FINISHING SOLUTION SIMPLIFIED

Recent R&D has revealed a significant breakthrough in one component electroless nickel plating

BY MIKE BLACK

Electroless plating is the deposition of a metal coating by a controlled chemical reaction, with the absence of electrical current. The reaction begins on the substrate (typically steel, copper, aluminum etc.) and continues to build upon the initial coating.

In an Electroless Nickel (EN) plating bath there are two primary chemical reactions occurring: oxidation and reduction as seen below.

Oxidation

$$H_2PO_2^- + H_2O \rightarrow H_2PO_3^- + 2H^+ + 2e^-$$

Reduction

$$Ni^{+2} + 2e^- \rightarrow Ni^0$$

EN is a versatile coating commonly used to provide protection from abrasion and wear, provide resistance against corrosion, and for its hardness properties. It can be seen across a range of coating applications in engineering, electronics, energy, aerospace, amongst many others. This adaptable process allows nickel plating to fill recessed areas on parts and provide flexibility to the desired thickness of the finished plate. Unlike nickel electroplating, the part's position in the plating solution is irrelevant in electroless plating.

Physical properties of the EN coating are affected by the phosphorus content in the coating and traditionally low, medium, and high phosphorus containing processes are available. The hardness, wear resistance, corrosion resistance, magnetism, ductility, and electrical resistivity are all directly related to the phosphorus content. The EN acts as a barrier protection to the underlying substrate and the porosity and thickness of the coating affects the protection. A high phosphorus deposit is the most corrosion resistant where the low phosphorus deposit offers more protection in strong alkaline solutions. Heat treatment will cause EN coatings to increase in hardness to levels similar to hard chrome, but corrosion resistance is lost in the process.

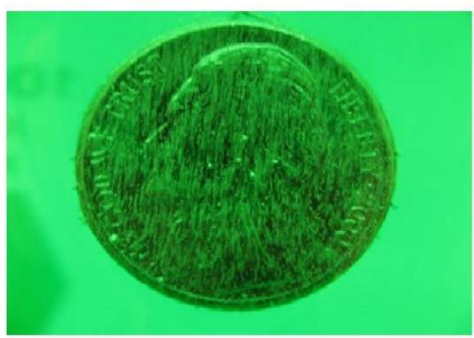
A historic EN plating solution is comprised of a nickel salt and a phosphorous containing reducing agent and is commercially offered in three components A, B, and C. The below chart outlines how the three components contribute to the plating bath.

Initially the ABC system was developed to allow for certain ingredient ratios at make up and during the life of the bath. This avoids combining the metal salt with the reducing agent prior to their introduction to the plating bath. This helped to ensure the pH compatibility of the individual ingredients for stability in shipping and storage.

Although designed with the correct intentions, the historic process does have some limitations. Logistically there are issues maintaining the bath with three separate products. Applicators often experience concerns with ordering, documenting, shipping, inventorying, and warehousing the three different products. This leads to confusion with the usage of the different chemicals, wasted time and effort in setting up manual operations or multiple dosing pump systems, and in dire situations, contamination of the bath or the ingredients. The consequences of mismanagement can be noted in the performance of the bath, the life of the bath, the overall quality of the plating, and the expenses associated with correcting errors.

A thorough understanding of the wants and needs of platers everywhere coupled with the technical abilities to perform the necessary R&D related activities led to a significant breakthrough in EN plating; The Single Component Electroless Nickel. The one component is a solution that is stable, pH compatible, and with all the necessary ingredients coexisting for both make-up and replenishment. It is the simplest electroless nickel bath ever, overcoming the many shortcomings of the decades-old practice of using three different components.

Some of the obvious benefits of using the one component would be seen in the simplified logistics. Only one product to



Component	Typical Chemistry	Typical Concentration	Typical Use
A	Nickel Sulphate	~5%	Make up and Replenishment
B	NaH_2PO_4 with complexers, stabilizers, pH, Etc.	~15%	Make Up
C	NaH_2PO_4 with complexers, stabilizers, pH, Etc.	~10%	Replenishment

order, ship, and inventory also means only one price from your supplier. No more difficult invoices to manage or wasted floor space. Only one product data sheet and one SDS sheet.

Some of the less obvious benefits with the breakthrough solution would be the ability to "drop in" the one component into an existing setup. The same tank, pumps, and filters can be used and in the laboratory the same chemical process and analysis are used to maintain the tank. The bath itself provides less of a chance for confusion in additions or contamination and enables greater consistency and productivity. Any existing pretreatment could still be used.

The One Component EN system is available in the traditional Low, Medium, and High phosphorus contents and the physical properties of the coating wouldn't be any different than a traditional three component process. It produces an EN to standard parameters and specifications. The one component simply offers a flexible and practical way of applying the coating. The one component baths are still maintained at an activity between 80 – 100 per cent and the operating conditions (temperature, pH, bath loading, plating rate, agitation etc.) are typical as with a historical bath, making a transition smooth and effortless.

Some of the physical properties of the different systems are outlined in the chart below. The bath life is still measured by metal turnovers (MTO's). The metal turnover is achieved when the quantity of nickel in a brand-new bath has been converted into a NiP deposit. In a historic EN process operating at 6 g/L of nickel, a MTO has been achieved when 6 g/L of nickel has been deposited "out" of the bath. In other words when the total additions of replenishment metal are equal to the amount of metal originally in the bath.One very important feature of the one component bath is the ability to make large additions to the chemistry. Through the maintenance of a traditional ABC EN bath, when an addition is to be made that is greater than 20 per cent activity you throw the bath components out of sync. This leads to issues in plating. An example of this would be running at a Nickel Metal content of 6 g/L. After analysis you find your bath is at 4.8 g/L, requiring an addition of 1.2g/L or 20 per cent activity. An addition this large in size added into a traditional three component system would cause significant chemical imbalance and many operators have suffered the consequences and know to avoid doing this.

In the one component system the unique balance of plating components allows for the bath to accept larger additions without consequence. Although it is still best practice to make smaller and more frequent additions to the bath, the one component system is far more robust for when the large additions are needed.

As the bath ages the accumulation of by-products will still decrease the deposition rate and the corrosion protection. With the one component EN process a plater can still expect a bath life of four to six MTO with the high phosphorus system and a life of eight to 10 MTO with the mid phosphorus system. The life is shorter when plating with aluminum, which is no different from the historical three component bath.

One Component EN technology is gaining momentum and is currently available through affiliates worldwide. Many case studies have been conducted to show a holistic analysis of the cost advantages with converting to a single component system. Some of the key experiences would include the ease of stocking, reduced shipping costs, the lower bath make-up costs, more consistent quality, higher productivity, and less time between loads. One quality that is often overlooked and can be hard to monetize, would simply be how happy platers are using the one component system. Happier platers tend to result in increased productivity, higher quality, and greater retention. ■

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One Component System	Low Phosphorous	Mid Phosphorus	High Phosphorous
Phosphorus Content	3-5%	5-8%	10-13%
Deposit Density	8.7 g/cm³ (Average)	8.1 g/cm³ (Average)	8.25 g/cm³ (Average)
Hardness as Plated	60 RC	52 – 56 RC	46 – 48 RC
Hardness after Heat Treatment	68 RC (400° C for one hour)	66 – 68 RC (400° C for one hour)	66 – 68 RC (400° C for one hour)
Melting Point	1250 – 1360° C	900 – 1100° C	880 – 960° C
Salt Spray Results (as per ASTM B-117)	90-100 Hours (1.0 mil thickness)	96-120 Hours (1.0 mil thickness)	1000 Hours (1.0 mil thickness)
Tensile Strength	200 – 400 Mpa	400 – 1000 Mpa	650 – 900 Mpa