



Standard Terminology Relating to Electroplating¹

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INTRODUCTION

These definitions correspond to interpretations as applied to electroplating and do not necessarily correspond to the definitions used in other fields.

1. Referenced Documents

1.1 ASTM Standards:²

B 368 Test Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)

2. Terminology

abrasive blasting—a process for cleaning or finishing by means of an abrasive directed at high velocity against the work piece.

activator—in *diffusion coatings*, a chemical, usually a halide salt, that enters into a reaction with the source or master alloy, depositing the source on the substrate.

activation—elimination of a passive condition on a surface.

activity (ion)—the ion concentration corrected for deviations from ideal behavior. Concentration multiplied by activity coefficient.

addition agent—a material added in small quantities to a solution to modify its characteristics. It is usually added to a plating solution for the purpose of modifying the character of a deposit.

adhesion—the attractive force that exists between an electrodeposit and its substrate that can be measured as the force required to separate an electrodeposit and its substrate.

adhesion, practical, *n*—the force or work required to detach or remove a coating from the underlayer or substrate; it can be measured in terms of peel, pull, or shear strength as an experimentally determined quantity.

aluminizing—forming of an aluminum or aluminum alloy coating on a metal by hot dipping, hot spraying, or diffusion.

amorphous—noncrystalline, or devoid of regular structure.

ampere—the current that will deposit silver at the rate of 0.0011180 g/s. Current flowing at the rate of 1 C/s.

angstrom unit (Å)— 10^{-8} cm.

anion—a negatively-charged ion.

anode—the electrode in electrolysis, at which negative ions are discharged, positive ions are formed, or other oxidizing reactions occur.

anode corrosion—dissolution of anode metal by the electrochemical action in an electrolytic cell.

anode efficiency—current efficiency of a specified anodic process.

anode film—(1) the layer of solution in contact with the anode that differs in composition from that of the bulk of the solution. (2) The outer layer of the anode itself consisting of oxidation or reaction products of the anode metal.

anode polarization—See **polarization**.

anodic coating—a protective, decorative, or functional coating, formed by conversion of the surface of a metal in an electrolytic oxidation process.

anodizing—an electrolytic oxidation process in which the surface of a metal, when anodic, is converted to a coating having desirable protective, decorative, or functional properties.

anolyte—the portion of electrolyte in the vicinity of the anode; in a divided cell, the portion of electrolyte on the anode side of the diaphragm.

anti-pitting agent—an addition agent for the specific purpose of preventing gas pits in a deposit.

autocatalytic plating—deposition of a metal coating by a controlled chemical reduction, catalyzed by the metal or alloy being deposited.

automatic machine (or conveyor)—a machine for mechanically processing parts through treatment cycles, such as cleaning, anodizing, or plating.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.



automatic plating: (1) *full*—plating in which the cathodes are automatically conveyed through successive cleaning and plating tanks. (2) *semi*—plating in which the cathodes are conveyed automatically through only one plating tank.

auxiliary anode—a supplementary anode employed during electrodeposition to achieve a desired thickness distribution of the deposit.

auxiliary cathode—See **thief**.

back emf (electromotive force)—the potential set up in an electrolytic cell that opposes the flow of current, caused by such factors as concentration polarization and electrode films. See **emf (electromotive force)**.

ball burnishing—See **barrel burnishing**.

barrel burnishing—the smoothing of surfaces by means of tumbling the work in rotating barrels in the presence of metallic or ceramic shot, and in the absence of abrasive. In ball burnishing, the shot consists of hardened steel balls.

barrel electroplating—an electroplating process in which electrodeposits are applied to articles in bulk in a rotating, oscillating, or otherwise moving container.

barrel finishing (or tumbling)—bulk processing in barrels, in either the presence or absence of abrasives or burnishing shot, for the purpose of improving the surface finish.

barrel plating (or cleaning)—plating or cleaning in which the work is processed in bulk in a rotating container.

barrel processing—mechanical, chemical, cleaning, or electrolytic treatment of articles in bulk or in a rotating, oscillating, or otherwise moving container.

barrier layer—in *anodizing aluminum*, the thin, pore-free, semiconducting aluminum oxide region nearest the metal surface and distinct from the main anodic oxide coating which has a pore structure.

base metal—(1) See **basis metal**; (2) in *diffusion coatings*, the metal present in the largest proportion in an alloy.

basis metal (or material)—material upon which coatings are deposited.

bipolar electrode—an electrode that is not directly connected to the power supply but is so placed in the solution between the anode and the cathode that the part nearest the anode becomes cathodic and the part nearest the cathode becomes anodic.

black oxide—a finish on metal produced by immersing a metal in hot oxidizing salts or salt solutions.

blasting—See **sand blasting**; **grit blasting**; **wet blasting**.

blister—a dome-shaped imperfection or defect, resulting from loss of adhesion between a metallic deposit and the substrate.

bloom—a visible exudation or efflorescence on a surface.

blue dip—a solution, once widely used, containing a mercury compound used to deposit mercury upon a metal by immersion, usually prior to silver plating.

blueing—the formation of a thin oxide film on steel, either by heating in air, or by immersion in oxidizing solutions.

bright dip (nonelectrolytic)—a solution used to produce a bright surface on a metal.

bright electroplating—a process that produces an electrodeposit having a high degree of specular reflectance in the as-plated condition.

bright electroplating range—the range of current densities within which an electroplating solution produces a bright deposit under a given set of operating conditions.

bright plating—a process that produces an electrodeposit having a high degree of specular reflectance in the as-plated condition.

bright plating range—the range of current densities within which a given plating solution produces a bright plate.

brightener—an addition agent that leads to the formation of a bright plate, or that improves the brightness of the deposit.

bright-throwing power—the measure of the ability of a plating solution or a specified set of plating conditions to deposit uniformly bright electroplate upon an irregularly shaped cathode.

bronzing—the application of a chemical finish to copper or copper alloy surfaces to alter the color.

brush plating—a method of plating in which the plating solution is applied with a pad or brush, within which is an anode and which is moved over the cathode to be plated.

brush polishing (electrolytic)—a method of electropolishing (q.v.) in which the electrolyte is applied with a pad or brush in contact with the part to be polished.

buffer—a compound or mixture that, when contained in solution, causes the solution to resist change in pH. Each buffer has a characteristic limited range of pH over which it is effective.

buffing—the smoothing of a surface by means of a rotating flexible wheel to the surface of which fine, abrasive particles are applied in liquid suspension, paste, or grease stick form.

building up—electroplating for the purpose of increasing the dimensions of an article.

burn off—the unintentional removal of an autocatalytic deposit from a nonconducting substrate, during subsequent electroplating operations, owing to the application of excess current or a poor contact area.

burnishing—the smoothing of surfaces by rubbing, accomplished chiefly by the movement rather than the removal of the surface layer.

burnt deposit—a rough, noncoherent or otherwise unsatisfactory deposit produced by the application of an excessive current density and usually containing oxides or other inclusions.

bus (bus bar)—a rigid conducting section, for carrying current to the anode and cathode bars.

butler finish—a finish composed of fine, uniformly distributed parallel lines, having a characteristic luster usually produced with rotating wire brushes or cloth wheels with applied abrasives.

calomel half cell (calomel electrode)—a half cell containing a mercury electrode in contact with a solution of potassium chloride of specified concentration that is saturated with mercurous chloride (calomel).

calorizing—imparting resistance to oxidation to an iron or steel surface by heating in aluminum powder at 800 to 1000°C (1470 to 1830°F).

CASS test (copper accelerated salt spray)—an accelerated corrosion test for some electrodeposits and for anodic coatings on aluminum (see Test Method B 368).

cataphoresis—See **electrophoresis**.

cathode—the electrode in electrolysis at which positive ions are discharged, negative ions are formed, or other reducing actions occur.

cathode efficiency—the current efficiency of a specified cathodic process.

cathode film—the layer of solution in contact with the cathode that differs in composition from that of the bulk of the solution.

cathode polarization— See **polarization**.

catholyte—the portion of the electrolyte in the vicinity of the cathode; in a divided cell the portion of the cathode side of the diaphragm.

cation—a positively-charged ion.

caustic dip—in *diffusion coatings*, a strongly alkaline treatment applied by dip or spray for neutralizing acid residues.

cementation—See **pack cementation**.

chelate compound—a compound in which the metal is contained as an integral part of a ring structure and is not readily ionized.

chelating agent—a compound capable of forming a chelate compound with a metal ion. See **chelate compound**.

chemical milling—the shaping of a work piece by immersion in an etchant employing a resist for selective removal of material.

chemical plating—deposition of a metal coating by chemical, non-electrolytic methods. See also **immersion plate**, **contact plating**.

chemical polishing—the improvement in surface smoothing of a metal by simple immersion in a suitable solution. See **bright dip (nonelectrolytic)**.

chromating—a process for producing a conversion coating containing chromium compounds.

chromizing—a surface treatment at elevated temperatures, generally carried out in pack, vapor, or salt baths, in which an alloy is formed by the inward diffusion of chromium into the base metal.

cleaning—the removal of grease, oxides, or other foreign material from a surface.

alkaline cleaning— cleaning by means of alkaline solutions.

anodic or reverse cleaning—electrolytic cleaning in which the work is the anode.

cathodic or direct cleaning—electrolytic cleaning in which the work is the cathode.

diphase cleaning— cleaning by means of solutions that contain a solvent layer and an aqueous layer. Cleaning is effected both by solvent and emulsifying action.

direct current cleaning—See *cathodic or direct cleaning*.

electrolytic cleaning—alkaline cleaning in which a current is passed through the solution, the work being one of the electrodes.

emulsion cleaning— cleaning by means of solutions containing organic solvents, water, and emulsifying agents.

immersion—See *soak cleaning*.

reverse current cleaning—See *anodic or reverse cleaning*.

soak cleaning— cleaning by immersion without the use of current, usually in alkaline solution.

solvent cleaning— cleaning by means of organic solvents.

spray cleaning— cleaning by means of spraying.

ultrasonic cleaning—cleaning by any chemical means aided by ultrasonic energy.

cleaning-emulsifiable solvent—two-stage cleaning system wherein a concentrate containing organic solvents and surface-active agents is applied to a surface, subsequently emulsified, and removed along with the soil, by water rinsing.

coating cycle—specific time and temperature to achieve desired depth of diffusion.

coating, diffusion—an alloy coating produced by applying heat to one or more coatings deposited on a metal substrate.

colloidal particle—an electrically-charged particle, generally smaller in size than 200 mμ, dispersed in a second continuous phase.

color anodizing—in *anodizing aluminum*, formation of a colored coating on aluminum where the colored compound, pigment, or dye is incorporated after the coating has been formed.

coloring—(1) the production of desired colors on metal surfaces by appropriate chemical or electrochemical action.

(2) light buffing of metal surfaces for the purpose of producing a high luster. Called “color buffing.”

complex ion—an ion composed of two or more ions or radicals, both of which are capable of independent existence, for example, cuprocyanide $(\text{Cu}(\text{CN})_3)^-$.

complexing agent—a compound that will combine with metallic ions to form complex ions. See **complex ion**.

composite coating—a coating consisting of deposits incorporating particles of another material. See also **dispersion coating**.

composite plate—an electrodeposit consisting of two or more layers of metal deposited successively.

concentration polarization—that part of the total polarization that is caused by changes in the activity of the potential-determining components of the electrolyte.

conductance—the capacity of a medium, usually expressed in mhos, for transmitting electric current. The reciprocal of resistance.

conducting salt—a salt added to the solution in order to increase its conductivity.

conductivity—specific conductance—the current transferred across unit area per unit potential gradient. In the metric system, K = amperes per square centimetre divided by volts per centimetre. The reciprocal of resistivity.

contact plating—deposition of a metal by the use of an internal source of current by immersion of the work in solution in contact with another metal.

contact potential—the potential difference at the junction of two dissimilar substances.

conversion coating—the conversion of the surface of a metal into a superficial coating that more readily accepts applied coatings or provides for a more corrosion-resistant surface by a chemical or electrochemical process in which compounds of the metal in question become part of the coating,

or both. For example, zinc phosphate coatings from phosphoric acid-based treatment of zinc or aluminum oxide/chromium oxide coatings from the treatment of aluminum with chromium compounds in the plus six oxidation state.

conversion treatment—a chemical or electrochemical process producing a superficial layer containing a compound of the metal.

Corrodokote test—an accelerated corrosion test for electrodeposits (see Method B 380²).

corrosion—(1) gradual solution or oxidation of a metal.

(2) solution of anode metal by the electrochemical action in the plating cell.

coulomb—the quantity of electricity that is transmitted through an electric circuit in 1 s when the current in the circuit is 1 A. The quantity of electricity that will deposit 0.0011180 g of silver.

coulometer—an electrolytic cell arranged to measure the quantity of electricity by the chemical action produced in accordance with Faraday's law.

covering power—the ability of a plating solution under a specified set of plating conditions to deposit metal on the surfaces of recesses or deep holes. (To be distinguished from throwing power.)

crazing—a network of fine hairline cracks in a coating.

critical current density—a current density above which a new and sometimes undesirable reaction occurs.

current density (*cd*)—current per unit area.

current efficiency—the proportion, usually expressed as a percentage, of the current that is effective in carrying out a specified process in accordance with Faraday's law.

cut wire blasting—blasting with short, cut lengths of metal wire. See **abrasive blasting**.

cutting down—polishing or buffing for the purpose of removing roughness or irregularities.

deburring—the removal of burrs, sharp edges, or fins by mechanical, chemical, or electrochemical means.

decarburization—loss of carbon from the surface layer of a carbon containing alloy due to reaction with one or more chemical substances in a medium that contacts the surface.

decomposition potential—the minimum potential, exclusive of *IR* drop, at which an electrochemical process can take place at an appreciable rate.

degreasing—the removal of grease and oils from a surface.

solvent degreasing—degreasing by immersion in liquid organic solvent.

vapor degreasing—degreasing by solvent vapors condensing on the parts being cleaned.

deionization—the removal of ions from a solution by ion exchange.

depolarization—a decrease in the polarization of an electrode at a specified current density.

depolarizer—a substance or a means that produces depolarization.

detergent—a surface-active agent that possesses the ability to clean soiled surfaces.

anionic detergent—a detergent that produces aggregates of negatively-charged ions with colloidal properties.

cationic detergent—a detergent that produces aggregates of positively-charged ions with colloidal properties.

nonionic detergent—a detergent that produces aggregates of electrically-neutral molecules with colloidal properties.

diaphragm—a porous or permeable membrane separating anode and cathode compartments of an electrolytic cell from each other or from an intermediate compartment.

diffusion—(1) spreading of a constituent in a gas, liquid, or solid tending to make the composition of all parts uniform; (2) the spontaneous movement of atoms or molecules to new sites within a material.

diffusion coating—an alloy coating produced by applying heat to one or more coatings deposited on a basis metal.

diffusion cycle—specific time and temperature to acquire a depth of diffusion and composition.

diffusion treatment (or coating)—(1) process of producing a surface layer (diffusion layer) by diffusion of another metal or non-metal into the surface of the basis material.

(2) in electroplating, heat treatment applied to a work piece to achieve alloying or intermetallic compound formation between two or more coatings on a basis material.

dispersing agent—a material that increases the stability of a suspension of particles in a liquid medium.

dispersion coating—a coating consisting of particles of one material contained in a matrix of another metal or nonmetal.

divided cell—a cell containing a diaphragm or other means for physically separating the anolyte from the catholyte.

double salt—a compound of two salts that crystallize together in a definite proportion.

drag-in—the water or solution that adheres to the objects introduced into a bath.

drag-out—the solution that adheres to the objects removed from a bath.

ductility—the ability of a material to deform plastically without fracturing.

dummy (or dummy cathode)—a cathode in a plating solution that is not to be made use of after plating. Often used for removal or decomposition of impurities.

duplex coating—See **composite plate**.

electrochemical equivalent—the weight of an element, compound, radical, or ion involved in a specified electrochemical reaction during the passage of unit quantity of electricity, such as a Faraday, ampere-hour, or coulomb.

electrochemistry—the branch of science and technology which deals with transformations between chemical and electrical energy.

electrode—a conductor through which current enters or leaves an electrolytic cell, at which there is a change from conduction by electrons to conduction by charged particles of matter, or vice versa.

electrode potential—the difference in potential between an electrode and the immediately adjacent electrolyte referred to some standard electrode potential as zero.

dynamic E.P.—the electrode potential measured when current is passing between the electrode and the electrolyte.

equilibrium E.P.—a static electrode potential when the electrode and the electrolyte are in equilibrium with respect to a specified electrochemical reaction.



standard E.P.—an equilibrium electrode potential for an electrode in contact with an electrolyte in which all of the components of a specified chemical reaction are in their standard states. The standard state for an ionic constituent is unit ion activity.

static E.P.—the electrode potential measured when no net current is flowing between the electrode and the electrolyte.

electrodeposition—the process of depositing a substance upon an electrode by electrolysis. See **electroforming**, **electroplating**, **electrorefining**, and **electrowinning**.

electroforming—the production or reproduction of articles by electrodeposition upon a mandrel or mold that is subsequently separated from the deposit.

electrogalvanizing—electrodeposition of zinc coatings.

electroless plating—term in use but not recommended. See **autocatalytic plating**.

electrolysis—production of chemical changes by the passage of current through an electrolyte.

electrolyte—(1) a conducting medium in which the flow of current is accompanied by movement of matter. Most often an aqueous solution of acids, bases, or salts, but includes many other media, such as fused salts, ionized gases, some solids, etc. (2) a substance that is capable of forming a conducting liquid medium when dissolved or melted.

electrolytic cell—a unit apparatus in which electrochemical reactions are produced by applying electrical energy, or which supplies electrical energy as a result of chemical reactions and which includes two or more electrodes and one or more electrolytes contained in a suitable vessel.

electromotive series—a table that lists in order the standard electrode potentials of specified electrochemical reactions.

electrophoresis—the movement of colloidal particles produced by the application of an electric potential.

electroplating—the electrodeposition of an adherent metallic coating upon an electrode for the purpose of securing a surface with properties or dimensions different from those of the basis metal.

electropolishing—the improvement in surface finish of a metal effected by making it anodic in an appropriate solution.

electrorefining—the process of anodically dissolving a metal from an impure anode and depositing it cathodically in a purer form.

electrotyping—the production of printing plates by electroforming.

electrowinning—the production of metals by electrolysis with insoluble anodes in solutions derived from ores or other materials.

embrittlement, hydrogen— See **hydrogen embrittlement**.

emf (electromotive force)—an electrical potential.

emulsifying agent—a substance that increases the stability of an emulsion.

emulsion—a suspension of fine particles or globules of one or more liquids in another liquid.

energy efficiency—the product of the current efficiency and the voltage efficiency for a specified electrochemical process.

equivalent conductivity—in an electrolyte, the conductivity of the solution divided by the number of equivalents of conducting solute per unit volume, that is, the conductivity divided by the normality of the solution.

etch, *n*—a roughened surface produced by a chemical or electrochemical means.

etch, *v*—to dissolve unevenly a part of the surface of a metal.

faraday—the number of coulombs (96,490) required for an electrochemical reaction involving one chemical equivalent.

filler—a material used to increase the bulk of a product without adding to its effectiveness in functional performance.

filter aid—an inert, insoluble material, more or less finely divided, used as a filter medium or to assist in filtration by preventing excessive packing of the filter cake.

flash (or flash plate)—a very thin electrodeposit used for a final coating; for intermediate coatings of the same nature use **strike**.

flocculate—to aggregate into larger particles, to increase in size to the point where precipitation occurs.

flow brightening—the melting of an electrodeposit, followed by solidification, especially of tin plate.

formula weight—the weight, in grams, pounds, or other units, obtained by adding the atomic weights of all elemental constituents in a chemical formula.

free cyanide: (1) *true*—the actual concentration of cyanide radical, or equivalent alkali cyanide, not combined in complex ions with metals in solution. (2) *calculated*—the concentration of cyanide, or alkali cyanide, present in solution in excess of that calculated as necessary to form a specified complex ion with a metal or metals present in solution. (3) *analytical*—the free cyanide content of a solution, as determined by a specified analytical method.

NOTE 1—The true value of free cyanide is rarely known with certainty and is therefore usually only dealt with in discussions of theory. The calculated or analytical value is usually used in practice.

galvanic cell—an electrolytic cell capable of producing electrical energy by electrochemical action.

galvanic series—a list of metals and alloys arranged according to their relative potentials in a given environment. See **electromotive series**.

galvanizing—application of a coating of zinc.

gassing—the evolution of gases from one or more of the electrodes during electrolysis.

glass electrode—a half cell in which the potential measurements are made through a glass membrane.

grinding—the removal of metal by means of rotating rigid wheels containing abrasive.

grit blasting—abrasive blasting with small irregular pieces of steel or malleable cast iron.

half cell—an electrode immersed in a suitable electrolyte. It may be designed to yield a known constant potential, in which case unknown potentials may be measured against it; for example, the calomel half cell.

hard chromium—chromium plate for engineering rather than decorative applications. Not necessarily harder than the latter.



hard-coating—*in anodizing aluminum*, an anodic oxide coating on aluminum with a higher apparent density and thickness and a greater resistance to wear than conventional coatings.

Haring cell—A rectangular box of non-conducting material, with principal and auxiliary electrodes so arranged as to permit estimation of throwing power or electrode polarizations and potentials between them.

high lights—those portions of a metal article most exposed to buffing or polishing operations, and, hence, having the highest luster.

hot dip coating—a metallic coating obtained by dipping the basis metal into a molten metal.

Hull cell—a trapezoidal box of nonconducting material with electrodes arranged to permit observation of cathodic or anodic effects over a wide range of current densities.³

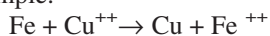
hydrogen embrittlement—embrittlement of a metal or alloy caused by absorption of hydrogen which may occur, for example, during pickling, cathodic cleaning, electroplating, and autocatalytic plating processes.

hydrogen overvoltage—overvoltage associated with the liberation of hydrogen.

hydrophilic—(1) tending to absorb water. (2) tending to concentrate in the aqueous phase.

hydrophobic—(1) tending to repel water. (2) lacking affinity for water.

immersion plate—a metallic deposit produced by a displacement reaction in which one metal displaces another from solution, for example:



indicator (pH)—a substance that changes color when the pH of the medium is changed. In the case of most useful indicators, the pH range within which the color changes is narrow.

inert anode—an anode that is insoluble in the electrolyte under the conditions prevailing in the electrolysis.

inhibitor—a substance used to reduce the rate of a chemical or electrochemical reaction, commonly corrosion or pickling.

interfacial tension—the contractile force of an interface between two phases. See **surface tension**.

ion—an electrified portion of matter of atomic or molecular dimensions.

ion exchange—a reversible process by which ions are interchanged between a solid and a liquid with no substantial structural changes of the solid.

IR drop—the voltage across a resistance in accordance with Ohm's law:

$$E = IR \quad (1)$$

where:

E = potential (voltage),

I = current, and

R = resistance.

karat—a twenty-fourth part by weight; thus 18-karat gold is 18/24 pure.

lapping—rubbing two surfaces together, with or without abrasives, for the purpose of obtaining extreme dimensional accuracy or superior surface finish.

leveling action—the ability of a plating solution to produce a surface smoother than that of the substrate.

limiting current density: (1) *cathodic*—the maximum current density at which satisfactory deposits can be obtained.

(2) *anodic*—the maximum current density at which the anode behaves normally, without excessive polarization.

mandrel—a form used as a cathode in electroforming; a mold or matrix.

masking—various materials applied to specific areas of parts to prevent coating from being deposited.

master alloy—an alloy rich in one or more desired addition elements that is added to a melt to raise the percentage of a desired constituent.

mat finish (matte finish)—a dull finish.

matrix—See **mandrel**.

measurement area—the surface area that is examined for conformance to one or more specified requirements.

mechanical cleaning—process for removing dirt, scale, or other deposits from surfaces through the use of mechanical means such as abrasive blasting.

mechanical plating—the application of a metallic layer by impacting spherical objects (for example glass beads) against the work surface in the presence of powdered coating metal and appropriate chemicals.

mechanical testing—determination of mechanical properties.

metal (or metallic) coating—generally denotes all metal coatings obtained by any method applied to a basis material.

metal distribution ratio—the ratio of the thickness of metal upon two specified areas of a cathode. See **throwing power**.

metal spraying—application of a metallic coating by projecting molten or heat-softened metal from a source (gun) onto the workpiece.

metallizing—(1) the application of a metal layer to the surface of non-conducting or non-metallic materials.

(2) the application of metallic coatings by nonelectrolytic procedures such as spraying of molten or heat-softened metal or deposition from the vapor phase.

microinch—one millionth of an inch, 0.000001 in. = 0.001 mil.

micrometer (μm)—one millionth of a meter, 0.001 mm.

micron—obsolete (see **micrometer**).

microthrowing power—the ability of a plating solution or a specified set of plating conditions to deposit metal in pores or scratches.

mil—one thousandth of an inch, 0.001 in. = 25.4 μm.

mill scale—the heavy oxide layer that forms during hot fabrication or heat treatment of metals.

modulated current plating—a method of electroplating in which the cathode current density is changed periodically. See **pulse plating**, **ripple plating**, **periodic reverse plating**.

motor-generator (MG set)—a machine that consists of one or more motors mechanically coupled to one or more generators. In plating, such a machine in which the generator delivers dc of appropriate amperage and voltage.

³ U. S. Patents 2,149,344; 2,760,928; and 2,801,963.

multilayer deposit—a deposit consisting of two or more layers of metal deposited successively, consisting of either different metals or layers of the same metal with different characteristics.

noble metal—a metal that does not readily tend to furnish ions, and therefore does not dissolve readily, nor easily enter into such reactions as oxidations, etc. The opposite of base metal.

NOTE 2—Since there is no agreement over the sign of electrode potentials, the words noble and base are often preferred because they are unambiguous.

nodule—a rounded projection formed on a cathode during electrodeposition.

orange peel—a finish resembling the dimpled appearance of an orange peel.

overvoltage—the irreversible excess of potential required for an electrochemical reaction to proceed actively at a specified electrode, over and above the reversible potential characteristics of that reaction.

oxidation—a reaction in which electrons are removed from a reactant. Sometimes, more specifically the combination of a reactant with oxygen.

oxidizing agent—a compound that causes oxidation, thereby itself becoming reduced.

pH—the cologarithm (negative logarithm) of the hydrogen ion activity, less precisely, concentration, of a medium, as determined by inhibitors or electrometric means.

pack cementation—*in diffusion coatings*, a coating process similar to pack carburizing that involves packing the parts to be coated into a retort with a carefully blended mixture of powders and then exposing the pack under hermetically sealed conditions or in an inert atmosphere to elevated temperatures.

passivating—a process for creating passivity (q.v.).

passivity—the condition of a metal that retards its normal reaction in a specified environment and associated with the assumption of a potential more noble than its normal potential.

peeling—the detachment or partial detachment of an electrodeposited coating from a basis metal or undercoat.

peen plating—See **mechanical plating**.

peening—See **shot peening**.

periodic reverse plating—a method of plating in which the current is reversed periodically. The cycles are usually no longer than a few minutes and may be much less.

pickle—an acid solution used to remove oxides or other compounds from the surface of a metal by chemical or electrochemical action.

pickling—the removal of oxides or other compounds from a metal surface by means of a pickle.

pit—a small depression or cavity produced in a metal surface during electrodeposition or by corrosion.

plastisol—a suspension of a finely divided resin in a plasticizer, that can be converted to a continuous film by the application of heat. Distinct from baking enamels etc., in that substantially all the original mixture becomes a part of the film; there is no significant evaporation of solvent. The films

are usually much thicker than obtainable from coatings which depend on the evaporation of a volatile solvent.

plating range—the current density range over which a satisfactory electroplate can be deposited.

polarization—the change in the potential of an electrode during electrolysis, such that the potential of an anode always becomes more noble and that of a cathode less noble than their respective static potentials. Equal to the difference between the static potential and the dynamic potential.

polarizer—a substance or a means that produces or increases polarization.

polishing—the smoothing of a metal surface by means of the action of abrasive particles attached by adhesive to the surface of wheels or endless belts usually driven at a high speed.

pore—a discontinuity, essentially circular in cross section, in a coating extending through to the underlying coating or basis material.

primary current distribution—the distribution of the current over the surface of an electrode in the absence of polarization.

protective atmosphere—(1) a gas envelope surrounding the part to be brazed, welded, or thermal sprayed, with the gas composition controlled with respect to chemical composition, dew point, pressure, flow rate; (2) the atmosphere in a heat treating or sintering furnace formulated to protect the parts or compacts from oxidation, nitridation, or other contamination from the environment.

pulse plating—a method of electroplating in which the current is frequently interrupted or periodically decreased.

rack, plating—a frame for suspending and carrying current to articles during plating and related operations.

rectification—the conversion of alternating into direct current.

rectifier—a device that converts alternating into direct current by virtue of a characteristic permitting appreciable flow of current in only one direction.

reducing agent—a compound that causes reduction, thereby itself becoming oxidized.

reduction—a reaction in which electrons are added to a reactant. More specifically, the addition of hydrogen or the abstraction of oxygen. Such a reaction takes place, for example, at the cathode in electrolysis.

reflowing—See **flow brightening**.

relieving—the removal of material from selected portions of a colored metal surface by mechanical means, to achieve a multicolored effect.

resist, n—(1) a material applied to a part of a cathode or plating rack to render the surface nonconductive. (2) A material applied to a part of the surface of an article to prevent reaction of metal from that area during chemical or electrochemical processes.

retorts—containers fabricated from various metals in which parts are loaded to be diffusion coated or diffusion heat treated.

ripple (dc)—regular modulations in the dc output wave of a rectifier unit, or a motor-generator set, originating from the

harmonics of the ac input system in the case of a rectifier, or from the harmonics of the induced voltage of a motor generator set.

ripple plating—a method of electroplating in which the current is changed periodically by superimposing surges, ripples, pulses, or alternating current to the d-c electroplating current.

robber—See **thief**.

roll straightening—*in diffusion coatings*, straightening of metal stock of various shapes by passing it through a series of staggered rolls, the rolls usually being in horizontal and vertical planes.

sacrificial protection—the form of corrosion protection wherein one metal corrodes in preference to another, thereby protecting the latter from corrosion.

sand blasting—abrasive blasting with sand.

saponification—the alkaline hydrolysis of fats whereby a soap is formed; more generally, the hydrolysis of an ester by an alkali with the formation of an alcohol and a salt of the acid portion.

satín finish—a surface finish that behaves as a diffuse reflector and which is lustrous but not mirrorlike.

scale—an adherent oxide coating that is thicker than the superficial film referred to as tarnish.

sealed (anodic) coating—*in anodizing aluminum*, an anodic oxide coating on aluminum that has been treated in an aqueous or steam medium resulting in reduced porosity of the coating.

sealing of anodic coating—a process which, by absorption, chemical reaction, or other mechanism, increases the resistance of an anodic coating to staining and corrosion, improves the durability of colors produced in the coating, or imparts other desirable properties.

sequestering agent—an agent that forms soluble complex compounds with, or sequesters, a simple ion, thereby suppressing the activity of that ion. Thus, in water treatment the effects of hardness can be suppressed by adding agents to sequester calcium and magnesium. See **chelating agent**.

shelf roughness—roughness on upward facing surfaces where undissolved solids have settled on parts during a plating operation.

shield, *n*—a nonconducting medium for altering the current distribution on an anode or cathode.

shield, *v*—to alter the normal current distribution on an anode or cathode by the interposition of a nonconductor.

shot blasting—blasting with small spherical objects, such as metallic shot, propelled against a metallic surface. See **abrasive blasting**.

shot peening—a process whereby hard, small spherical objects (such as metallic shot) are propelled against a metallic surface for the purpose of introducing compressive stresses into that surface, hardening it or obtaining decorative effects.

siliconizing—*in diffusion coatings*, diffusion of silicon into solid metal at elevated temperatures.

slurry—a suspension of solids in water.

spotting out—the delayed appearance of spots and blemishes on plated or finished surfaces.

stalagmometer—an apparatus for determining surface tension. The mass of a drop of a liquid is measured by weighing a known number of drops or by counting the number of drops obtained from a given volume of the liquid.

standoff—*in abrasive blasting*, distance from blast nozzle to part when abrasive blasting.

stardusting—an extremely fine form of roughness on the surface of a metal deposit.

stop-off—See **resist**.

stopping off—the application of a resist to any part of an electrode—cathode, anode, or rack.

stray current—current through paths other than the intended circuit, such as through heating coils or the tank.

strike: (1) *n*—a thin film of metal to be followed by other coatings.

(2) *n*—a solution used to deposit a strike.

(3) *v*—to plate for a short time, usually at a high initial current density.

strip, *n*—a process or solution used for the removal of a coating from a basis metal or an undercoat.

strip, *v*—to remove a coating from the basis metal or undercoat.

substrate—*in diffusion coatings*, material on which coating is deposited.

superimposed ac—a form of current in which an alternating current component is superimposed on the direct plating current.

surface active agent—a substance that affects markedly the interfacial or surface tension of solutions even when present in very low concentrations.

surface tension—that property, due to molecular forces, that exists in the surface film of all liquids and tends to prevent the liquid from spreading.

tank voltage—the total voltage between the anode and cathode of a plating bath or electrolytic cell during electrolysis. It is equal to the sum of: (1) the equilibrium reaction potential, (2) the *IR* drop, and (3) the electrode potentials.

tarnish—corrosion products in the form of thin films or spots that do not protrude significantly from the surface of the metallic coating; for example, reaction products of copper from oxygen or reduced sulfur.

thief—an auxiliary cathode so placed as to divert to itself some current from portions of the work which would otherwise receive too high a current density.

throwing power—the improvement of the coating (usually metal) distribution over the primary current distribution on an electrode (usually cathode) in a given solution, under specified conditions. The term may also be used for anodic processes for which the definition is analogous.

total cyanide—the total content of cyanide expressed as the radical CN⁻, or alkali cyanide whether present as simple or complex ions. The sum of both the combined and free cyanide content of a solution.

transference (or transport, or migration)—the movement of ions through the electrolyte associated with the passage of the electric current.

transference number (transport number)—the proportion of the total current carried by the ions of a given kind.



trees—branched or irregular projections formed on a cathode during electrodeposition especially at edges and other high current density areas.

tripoli—friable and dustlike silica used as an abrasive.

tumbling—See **barrel finishing**.

vapor deposition:

chemical—ion, induced by heat or gaseous reduction of a vapor condensing on the substrate.

physical—a process for depositing a coating by evaporating and subsequently condensing an element or compound, usually in a high vacuum.

vibratory finishing—a process for deburring and surface finishing in which the product and an abrasive mixture are placed in a container and vibrated.

void—a defective area in which a part of the basis material or underlayer is visible after final coating.

voltage efficiency—the ratio, usually expressed as a percent-

age, of the equilibrium reaction potential in a given electrochemical process to the bath voltage.

water break—the appearance of a discontinuous film of water on a surface signifying nonuniform wetting and usually associated with a surface contamination.

wet blasting—a process for cleaning or finishing by means of a slurry of abrasive in water directed at high velocity against the work pieces.

wetting agent—a substance that reduces the surface tension of a liquid, thereby causing it to spread more readily on a solid surface.

whiskers—metallic filamentary growths, often microscopic, sometimes formed during electrodeposition and sometimes spontaneously during storage or service, after finishing.

work (plating)—the material being plated or otherwise finished.

DEFINITIONS RELATING SPECIFICALLY TO PLATING ON PLASTIC SUBSTRATES

cleaning—the removal of unwanted materials, such as mold release agents.

conditioning—the conversion of a surface to a suitable state for successful treatment in succeeding steps.

nucleation—the preplating step in which a catalytic material, often a palladium or gold compound, is absorbed on a

surface to act as sites for initial stages of deposition.

post-nucleation—the step where, if necessary, the catalyst is converted to its final form. This is the final step prior to electroless plating.

sensitization—the absorption of a reducing agent, often a stannous compound, on the surface.

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