

# Plating Metals

Metal coatings are added to base parts for protection and decoration. In some circumstances, thin metal platings are used to provide specific material properties such as high optical reflectivity (as in the case of telescope mirrors), low toxicity (protection against dust from beryllium metal), or high electrical conductivity. Screws, nuts, and other small parts are economically coated in large drums filled with plating solution. In the manufacture of tin cans, a layer of tin only 0.000015 inch (0.4 micron) thick can be electroplated onto steel strips at rates up to 2000 feet (610 m) per minute.

Today, most metal coatings are deposited through the electroplating process. Before the development of reliable sources of direct-current electricity, however, metalworkers had to develop other techniques. One crude method was to fabricate the base article in its desired shape and then solder a thin sheet of plating onto its surface; obviously, coating complex surfaces was extremely difficult, if not impossible, with this technique.

The first popular and economical plating method was the use of the "Sheffield plate" to place silver on the surface of serving dishes, candle sticks, buttons, snuff boxes, and tea urns. In 1743, Thomas Boulsover—a cutlery craftsman in Sheffield, England—discovered, while repairing a copper and silver knife handle, that the two metals could be fused. Boulsover then made a second important discovery: when the fused metals were rolled on a rolling mill, they expanded together like a single metal. Boulsover's technique was rapidly adopted by other Sheffield metal workers, and also gained popularity in the town of Birmingham. The metal fusion process of Sheffield plate was popular from 1750 to about 1880, when it was superseded by electroplating.

In the early 1800s, Alessandro Volta's new battery made reliable amounts of electric current available for the first time. Later in that century, the availability of electricity was an important factor in the development of electroplating. In the electroplating process, a piece of the metal to be deposited acts as the anode and the object to be plated acts as the cathode; both are submerged in an electrolyte solution, usually containing ions of the metal to be deposited. When an electric voltage is applied between the anode and cathode, metal ions are attracted from the electrolyte and deposited on the cathode; the anode

metal dissolves to replace ions lost from the electrolyte solution.

Volta's battery was first applied to deposit zinc, copper, and silver onto themselves, as well as onto other base metals such as iron and gold. Electroplating began on a commercial scale in 1840, and was soon enhanced by the discovery of cyanide electrolyte solutions for plating copper, gold, silver, and brass directly onto iron or steel—with excellent adherence. Earlier solutions, such as copper sulfate, corroded iron and steel, leaving nonadherent deposits of the plated metal.

Finely buffed nickel-silver alloy electroplated with a silver coating, or brass plated with a nickel coating, eventually replaced flatware produced by the Sheffield plate process. Silver and nickel both gave a bright and attractive appearance and were nontoxic. The metal coatings could be deposited in greater thicknesses at the points of maximum wear—for example, at the center of a spoon bowl.

In the least expensive silver plating process, called "bright plating," a thin coating of silver is deposited on the base metal, but receives no final polishing; such coatings usually last only a short time, and generally are used solely on lower-grade articles. Stainless steel flatware, introduced in 1920, has since dominated the market.

Gold plate, used for purely decorative purposes because of its attractive nontarnishing finish, is often applied in layers as thin as 0.000002 inch (0.05 micron). Gold is also applied in greater thicknesses where low electrical contact resistance is desired.

Copper is most often used as a "preplating" layer to cover small defects in the surface of the base metal; the outer coating of copper is then covered with other metals—most commonly nickel and chromium. Copper is used as a preplating layer because it is simple to apply and, when additional finishing is needed, easier to buff than other metals such as steel.

Chromium was first plated commercially in 1925. Bright chromium, which retains its brightness indefinitely, quickly found wide use in the appliance industry and in the automotive industry. For outdoor uses, such as automobile bumpers, plating is applied in three layers: an undercoating of copper, then a layer of nickel, and finally an outer layer of 0.00001-inch (0.25-micron)-thick chromium. "Hard" chromium plating—found on cutting tools, rolls, and dies—is thicker (0.004 to 0.01

inch, or 100 to 300 microns). Certain mismatched or worn parts can be rebuilt by plating them with successive layers of iron, nickel, or chromium, and at a cost far below the cost of replacing the parts.

Other metals can be plated on steel as protective layers against wear and corrosion. Dull zinc plating protects steel against corrosion in items that do not require a shiny finish. Tin plating is used as a nontoxic layer on steel sheets for the manufacture of cans. Cadmium-plated steel is widely used to protect against harsh seaside atmospheres. Brilliant rhodium plating is used on reflectors for high-intensity light.

It is also possible to plate certain alloys—such as brass (copper-zinc) and bronze (copper-tin)—onto base metals. Alloys or compounds of metals that cannot be produced by melting and casting can be deposited; for example, a commercially valuable compound of 65% tin and 35% nickel cannot be produced in any way other than electroplating. This tin-nickel alloy is very hard and remarkably tarnish- and corrosion-resistant, and is frequently used on watch parts and brake pistons.

Methods have been developed for plating even nonconductive surfaces such as plastics, wood, or leather, after the base material has been made conductive by vaporized coatings, conductive lacquer, or graphite. A surge of interest in electroplated plastics began in 1963 with the introduction of acrylonitrile-butadiene-styrene (ABS) plastic, which was readily plated. Dipping the plastic part into a hot mixture of chromic acid and sulfuric acid, sensitizing and activating it in stannous chloride, and then palladium chloride, made possible a reasonable degree of adhesion in the metal coating, though not at all comparable to the adhesion of metal coatings on metal surfaces.

Recent advances in applying thin layers with varying material properties have made it possible to create multilayer materials with nearly "made-to-order" physical properties. Refinements in integrated circuit design are demanding ever finer control over the deposition of precise layers of conducting metals in accurate patterns. New methods for applying thin coatings of metals, such as chemical vapor deposition and sputter deposition, have become extensions of old "plating" technologies that have been pushed to their limits.

KEVIN J. ANDERSON