



## Standard Terminology Relating to Electroplating<sup>1</sup>

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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*:<sup>2</sup>

**B368 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.

**ångström unit ( $^{\circ}\text{A}$ )**— $10^{-8}$  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.

<sup>1</sup> This terminology is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.01 on Ancillary Activities.

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<sup>2</sup> 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.

**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.

**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 **B368**).
- 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  $\mu\text{m}$ , 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 B380<sup>2</sup>).

**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.)

**cracking**—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.<sup>3</sup>

**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.

<sup>3</sup> U. S. Patents 2,149,344; 2,760,928; and 2,801,963.