EPIG: A Nickel-free Surface Finish for Next-generation Products

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by George Milad, UYEMURA

In recent years, electronic devices, such as smartphones and tablet PCs, have been miniaturized. Chip-size package (CSP) used inside the electronic devices have been miniaturized as well, and the spacing between the lines continues to diminish every year. Some of the latest packages have spacing as little as 15 µm or less. If electroless nickel electroless palladium immersion gold (ENEPIG) is used with an EN thickness of 5–6 µm, only 5 µm of spacing would be left, increasing the risk of shorts between the traces.

Electroless palladium immersion gold (EPIG), an alternate surface finish, eliminates the use of EN and allows for greater spacing between the traces. EPIG is both solderable and wire-bondable. EPIG finished parts do not exhibit the skin effect of EN, making it ideally suited for high-frequency RF applications.

In addition, eliminating EN dramatically reduces processing time at the manufacturing site. The plating process for EPIG is similar to ENEPIG except for the EN step (the longest step in the process), which is eliminated.

For EPIG, electroless phosphorous-palladium (P-Pd) is the better choice for plating on copper. The use of reduction-assisted immersion (RAI) gold as the top layer gives a better rate of deposition on EP, as well as allowing for a thicker gold layer to be deposited. At present, no IPC specifications for EPIG exist. For EP and IG thickness, refer to supplier recommendations for soldering and wire bonding applications.

Table 1 shows the plating process for EPIG on copper. Other variations of EPIG may be used for specific applications. These include EPIG on copper with a different activator; here, an immersion gold activator is used instead of the Pd activator. Another variation is to use a thin (0.15-µm) electroless nickel layer before applying EPIG. The latter variation will give a Ni/Sn intermetallic compound (IMC) while maintaining the advantages of EPIG like no signal loss due to excessive Ni thickness and does not interfere with the spacing for fine-line applications.

Soldering to EPIG

When soldering to EPIG (EP: 0.1–0.15 µm; IG: 0.1–0.2 µm), a Cu/Sn IMC is formed as contrasted with ENEPIG where a Ni/Sn IMC is formed. The Pd and the gold are dissipated into the molten solder, and the solder joint is formed on the copper surface. From the re-

Process Step	Chemical	Temperature (°C)	Time (minutes)
Cleaner	Mild alkaline	50	5
Micro-etch	Persulfate type	30	2
Acid rinse	10% sulfuric acid	RT	1
Acid pre-dip	4% sulfuric acid	Rt	1
Activator	Pd type	30	1.5
Acid post-dip	Acid type	50	0.5
Electroless Pd	P-Pd	60	5, 10, 20
Immersion gold	RAI gold	78	6, 12, 24, 36

Table 1: EPIG plating process (target thickness, EP: 0.05, 0.1, 0.2 µm; IG: 0.05, 0.1, 0.2, 0.3 µm).

sults of EDS, when using EPIG surface finish, Cu_6Sn_5 was formed as layer 1, and Cu_3Sn was formed near Cu layer as layer 2. This solder joint is similar to immersion silver, immersion tin, and OSP solder joints, and is expected to demonstrate similar solder joint reliability.

Gold Wire Bonding

EPIG is a gold wire-bondable finish. Excellent bond strength and wire break location were easily achieved with the “as-plated” EPIG. However, after heat treatment for 16 hours at 175°C, there was a drop in pull strength and the corresponding wire break location. The drop is affected directly by the diffusion of copper and palladium to the bonding surface during heat treatment. The thickness of the palladium and gold layers have a direct impact on bond strength. To increase wire bond strength, the thickness of the EP and the IG layers have to be optimized.

Cu was detected after heat treatment when EP film was thinner; however, no peak of Cu was detected when the EP thickness increased. A thicker Pd deposit was effective in preventing copper diffusion to IG surface. Increasing the EP thickness to 0.15 µm will act as a diffusion barrier to copper from the substrate.

The diffusion of Pd to the surface of the IG layer after heat treatment was not dependent on the Pd thickness and was greatly dependent on the Au thickness. A thicker IG layer will reduce the ratio of EP in the IG surface. The diffusion of EP to the top surface of the IG is mitigated by increasing the thickness of the IG to 0.2 µm.

In addition, there is a marked improvement in the strength and wire break location when performing a wire pull test after plasma treatment. It was confirmed by AES analysis that any Cu diffused to the surface was removed after plasma treatment.

Conclusion

EPIG is a solderable and gold wire bondable surface finish. EPIG was introduced around 2016 and is gaining popularity as circuit miniaturization continues with tighter spacing between the traces. The elimination of thick EN mitigates Ni corrosion, reduces processing time, and eliminates the skin effect signal loss associated with propagating high-frequency RF signals. The absence of thick nickel makes EPIG ideally suited for flex applications where bending may cause nickel fractures. **PCB007**

George Milad is the national accounts manager for technology at Uyemura. To read past columns or contact Milad, click here.

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