to meet C_g of 1.33 = 3.75% COV @ 0.040 µm, 2.1 % COV in middle of Spec @ 0.070 µm. 3 % would be reasonable for a target of 0.050 µm

Failure to meet these target limits may be addressed by taking one or more of the following actions:

1) *The XRF unit may need to be serviced or in some instances replaced with a more capable unit.*

2) *Verification and recreation of the ENIG calibration file may improve the accuracy of the measurement but will not impact the COV*

Bowman offers a variety of XRF instruments that are all fully capable of meeting and exceeding the new IPC specifications. The combination of optimized hardware geometry along with the latest in detector technology provides the full capability of top level performance at relatively short testing times.

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