Fasteners for electronics

By Alan Gardner, global marketing manager, MacDermid Industrial Solutions

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Fasteners are extensively used in electronic applications such as computers, consumer units, mobile communications and switches. Fasteners for electronics are coated with finishes which both protect and enhance the base metal properties whilst avoiding thread fill on even the smallest of screws.

These coatings are designed to protect the fastener in indoor environments where condensation is possible. Similar to aerospace and automotive applications, they are also subject to legislations such as RoHS and WEEE. In this article we review the choice of coatings on ferrous materials for their attributes and conformity to today's electronic fastener requirements.

Coating attributes

The main requirements for this application can be summarised as:

- Conformity to RoHS and WEEE directives.
- 168 hours in neutral salt spray to 5% white corrosion.
- 500 hours in neutral salt spray to first base metal corrosion.
- Continuous current conductivity of 1 mA at 5V.
- Grounding resistance < 100 mW at 30A – 12V.
- Resistance to immersion in liquids such as water and methanol.
- Adhesion of organic screen printing inks and organic coatings.

Coatings which are typically applied in electronic component applications include black oxide, electroless nickel (EN), electrolytic nickel, tin and zinc and zinc alloys. Table One outlines the primary attributes of these finishes and their ability to meet the above criteria.

Table One	Oxide	EN	Nickel	Tin	Zinc	Zn alloy
RoHS / WEEE conformity	Yes	Yes	Yes	Yes	Yes[1]	Yes[1]
Neutral salt spray resistance	No	No	No	No	Yes	Yes
Immersion in liquids	No	Yes	Yes	Yes	Yes	Yes
Conductivity (continuous)	Yes	Yes	Yes	Yes	Yes[2]	Yes[2]
Conductivity (grounding)	Yes	Yes	Yes	Yes	Yes[2]	Yes[2]
Organic layer adhesion	No	Yes[3]	Yes	Yes	Yes[4]	Yes[4]

1. With trivalent passivation
2. Without topcoat
3. Without PTFE included in film
4. Low build passivate films are recommended

Finish description

Black Oxide – This can be described as a conversion coating of the steel. The finish is protected by applying a light oil. It is primarily used to improve aesthetics without altering dimensional tolerances. The only protection is by the light oil and for this reason is only recommended for screws with the finest dimensions in closed environments.

Electroless nickel – These composite coatings are an 'alloy' of corrosion resistant nickel and phosphorus. The resulting coating is very hard (450HV100 to 1,000HV100). If PTFE is included in the deposit, a coefficient of friction between 0.01 – 0.2 can be obtained. The EN coating gives a corrosion resistant, low friction deposit with a very even deposit. To meet the higher salt spray resistance requirements, a duplex layer using high phosphorus base layer is recommended. The coating retains its electrical conductivity so it can be used for earthing screws and fasteners.

Nickel – Nickel coatings are usually applied electrolytically in a mirror bright finish. They have excellent conductivity and adhesion of an organic layer. However, this coating will not give good base metal corrosion protection as it is more noble than the steel. Therefore its use is limited to applications where aesthetics is more important than corrosion resistance for example on front panels.

Tin – Tin coatings have very similar attributes to nickel coatings. They are applied electrolytically with a choice of dull or mirror bright finishes with excellent conductivity and adhesion of an organic layer. Similar to nickel, tin is more noble than the steel. Primary applications include earthing and where subsequent soldering is required.

Zinc and zinc alloys – The primary coating of choice in these applications are using zinc and zinc alloys. Depending on the passivate applied, the finish can be mirror 'chromium' bright, iridescent or black. Zinc based coatings have the advantage over others outlined above in that zinc is sacrificial to the steel substrate. This results in exceptional corrosion resistance, particularly in humid environments when non-sacrificial coatings would give limited protection.

One of the major advances in the last decade has been in extra high corrosion resistant coatings such as zinc-nickel. As these coatings have low white corrosion products, they retain their electrical conductivity longer compared to zinc coatings.

Which coating choice?

If solder-ability is not the prime criteria, then a zinc based coating is probably the best all round choice. As well as meeting the majority of performance criteria, it is also typically more economical to deposit than a nickel based coating. As mentioned above, the engineer also has choices in relation to zinc based coatings – zinc or zinc-nickel? Primarily the choice of system comes down to cost versus performance; secondly there are the coating aesthetics to consider.

Cost versus performance

When measured against the coatings attributes list, the main difference between zinc and zinc-nickel coating performance in electronic applications is the ability of the latter to resist voluminous white corrosion products. These white corrosion products do not conduct electricity and therefore impact on the continuous conductivity and earthing factors.

Zinc only coatings produce voluminous white rust which can be detrimental to conductivity

In comparison, zinc-nickel produces limited corrosion products

Regarding metal deposition, two factors affect the cost of this process:

- Metal costs – Nickel metal is some 10 times more expensive than zinc. Allowing for metal costs and percentage alloy composition, this makes a zinc nickel coating some 2.4 times more expensive than zinc alone (for the same thickness).

- Economies of scale – Zinc is very widely plated, whereas zinc alloys are a much more recent development. This is changing in Europe, but also, more slowly, in other parts of the world.

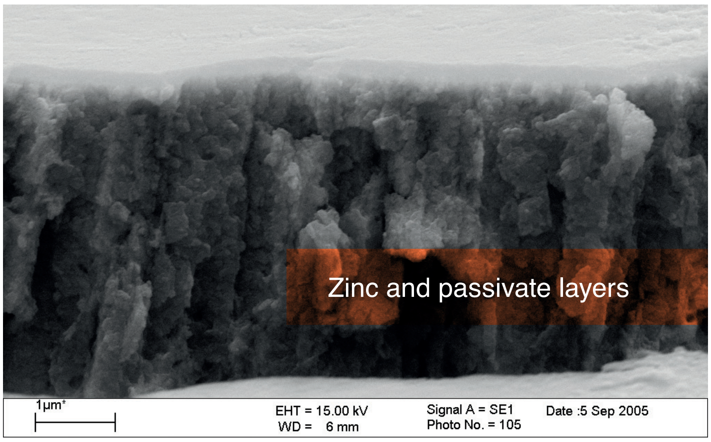
Resistance to immersion in liquids and the ability to accept organic coatings are a function of subsequent passivates and topcoats. In respect to the passivate, the choice is between low or high build films. The latter typically gives a film some 5 times thicker (Table Two) and therefore generally gives better corrosion resistance. However, with trivalent chromium passivates it is generally accepted that thicker films can be harder to apply the screen print and organic paint coatings due to inferior adhesion compared to the thinner films.

One should note as well that black passivates, which are always of the thicker film variety, when applied over zinc have a lower corrosion performance compared to an iridescent coating. When applied over zinc-nickel however, they give exceptional corrosion performance and are suitable for the toughest requirements.

Table Two – Thicknesses and composition of corrosion resistant passivate films

Type	Film thickness nm	Cr^{3+} (mg/dm^2)
Thin film	25 - 80	0.3
Thick film	200 - 400	1.2

Aesthetics may also play a part in choice. Low build films are associated with a blue or bright chromium-like appearance, suitable for applications that have high visibility. High build iridescent passivates are normally found in applications which are hidden (such as switch gear), while black can be found in both high and low visibility components.



Finally topcoats, if there is a requirement, for example to improve corrosion resistance, then an inorganic type would be suitable due to its ability to withstand immersion in liquids. On the other hand if improving adhesion of screen print or paint films was the most important criteria, a low weight organic topcoat would be beneficial. One must keep in mind that generally application of a topcoat will reduce the conductivity of the coating.

Summary

To meet RoHS/WEEE directives, provide good corrosion/liquid immersion resistance, with good conductivity and organic film adherence in electronic fastening applications, an engineer has a choice between sacrificial (i.e. zinc based) or non-sacrificial (i.e. nickel based) coatings.

When the benefits of these typical finishes are compared, zinc based coatings probably have the advantage. They are low cost, with excellent corrosion resistance. Additionally they conduct electricity will resist immersion in relevant liquids and can accept a subsequent organic film. ■

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