

Functional Enhancement Technologies for Wet-Process Nickel Alloying

Toshimitsu Nagao
Research, Metal Finishing
Okuno Chemical Industries Co., Ltd.

Alloy Plating

Alloy plating is a technology in which two or more species of metallic ions contained in a plating bath are reduced simultaneously and co-deposited in a coating. This technology has been adopted widely for industrial use as a means to derive functionality that a single metal alone cannot provide. Many alloy platings are superior in corrosion and abrasion resistance, and by varying the proportions of the metals used, the color tone and physical properties of the plated coating can also be changed.

To deposit two or more different metallic ions from a plating bath simultaneously, the deposition potential of each species must be similar. If the metals have similar standard electrode potentials, it is easy to obtain a plated alloy coating from a plating bath incorporating the blended, simple salts of each metal. However, such alloys are uncommon; most often, alloy coatings are produced by complexing the metallic ions in the plating bath to alter their electrodeposition potential.

Alloy platings are used widely for applications such as decorations, corrosion resistance, bondings, bearings, and electronic and mechanical components. Nickel-based alloy coatings in practical use, as befits the case, include Sn-Ni, Ni-Fe, Zn-Ni, Ni-P, Ni-W, Ni-Mo, Ni-Co, Pd-Ni, Au-Ni, and Cu-Ni.

Tin-nickel alloy plating

Tin-nickel alloy plating has unique characteristics different from those of other alloy platings. The compositional ratio of a tin-nickel alloy plating is 65 mass% tin and 35 mass% nickel, which corresponds to a composition with equal atom counts (50 at.% Ni and Sn respectively). As a result, the crystalline structure of tin-nickel alloy plating comprises only a single intermediate phase, NiSn. (Fig. 2).

The NiSn phase is a metastable phase that does not appear in the equilibrium diagram. Because this property derives from the crystalline structure unique to the plated coating, it is impossible to produce with molten heating techniques. The NiSn phase does not undergo recrystallization at temperatures of 300°C or lower and is stable at ambient temperature. When heat-treated at temperatures above 300°C, the NiSn phase is decomposed into Ni₃Sn₂ and Ni₃Sn₄. The hardness of a tin-nickel alloy plated coating is comparatively high, at approximately 800HV.

Corrosion Resistance

Figure 3 illustrates the corrosion resistance of tin-nickel alloy-plated coatings in salt spray and CASS testing. In atmospheric environments, a pinhole-free tin-nickel alloy-plated coating never loses its luster and shows superior corrosion resistance even in long-term evaluations of corrosion resistance. These properties are believed to derive from its composition of a single intermetallic compound phase, or to the fact that the oxide coating formed by a plated coating is fine and easily rendered non-conductive.

Tin-nickel alloy plating can also be used as an underlayer coating rather than an outermost layer. High corrosion resistance and an elegant plated appearance can also be achieved with a thin film by creating a multi-layer plating combining tin-nickel plating with existing nickel or chromium plating.¹⁾

Metal Allergies

Nickel-induced metal allergies have become a recent problem. Metal allergies are a generalized skin disease occurring in as many as one in 10 Japanese individuals.²⁾ In the disease process, metallic ions which leach from a metal bond with proteins in the body and are denatured into new proteins which the body recognizes as foreign substances, causing an allergic reaction. The EU has regulations regarding the use of nickel products which come into contact with skin directly and for long durations, and these regulations state that nickel leaching levels cannot exceed 0.5 µg/cm²/week. While Japan has not yet established such regulations, various industry groups related to the issue have

called for such countermeasures in advance of prospective regulations, and speculum alloy plating composed of copper and tin has already achieved some practicality for accessory and jewelry components. The plumbing fixture industry has concerns about nickel leaching from plumbing components.³⁾

In tin-nickel alloy plating, the plating bath contains nickel ions. However, tin-nickel alloy-plated coatings have superior chemical resistance. Even when such coatings are immersed in a solution of synthetic perspiration, nickel does not leach, and the appearance of the plated coating is also unaffected.

Tin-nickel alloy-plated coatings also have an elegant, pink-tinged hue, which has led to their application as a modern design element in sundry articles such as decorations, automobile and motorcycle parts, and plumbing fixture components. Additional, functional applications in practical use include battery-related components, steel sheets, connector components, and semiconductor devices. In the future, alloy plating technologies are also expected to provide development of yet more applications for nickel alloys created as high value-added plating coatings.

[Source of Reference]

- 1) Japanese Patent No. 6327655
- 2) <https://news.goo.ne.jp/article/otonanswer/life/otonanswer-31815.html>
- 3) Japan Valve Manufacturers' Association homepage:
https://j-valve.or.jp/env-info/env_water/398/