



Design Engineering

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New Possibilities with Alloy Engineering

There are several reasons to design a surface material to be an alloy. It could receive paint better, or be more oxidation resistant, or have an appealing or functional micromorphology. Perhaps a reflected color is desired. If it is to be heat treated for hardness, strength, etc., it may be possible to alloy plate and then heat-treat only the surface by laser. As discussed here, some new possibilities may be afforded by advanced codeposition and sophisticated alloy electrodeposition for surface laser-annealing metastable, precipitated or novel intermetallic structures with desirable properties.

How to Obtain an Alloy Surface
Normal surface compositions produced by metallurgical techniques differ from bulk, particularly with the core. This is mainly a result of differential cooling from the outside inward. Traditional techniques include surface enrichment by removing the less noble constituent(s) or alloy electroplating.

Many centuries ago, Peruvians smelted ores of gold, copper, etc. The metal (alloy) was hand-worked into masks, among other things. These were then "pickled" by covering with brine salts from the plains for weathering. The salts contained chloride, nitrate, etc., which dissolved the non-gold metals. After repeated pickling and cold-working, a very rich gold-colored surface resulted. When the Spanish conquistadores arrived, they thought they had found El Dorado—the gold-rich country—and ransacked the booty to take back to Spain. When the masks were melted, it was a surprise. So much for the booty.

Similarly, alloy electroplating can be a most appealing ... or an equally frustrating ... process. Many elements may be combined for alloy plating. Generally, alloy plating is more difficult to control than simple metal plating. Most plating surfaces change their composition, unless plating conditions (chemistry, pH, current density per "true" surface area, surface area/gallage, etc.) can be kept in the window within the boundary convection parameter (stirring). The main determinants for two or more elements to co-electrodeposit are their standard electrode potentials, their thermodynamic concentrations ("activities") and their summary cathode polarization overpotentials.

Without getting overly technical, alloys such as tin-lead, nickel-iron or nickel-cobalt, plate in uncomplexed baths. Using complexing agents (ligands) is the most important method of equalizing potentials to plate alloys. In 1971, nickel led all elements reported as plated with 27 binary alloys. Copper followed with 21, then silver, gold, cobalt, iron, zinc, etc. The advent of ion implantation and plasma vapor deposition is important in this regard, but will be discussed at another time (or in a column such as "SVC Topics").

How can designer alloys be utilized? The manipulation of grain size with gold content in silver-gold alloys is accomplished by pulse plating. Longer off-time and shorter on-time reduce gold content and grain size. By manipulating pulse on and off times, the reflectivity and color may be varied (with less silver content: White to green to yellow to

red). Increased content of tungsten (to 41.4 At.%) was achieved in pulse-plated cobalt-tungsten alloys by selective cobalt oxidation. Excimer laser surface annealing produces an extremely hard, smoother surface. Also, co-deposition of graphite particles, followed by laser, could form carbides of the matrix, such as chromium carbide or cobalt and tungsten carbides.

Sliding lubricated members have the advantage of reduced frictional drag when oil can "squeeze" via reliefs provided by a micron-sized pyramid surface, produced by pulse plating. Honda makes some of today's winningest powerplants, probably using pulse-plated iron {2,2,2} with a coefficient of friction less than that of Teflon® on pistons, rings and walls, crank and journal bearings. Earlier references described pulse-plated, fine-grained nickel-zinc alloy, nickel content and structure, and micro-hardness and thermal stability. P&SF

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