Issue No. 34 – October 2011 **Updated from Original April 2002 Publication**

Five pennies for your thoughts? - An overview of nickel coatings for electrical contact surfaces.

- **Hardness**
- **Wear Resistance**
- **Corrosion Resistance**
- **Residual Stress**

The next issue of Technical Tidbits will discuss creeping corrosion products.

Nickel as a Coating Material

Nickel coatings can be very hard and durable, and are often used in applications requiring wear resistance. Nickel has a wide range of properties depending on how it is applied. It is most often used as an undercoating, for many reasons which will be discussed in future editions of Technical Tidbits. This edition will discuss the properties, application methods, uses, and limitations of nickel as coating material.

One characteristic of nickel coatings that truly stands out is **hardness**, which can range anywhere from 150 HV to 700 HV. This provides good **wear resistance**, especially for sliding contacts. Nickel and nickel alloys are very widely known for **corrosion resistance**, and bright nickel has a very pleasing appearance. For electronic applications, Nickel is commonly applied by electroplating, electroless plating, and cladding.

Nickel will tend to form a hard oxide. Fortunately, this oxide is stable, and will not continuously grow at the expense of the coating layer. This oxide layer may make nickel-plated contacts susceptible to fretting corrosion, and requires the use of high contact force (much greater than 100 grams) to make good electrical contact. However, the oxide is usually thin. Battery contacts or charger contacts are often made with bare nickel coatings. They are not subject to micro-motion, so there is no potential for fretting corrosion. In addition, the voltages involved are substantial enough to drive the current through the oxide film.

The thickness of electroplated nickel depends on the current density on the surface of the substrate. It is virtually impossible to create a uniform current distributions in parts to be plated, therefore, the nickel will plate onto different areas of the surface at different rates. This will create non-uniformities in the plating thickness.

Electroless nickel is very hard and wear resistant. In fact, it is most often used in applications outside the connector industry that require hard, durable, and corrosion resistant coatings. (Some examples are plastic and glass molds, bearings, gears, and pressure vessels.) In these platings, the nickel is usually deposited with small percentages of boron or phosphorous. These coatings can be heat treated to high hardness (500-11000 HV for NiP, 700-2000 for NiB), although it is at the expense of ductility and formability. Since no electric current is used in the application process, electroless nickel coatings are very uniform in thickness. They are also less prone to porosity than electroplated nickel coatings.

Nickel platings (both electroplated and electroless) will contain **residual stress** induced during the deposition process. If the stress is tensile in nature, it can limit the fatigue life of the contact. Compressive residual stresses, on the other hand, can enhance the fatigue life. The amount and direction of the residual stress patterns depend on many variables, such as the composition, purity and pH of the bath; concentration of any brighteners; current density (electroplating); bath temperature; amount of alloying elements (like boron or phosphorous); and post-plating heat treatment time and temperature.

Nickel as a Coating Material (continued)

A nickel plating may limit the formability of the base material. This is especially true for electroplated nickel. The act of forming creates very high tensile stresses at the outer radius of the bend. Any residual tensile stress in the nickel plating will add to the outer fiber forming stress. This can cause separation of the plating, or cracking of the bend at a larger bend radius than one would see for the uncoated base metal. Any crack can easily propagate into the base metal, which contributes to premature fatigue failure of some nickel-plated parts. If the environment is corrosive, these cracks can also result in highly localized corrosion of the underlying base metal, as shown in Figure 1.

Clad nickel is usually applied as an undercoating along with a precious metal coating. It is generally more ductile, less porous, and forms more easily than plated nickel.

Nickel coatings have many uses in applications requiring durability and resistance to corrosion. Although most commonly used as an undercoating, there are some applications where it really shines (especially with the use of brighteners.) If care is taken to ensure that the residual stress is low or compressive, nickel will even work well in highly cycled applications.

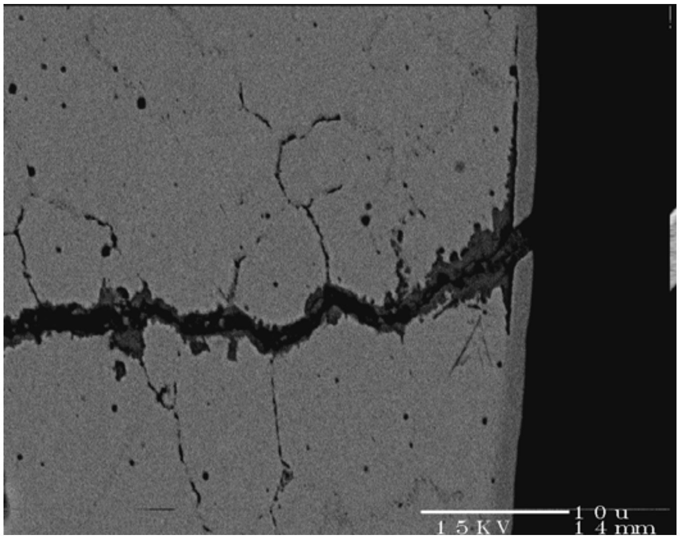

Figure 1. Selective corrosion at a crack in separated nickel plating, resulting in corrosion fatigue failure.

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References:

ASM Handbook V. 5
Surface Engineering
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