Tape-Peel Testing as a Simple Method to Evaluate the Adhesion of Coated Layers on Metal Core PCB

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Abstract

Conventional printed circuit boards (PCBs) may be replaced by thinner metal-core boards for some applications, as well as for package substrates. Using thin, metal-core technology may provide advantages for radio frequency (RF) circuits and packages, and increase heat dissipation for high power applications.

The metal-core technology discussed in this paper has several layers including the metal core, electro-coated dielectric, sputtered metal layers, and electroplated copper. For PCB and substrate reliability, it is important to have sufficient adhesion between the dielectric layer and plated copper. Sputtered metal layers with cleaning pre-treatments are one of the methods to improve the interfacial adhesion.

This paper describes an efficient testing method for the adhesion of a thin sputtered metal layer to a dielectric substrate. In this method, adhesive tape was attached to the surface and peeled off at 90 degrees in a tensile tester. Due to the sub-micron thickness of the sputtered layers, conventional peel test methods could not be applied. Typical adhesion testing of upper layers like paint coatings use a lattice pattern. The new method provided a convenient, repeatable way to evaluate the adhesion of three different sputtered metals with fifteen different pretreatment combinations. The test results were used to choose the sputtered metal and were later confirmed by testing the copper plated assembly using the metal adhesion specification in the industry standard IPC-TM-650.

A review of other methods and the need to identify an easy to use method which can provide repeatable quantitative measurements.

Keywords: Tape peel test, interfacial adhesion, printed circuit boards, metal-core technology, package substrates, sputtered layers, radio frequency (RF)

Introduction

Tape Peel Testing's objective is to find a good bonding between the metal layer and the top of the dielectric through a quick method without the electroplating process and to screen out the best pre-treatment processes. Fifteen 2" x 2" metal pieces were cut using Al, Cu, and Cr. Each metal needs to be pretreated and sputtered according to the researchers traveler guide.

According to PCB manufacturers, the standard for the minimum pull strength to remove the tape from the sputtered material is 2.5 lb/in. Although, the suppliers are increasing this pull strength to 3.5 lb/in to decrease failure rate between the dielectric and the sputtered layer. This increase in the pull strength provides a secure strength between the adhered layers to ensure that the layers remain bonded to one another.

Test Methods

Tensile tester is the most readily available testing method. The tensile test can quickly

determine how a certain material will react to forces being applied in tension. As the material is being pulled, one can find its strength along with how much it will elongate. The ultimate tensile strength can be determined which is the maximum load the substrate sustains during the test.

This method provides a convenient, repeatable way to evaluate the adhesion of the thin coatings. It is a fast and simple way to describe sputtered coatings on polymer surfaces. Also, it can be performed at press side to provide fast access to immediate results of adhesion strength. [10]

Experiment

Tape peel testing at CNSE is the tensile test method (See Figure 1). This test method uses an adhesive tape to determine the adhesion quality of a polymer coating to a metal substrate.

Tape:

A roll of 3M brand 600 one inch wide tape is used. The shelf life of the tape is one year. For an evaluation, it will be necessary that the same tape, preferably the same tape roll, be used as the tape adhesion may vary from one roll to the other. Variation in measured values is expected between different makes of tape but were not evaluated. [10]

Procedure:

Prepare and clean the substrate according to the researcher's procedure. Prime the surface of the substrate according to the researcher's procedure, if required. Press a strip of tape, 50 mm (2.0 in) minimum in length, firmly across the surface of the substrate (See Figure 2). [10]

Keep in mind; remove all air that is trapped underneath the tape. The time between application and removal of tape should be less than one minute.

Please note that the adhesive tape extends beyond the sample providing a lead to be grabbed the tester to grab for peel testing this alleviating the need to initiate peel of the thin film manually, and also alleviating the need to grab an edge portion of the thin film itself.

Remove the tape by a uniform pull force applied perpendicular (90 degrees) to the test area (See Figure 3). To ensure consistent results, the tape must be pulled off in a prescribed fashion. For each test, an unused strip of tape must be used. Visually examine tape and check for any segments of material tested have been removed from the substrate. Variable data should

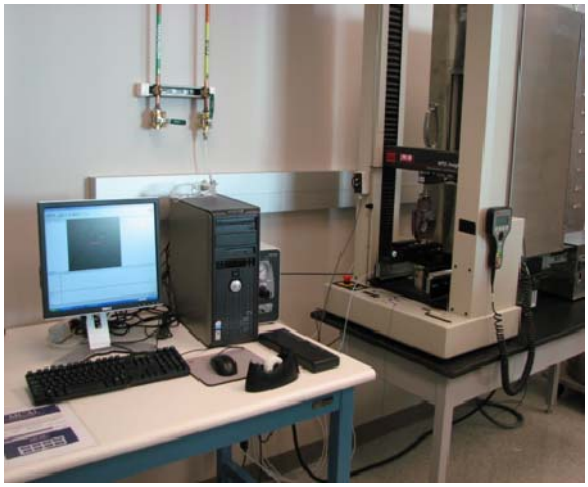

Figure 1: CNSE Tensile Tester

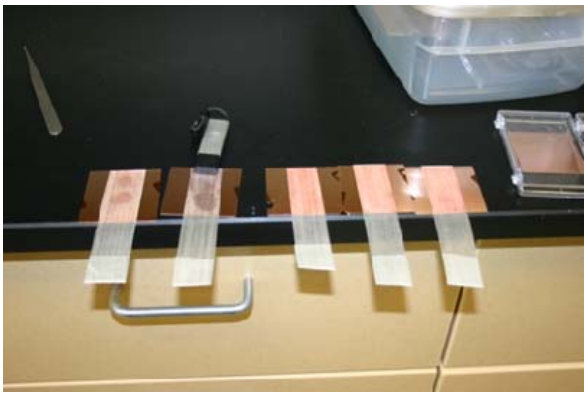

Figure 2: Tape if applied firmly and evenly across the surface of the substrate

Figure 3: Tape is peeled at a 90° uniform pull from the substrate

be recorded and processed for analysis using researcher's recommended software. [10]

Results

Tape peel test is an efficient, viable, and accurate method to test interfacial adhesion between sputtered layers and metal core substrate. Multiple tests have been conducted to examine numerous pre-treatment applications and test the underlying adhesion. Throughout testing, the strongest interfacial adhesion came with the combination of different pre-treatment samples. These combinations have been altered and specified according to each process.

Correlation analysis has been conducted to interpret peel strength results between Peel Test vs. Tape Peel Test. Results indicate a correlation among tested strips. (As seen in Figure 4) Slope received from best fit line is 0.7185 and shows the correlation between the two tests. These results show that the tape peel test can be used as a go-no go test to evaluate adhesion of sputtered metals. This can be used as a preliminary press side test to indicate whether adhesion is sufficient enough to undergo further analysis.

Another set of data has been analyzed between Peel Strength and Max. Tape Peel Strength. This data has been computed to analyze the difference *1.* Peel Strength vs. Tape Peel Strength and *2.* Peel Strength vs. Max. Tape Peel Strength. These results show that there is a better correlation between the tests of set *1.* This is represented in Figure 4. Set 2 results show a weaker correlation of slope 0.6405 among tests, due to the fact that the max peak value was used from the Tape Peel Test. (As seen in Figure 5)

Discussion

Metal Core substrates based on copper or a nickel-steel alloy (Invar) have been used to address coefficient of thermal expansion (CTE) issue. Depositing copper on top of Invar allows modification of CTE and improves head spreading capabilities. Invar offers a better CTE match, better heat removal capability, enhanced electrical capabilities, and more dimensional stability compared to standard substrates. [11]

Circuitry is created on the surface of the substrate through the vias making electrical

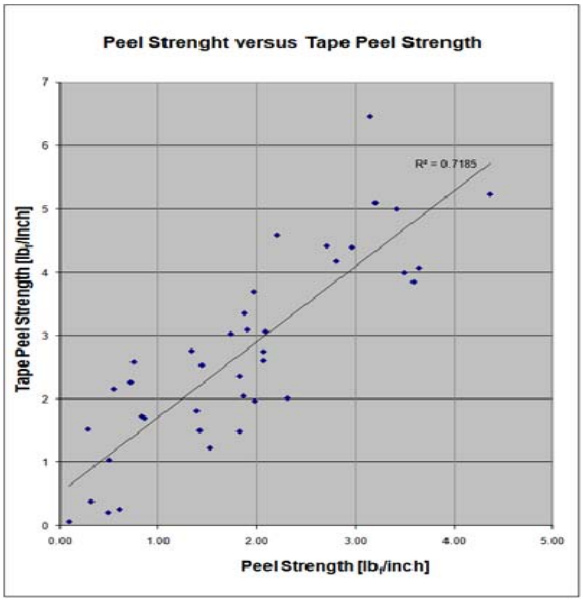

Figure 4: Peel Strength vs. Tape Peel Strength

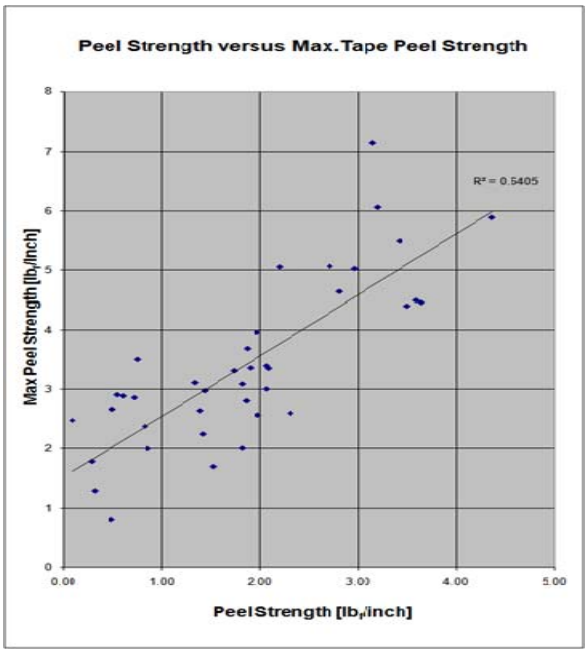

Figure 5:
Peel Strength vs. Max. Tape Peel Strength

connection between the top and bottom layers. Thus high density wiring is created on and between the layers of the substrate.

Conclusion

Tape peel testing is an efficient testing method for the adhesion of thin sputtered metal layer to a dielectric substrate. Throughout testing,

tape peel test is an efficient, fast, repeatable and reliable method to evaluate the adhesion of different pre-treated sputtered metals.

Tape peel test has a correlation to the peel test strength, of ~72%. This correlation describes that the tests are providing similar results and that tape peel test is a good preliminary test method to evaluate adhesion of different materials on a go-no go basis. A review of this indicates that method is simple and fast, and can provide repeatable quantitative measurements.

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