Dr. Joseph A. Abys • EC&S
236 Richmond Valley Road • Staten Island, NY 10309 • 718/317-4490

Solderability & Wirebonding Performance Of Nickel/Palladium-plated Leadframes

Palladium surface finishes have been increasingly applied to semiconductor leadframes, Fig. 1. The superior functionality and lower total cost of palladium pre-plated leadframes (Pd PPFs), due to process simplification and positive environmental impact of replacing tin-lead solder, have provided the impetus for this technological change.

The technology utilizes high-speed nickel and palladium plating (Pd/Ni) of the entire leadframe surface, to replace the standard selective silver plating for die attach and wirebonding, and solder plating of the external leads for solderability. The latter, SnPb, is usually applied after package assembly (Fig. 1).

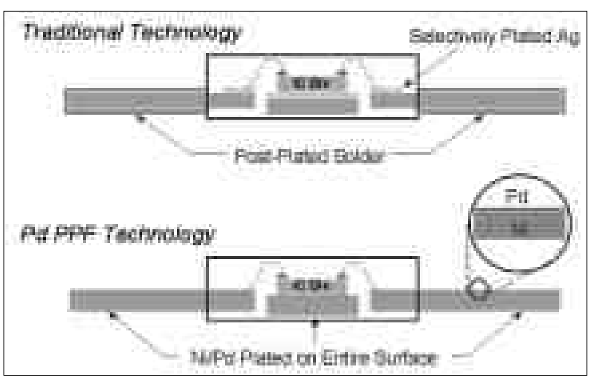

Fig. 1—Schematic cross sections of the leadframes with Ag/SnPb or Ni/Pd, after die attachment, wirebonding & encapsulation. Before trimming and forming.

The Pd layer with a typical thickness of ~0.1 µm is plated over a Ni electrodeposit, 1-3 µm thick. Pd acts as a protective layer preventing oxidation of Ni during the packaging and assembly operations, even after exposure to high-temperature excursions. The Ni, functioning as a barrier layer, ensures the integrity of the Pd finish by preventing diffusion of base metals (*e.g.*, Cu) to the surface. This eliminates the formation of oxides or corrosion products that are detrimental to performance.

Problem

IC packaging operations require the external leads of a leadframe to undergo a bend of 82-90° with an inner radius

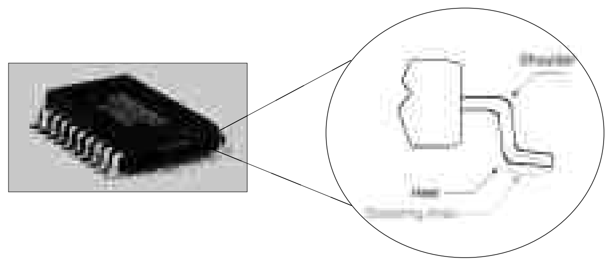

Fig. 2—A schematic gull-wing shape lead after forming.

of about 0.25 mm. Most leads will have a gull-wing shape as illustrated in Fig. 2. This process challenges the integrity of both the leadframe substrate material and surface finish (Fig. 3), demanding significant elongation to avoid cracking and exposure of base metals.

Analysis

Typical Ni/Pd finishes do not survive this degree of bending and exhibit substantial cracks where surface elongation is greatest, Fig. 3. The substrate is then exposed, Fig. 4 (a), and is vulnerable to corrosion, which compromises the functionality of the IC package. For example, corrosion products at the heels of the gull-wing leads may significantly increase the wetting time during soldering operations, jeopardize solder coverage and reduce solder joint strength.

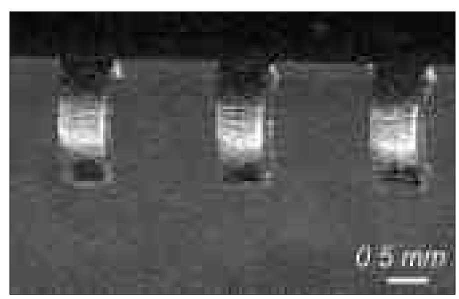

Fig. 3—The cracked heels/gull-wing leads with typical Ni/Pd.

Testing Techniques Utilized

- ASTM Bend Test
- Optical & SEM Microscopy
- Dip & Look Solderability
- Wetting Balance
- Wirebonding/Pulling

Sample Size:
100 Tests Under Each Condition

Observables	Au to Pd Bonding	Au to Au Bonding	Requirement
Bonding failure	None	None	None
Pull force (g): mean	7.80	8.00	≥ 7.00
Std. dev.	0.65	0.81	≥ 10% of mean
Minimum	6.16	6.41	≥ 5.00
Maximum	9.35	10.10	—

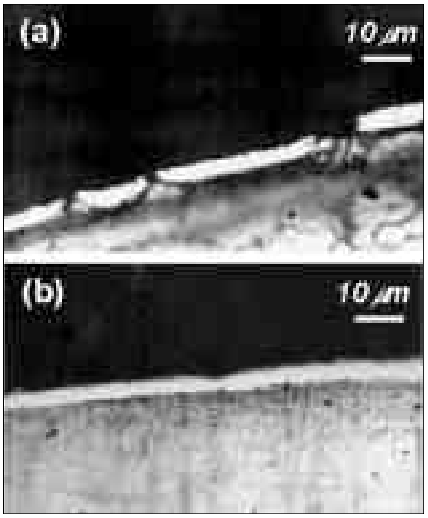

Fig. 4—Cross sections of: (a) typical Ni; (b) conformable Ni/Pd plated Olin 194 leadframes after 90° bend with a radius of 0.25 mm.

Solution

Typical Ni finishes exhibit severe cracking after bending, Fig. 3 & 4(a). Alternatively, a nickel plating process developed by EC&S produces highly ductile, conformable deposits without cracks, Fig. 4(b). The cracked deposits, Fig. 4(a), exhibit solder coverage lower than the 95% minimum, Fig. 5(a). In contrast, complete solder coverage was consistently obtained with the conformable Ni/Pd finish as shown in Fig. 5(b).

The wetting balance test also demonstrates a clear distinction between the Pd finish plated over typical and conformable Ni. Industry standards demand a wetting time (T^w) less than 1 sec and a wetting force at 2.5 sec greater than 0.20 mN/mm. The results in Fig. 6 demonstrate that typical Ni/Pd composite finish needed 5 to 6 sec to wet and eventually reached a wetting force of only 0.11 mN/mm. The conformable Ni, by comparison, showed a wetting time less than 0.50 sec and a wetting force of 1.03 mN/mm at 2.5 sec.

Wirebonding failure is reportedly the major cause of yield losses in IC packaging. Furthermore, the bonding process is one of the most expensive steps in the packaging operation. Thus, wirebonding yield and reliability are of paramount importance to process cost. The conformable Ni/Pd surface finish showed excellent wirebonding yield and reliability with no bonding failures. The pull test results met the industry requirements and were comparable to Au-to-Au wirebonding results (see table). No breaks occurred at the interface between bond and surface finish. The wire

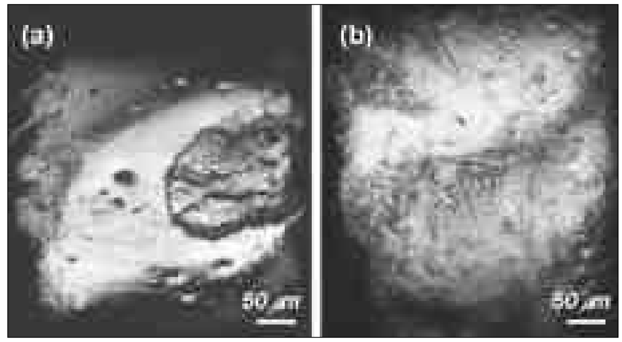

Fig. 5—Solder coverage on: (a) typical Ni; (b) conformable Ni/Pd plated Olin 194 leadframes, 90° bend with a radius of 0.25 mm, 8 hr steam aging at 93°C and 95% RH.

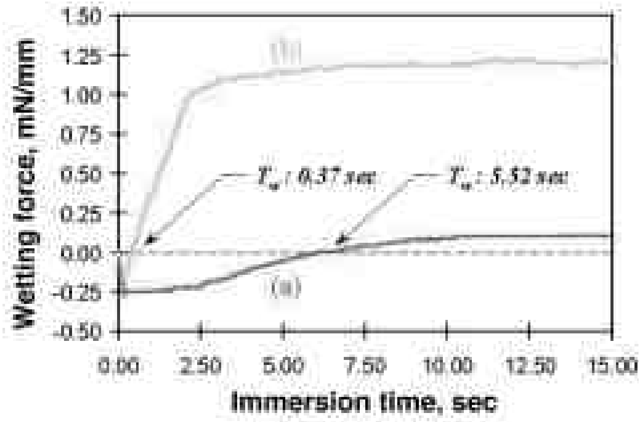

Fig. 6—Wetting balance test on: (a) typical Ni; (b) conformable Ni/Pd plated Olin 194 leadframes, 90° bend with a radius of 0.25 mm, 8 hr steam aging at 93°C and 95% RH.

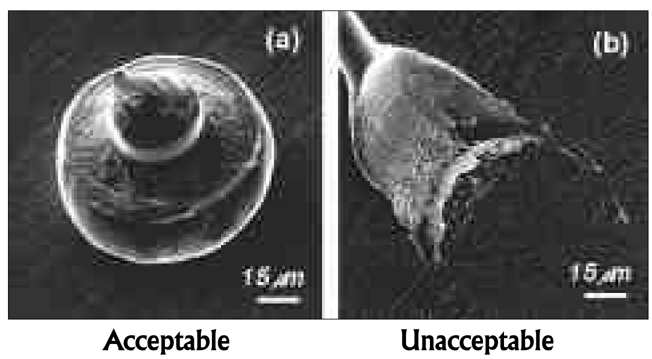

Fig. 7—Wirebonding pull strength test results.

typically broke at the ball neck, as shown in Fig. 7. This is related to the weakness of the wire at the heat-affected zone (grain growth area) after ball formation.

Compared with traditional selective silver/solder surface finishing, the Pd PPF technology simplifies plating processes, improves product quality, reduces environmental concerns and lowers overall packaging costs. However, only when applied in combination with the conformable nickel underlayer can the substantial advantages of the Pd PPF technology be fully realized. *P&SF*