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## Electrolytic Nickel-Phosphorous Reel-to-Reel Plating for Aluminum Wire Bonding Applications

by Vince Azzano

### Introduction

Aluminum wire bonding is used extensively in the electronics industry as an interconnection in hybrid integrated circuits and automotive sensor applications. These types of aluminum wire bonds can be commonly found in fuel injection modules, anti-lock brake modules, transmission control modules and air-flow sensors.

In these applications ultrasonic aluminum wire wedge bonds are typically used to connect the sensor die or hybrid circuit to a lead frame produced from a metal substrate. In the past these metallic lead frames have been inlaid with aluminum in the area intended for bonding. While aluminum inlaid surfaces provided a highly reliable surface for aluminum wire bond applications the high cost of using inlaid material has forced engineers to look for more cost effective alternatives.

Electrolytic plated nickel sulfamate has shown to be a reliable alternative to aluminum inlay in these aluminum wire bond applications; however, unprotected nickel surfaces will slowly oxidize resulting in wire bonding problems. To combat this oxidation engineers have developed specifications calling for a thin coating of precious metal or electroless nickel-phosphorous. On the precious metal front, the use of electrolytic gold plating has been shown to exhibit reliability issues when used in these applications. These problems may be related to the rapid formation of aluminum-gold intermetallics and the potential for Kirkendall voids; however, more study would be necessary to identify the source of these reliability issues. Electroplated palladium has been shown to be a much more reliable choice in these applications and it has the added advantage of being more cost effective than gold. Thin layers of electroplated palladium over nickel sulfamate have been used for over a decade in aluminum wire bonding applications and have a proven history of reliability.

For lead frames that can be rack or barrel plated overall, a thin layer of electroless nickel-phosphorous, over electrolytic nickel sulfamate has also been proven to be a reliable alternative to aluminum inlay. However, because electroless nickel-phosphorous has a relatively slow deposition rate it has not been practical or cost effective in reel-to-reel plating applications.

Recent developments in nickel-phosphorus plating chemistry have provided a deposit that can be applied in an electrolytic system. This chemistry allows for a faster deposition rate than its electroless cousin and in reel-to-reel applications can be applied selectively on either continuous coils of flat stock material or on pre-stamped reel-to-reel lead frames.

Recently, Precision Plating put this new electrolytic nickel-phosphorous chemistry to the test by conducting a design of experiments that compared the aluminum wire bondability of this new electrolytic nickel-phosphorous finish side-by-side with proven palladium and electroless nickel-phosphorous coatings.



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## Design of Experiments Test Matrix

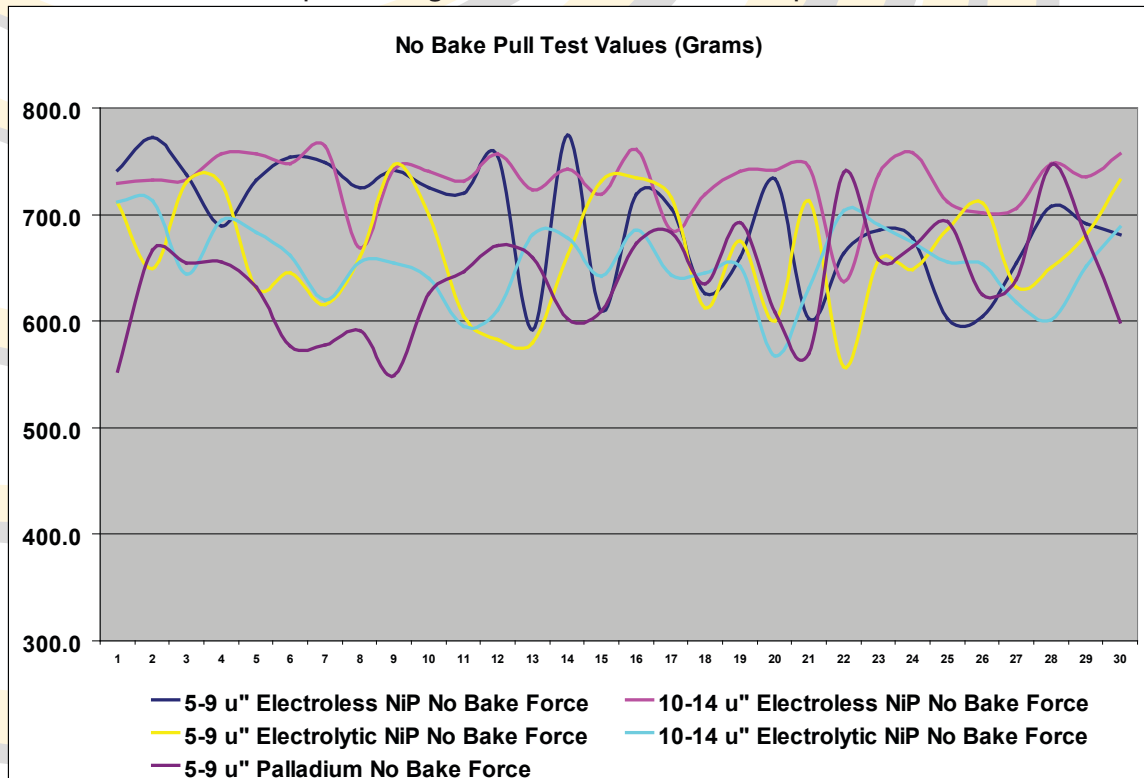
For our DOE we plated five groups of samples;

SAMPLE GROUP #1	5-9 u" PALLADIUM
SAMPLE GROUP #2	5-9 u" <u>ELECTROLYTIC</u> NICKEL PHOSPHORUS
SAMPLE GROUP #3	10-14 u" <u>ELECTROLYTIC</u> NICKEL PHOSPHORUS
SAMPLE GROUP #4	5-9 u" <u>ELECTROLESS</u> NICKEL PHOSPHORUS
SAMPLE GROUP #5	10-14 u" <u>ELECTROLESS</u> NICKEL PHOSPHORUS

Each sample group was plated over a commonly used 260 brass lead frame material and each sample was under-plated with a 50 u" layer of electrolytic nickel-sulfamate. Additionally, each sample was broken into two additional groups with one group aged by baking the samples at 250 F for three hours. The baked samples were designed to test the top coating's ability to protect the underlying nickel-sulfamate layer from oxidation. All of the groups were then tested by an outside third-party test laboratory by wedge bonding and pull testing 30 wire bonds using 0.010" aluminum wire.

## Test Results

Table 1 shows the pull strength values for the no bake samples and Table 2 shows the pull strength values for the bake samples.



**Table 1**



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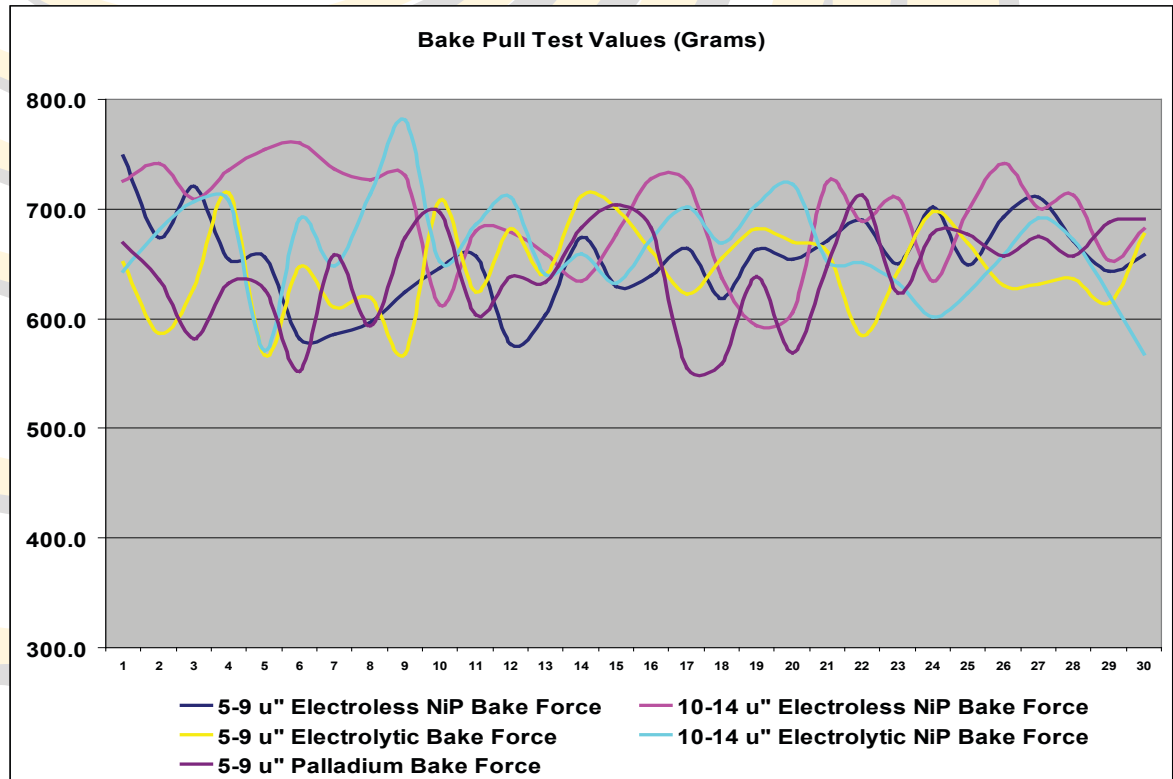
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From these results we can see that all of the samples performed comparably well with no pull test readings below 500 grams. All of the samples tested failed either at the neck of the wedge bond or in the span of the wire. None of the samples tested exhibited wedge bond lifts. Table 1 shows a summary of the data with minimum values, maximum values, averages, standard deviations for each of the ten test groups.

**Table 1: Pull Test Data Summary (Grams)**

	5-9 u"		10-14 u"		5-9 u"		10-14 u"		5-9 u"	
	Electroless NiP		Electroless NiP		Electrolytic NiP		Electrolytic NiP		Palladium	
	No Bake	Bake	No Bake	Bake	No Bake	Bake	No Bake	Bake	No Bake	Bake
<b>Average</b>	694.5	653.5	730.9	693.2	666.2	646.5	654.7	665.5	639.4	643.1
<b>Std. Dev.</b>	54.8	40.7	28.7	46.2	53.2	40.7	35.4	45.5	49.8	46.2
<b>Max</b>	773.9	748.0	764.0	760.7	747.1	714.3	712.5	781.3	746.6	712.6
<b>Min</b>	592.1	576.8	636.7	594.0	557.1	566.8	567.7	567.7	548.6	552.4



**Table 2**



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## **Conclusion**

Based on the pull test results from our DOE, there appears to be no appreciable difference in bond pull strength values between the proven palladium and electroless nickel-phosphorus plating finishes and the new electrolytic nickel-phosphorous plating chemistry. This is excellent news and provides our customers with a cost effective alternative in selective reel-to-reel aluminum wire bond applications.

Precision Plating is a World Class; ISO/TS 16949:2002 certified electroplating facility located in Chicago. Precision Plating is dedicated to being the best barrel, rack and high-speed reel-to-reel continuous precious and non-precious electroplating job shop in the world. We are proud to be able to leverage our extensive plating experience and unsurpassed technical expertise to provide our customers with cutting edge technology that provides unique solutions to the industries toughest plating challenges.

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