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Multilayer Printed Circuit Board Analysis of Interlayer Adhesion Failure

Introduction

Multilayer structures have been widely used in various industries (*e.g.*, printed circuit board) because of their superior material properties. Adhesion at the interface of the layers is of paramount importance for performance and reliability.

Problem

An electronic device manufacturer was experiencing delamination of their multilayer printed circuit boards, which were mounted with a conductive adhesive to an aluminum pallet acting as heat sink (Fig.1). Samples were submitted to determine the overall adhesion strength of the multilayer structure and to elucidate the adhesion failure mechanism.

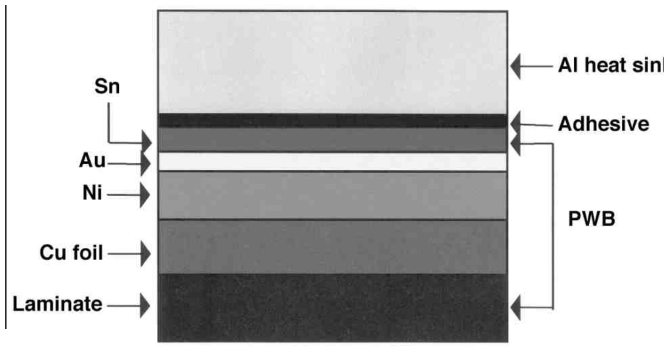

Fig. 1—Schematic cross-section of multilayer circuit board.

Analysis

The following analyses were conducted to determine the root cause of the problem.

- A 90° pull-up test was used to quantitatively measure the adhesive force.
- The elemental composition and chemical state of the surfaces at the failure sites were determined using X-ray photoelectron spectroscopy (XPS or ESCA).

The adhesive strength was measured using a Romulus III Universal Tester. In Fig. 2, the peel force is plotted versus time, from which a “steady-state” bond strength of 11.4 N/cm has been determined—much smaller than the required value of 35 N/cm.

In Fig. 3, the XPS spectra of the failed interface (Al-side and PWB-side—see Fig.1) are shown. Ni, C and O are found on both surfaces, while Cu was identified only on the PWB surface. This result clearly demonstrates that the failure occurs within the electroless Ni layer and very close to the interface between the electroless Ni and Cu layer.

Figure 4 shows a detailed view of the binding energy of $Ni2p_{3/2}$. On the other hand, $Ni2p_{3/2}$ shows two peaks at 852.4 and 856.1 eV, Fig.4, which are assigned to metallic nickel and $Ni(OH)_2$, respectively. This assignment is

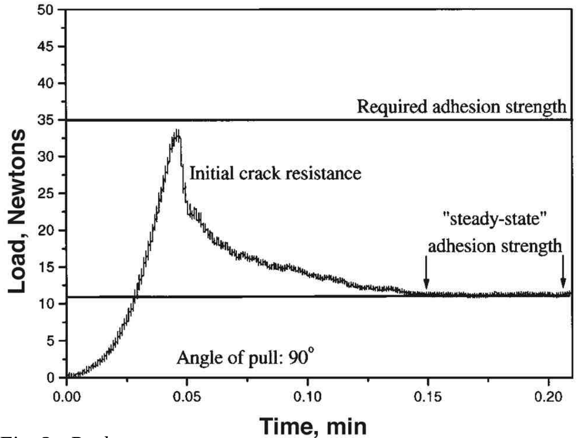

Fig. 2—Peel test.

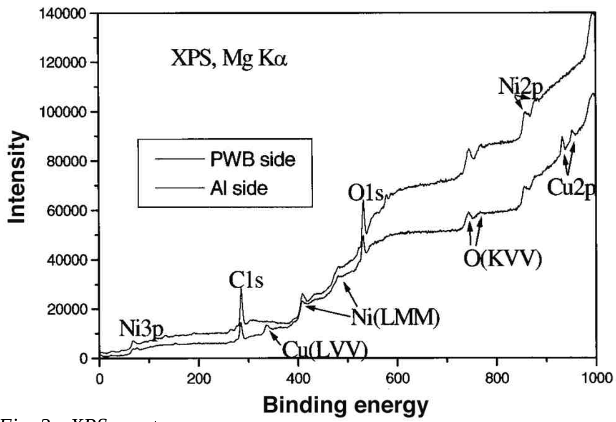

Fig. 3—XPS spectra.

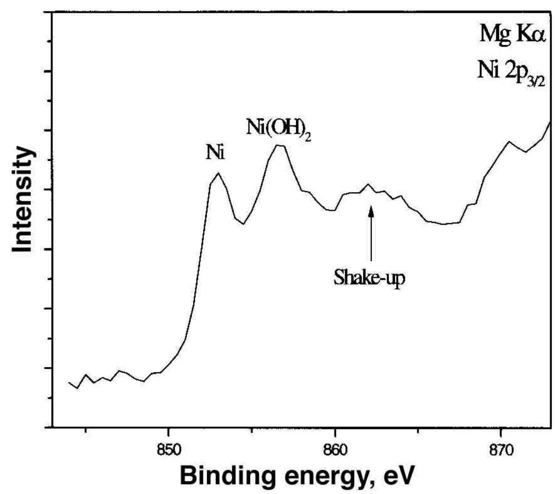

Fig. 4—Expanded view of the Ni2p$_{3/2}$ XPS.

further confirmed by the O1s binding energy of 531.7 eV (see Fig. 3), typical for hydroxide species.

Conclusion

The XPS results demonstrate that a weak boundary layer is present at the interface of the electroless nickel and Cu substrate. It is likely that nickel hydroxide is formed during the early stage of the electroless deposition process. This $Ni(OH)_2$ layer is the weak link in the multilayer structure, and leads to adhesive failures. *P&SF*