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Recent Trends in Surface Finishing Technology Responded to Environmental Regulations

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1. Introduction

Surface finishing, especially plating technology has been widely used in many industries due to the excellent properties. But in the plating process or plated films some hazardous and toxic substances such as hexavalent Cr, cyanide, lead and so on are incorporated, and in order to protect human health or conserve a living environment these substances are severely regulated. Regulations are always strong impetus to develop a new or alternative technology. Here recent trends in plating technology responded to the regulatory movements are overviewed.

2. Environmental regulations and responding technologies

ELV directive, 2000/53/EC banned Cr(VI) in the materials and components of vehicles from July 1, 2003 except corrosion preventive coatings on vehicle components, but Annex II of the ELV directive was amended and the effective date was changed to July 1, 2007 and then the expiry date was again amended to July 1, 2008 about bolt and nut assemblies for chassis applications. RoHS directive, 2002/95/EC also banned Pb, Hg Cd and Cr(VI) in electrical and electronic equipments. U.S. OSHA issued a new standard that greatly lowered the limit on workers exposure to Cr(VI) from 52 to 5μg/m3. On Dec. 11, 2006 Japan Ministry of Environment lowered permissible limit of Zn from 5 mg/L to 2 mg/L in the effluent standards.

1) Alternatives to hexavalent chromate coating

Chromate coating effectively protects Zn or Zn alloys from white rust due to the self-healing action of leachable Cr(VI) in the film. But Cr(VI) is carcinogenic and so trivalent chromate (should be called "chromite" accurately) has replaced it in the automotive industry. Corrosion resistance of trivalent chromate is comparable to that of hexavalent chromate, But Cr(VI) was detected from the boiling water extracts of trivalent chromate films obtained from an organic type solution containing Co(II) ion. Therefore Cr free coating is the target to develop next generation corrosion prevention technologies. Among those are tannic acid films, tungstate, molybdate, vanadate, permanganate, cerium salt, zirconium oxide, silanes, titanate, alkoxide, thioglycollate and Zn-Ni alloy plating with high Ni content(12- 15wt.%).

2) Alternatives to hexavalent Cr plating

Decorative trivalent Cr baths have been successfully commercialized, but functional ones are now under investigation. Most of the chemistries that have been reported to date make use of complexing agents that can be found in the decorative trivalent Cr baths. Another two types of chemistries are interesting. In one chemistry hexavalent Cr is reduced to trivalent form by methanol. It enables higher trivalent Cr ion concentration and hence higher current density and greater productivity. The other utilizes chrome tan as a raw material. This is a trivalent species manufactured from sodium dichromate. Both of these chemistries are similar in that adherent deposits can only be obtained on nickel substrates. The deposits are all amorphous. With heat treatment at 350-370℃ amorphous deposits are converted to bcc structure.

Electroless Ni-B alloys, Ni-W alloy, and Ni- and Co-based nanocomposite are all promising candidates replacing functional hexavalent Cr plating. HVOF is also interesting alternative.

3) Others

Sn alloys such as Sn-Cu, Sn-Ag and Sn-Bi, and pure matte Sn are the substitutes for Sn-Pb alloy plating. In electroless Ni plating Bi is used instead of Pb as a stabilizer. Perfect closed plating process is the most effective method to respond to stringent effluent standards.