

**A Glossary of Terms Relative to
Photochemical Machining**

**As Developed by PCMI
The Photochemical Machining Institute**

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The CONARD Corporation
Specializing in Photochemical Machining
since 1965

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PCM Glossary: Terms & Definitions

A

A A(S): Atomic Absorption (Spectrometry) is used for analyzing solutions for their metal content.

Acid: A substance which, when dissolved in water, forms a solution, with a pH of less than 7. The etchant used to dissolve the substrate, to form the component/features.

Actinic: Optical energy that is absorbed by radiation-sensitive coatings to produce an image by chemical changes.

Alignment: The accuracy of the relative position of an image on a phototool with respect to: (a) an existing image on a substrate, or (b) each of the two pieces of film making the phototool.

Alignment Mark: An image selectively placed within or out of an array for either testing or aligning or both.

Alkali: A substance which, when dissolved in water, forms a solution with a pH more than 7.

Ammoniacal: An ammonia-based etchant commonly used for copper.

Angstrom: Unit to define wavelength of light, ultraviolet energy and x-rays; one angstrom is equivalent to 10^{-1} nanometers (10^{-10} meters).

Anode: The positive electrode in an electrolytic cell.

Aperture Masks: Perforated metal foil used in the production of color television screens.

Array: A block of multiple images arranged in columns and rows.

Artwork: An accurately scaled pattern (usually a single image) which is used to produce the artwork master or phototool(s); a product consisting of an image on the surface of a stable base. The proper description of the artwork must include the required specification for tone and orientation, as these specifications impact subsequent photo processing operations and/or usability.

Artwork Master: An accurate one-to-one pattern, usually a single image, which is

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Aqua Regia: Used for etching gold; conc.HCl:conc.HNO₃. (3:1 by volume).

B

Background: The surface area against which the pattern is contrasted. The surface area of the background is usually much greater than the area of the pattern, as with a clear pattern on a black background or a black pattern on a clear background.

Backlighting: Viewing or photographing an object by placing it between a light source and the eye or recording medium.

Bake: A thermal process used to dry or cure.

Base Material: The material to which a coating or plating is applied, and/or from which stock is selectively removed by chemical machining; the material onto which a photosensitive, strippable or scribable material is applied for use in producing phototools.

Baumé: Designating or conforming to either of the scales used by the French chemist Antoine Baumé in the graduation of his hydrometers or relating Baumé hydrometers. There are two Baumé hydrometers. One (Heavy Baumé), which is used with liquids heavier than water, such as ferric chloride etchants, sinks to zero degrees in pure water and to 15 degrees in a 15 percent salt solution. The other (Light Baumé), for liquids lighter than water, sinks to zero degrees in a 10 percent salt solution and 10 degrees in pure water.

Bend Lines: Lines approximately half etched into the metal surface that can be used to assist with bending the part in a subsequent operation.

Blank: The work piece, cut to size for processing. See [Etched Blank](#).

Blister: A raised spot on the surface of metal caused by expansion of gas in a subsurface zone during thermal treatment.

Border Area: Region outside the functional pattern area(s).

Border Data: Patterns which appear in the border area of photo tooling; these patterns may include tooling hole "bull's eyes," identification, test patterns, registration and fiducial marks.

registration and fiducial marks.

Buckle: Also called "oil canning"; a distortion of a metal surface, appearing as a bulge or wave, resulting from unbalanced stresses in the metal. Buckles in the center of the sheet are referred to as center buckles and those away from the center are called quarter buckles.

Bulls Eye: Stylized pattern located in the border area of a phototool to assist in photo tooling alignment and/or registration.

Burn-in: The process of heating a developed photo resist image until the resist coating becomes chemically resistant, or the process utilized to complete fine line image developing of photo resist.

Burr: The sharp protrusion of the edge of a slit or sheared strip resulting from the fracture effect of the slitting or shearing operation; remnant of a breakout tab.

C

CAD: Computer Aided Design (or Drawing) utilized to produce engineering drawings and associated photo tooling files for photoplotter.

Camber: The deviation of the edge of a length of flat metal from a straight line.

Camera Reduction: The process of photographically reducing the size of a scaled artwork; the product produced by such a process.

Candela: A standard of luminous intensity defined as one-sixtieth of the luminous intensity of one square centimeter of a blackbody radiator operated at the temperature of freezing platinum.

Cans: See [Screening Cans](#).

Cathode: The negative electrode in an electrolytic cell.

CDE: Controlled Etch Depth.

Chatter: The saw tooth pattern along a cut line on artwork caused by an uneven application of the blade during scribing.

Characteristic Curve: A curve in which D is plotted against Log Exposure resulting from photographic plates exposed to light of constant I (intensity) for a series of times (timescale exposures.)

Chemical Blanking: Originally used to describe PCM. See [Photo Chemical Machining](#).

Chemical Machining: The selective removal of stock from base material by chemical means. Used extensively for weight reduction in the aircraft industry.

Chemical Milling: Originally used to describe PCM. See [Photo-Chemical-Machining](#).

Chemical Reversal: See [Reversal Developing](#).

Chinch Mark: See [Eyebrow](#).

Chlorine Regeneration: Used to regenerate ferric chloride to maintain good quality acid for the etching process.

Chrome on Glass: Phototool used for precise and accurate work.

Cleanliness Classes: The statistically allowable number of particles per cu ft of air as per Clean Room Standard 209 E.

Class Name	Measured Particle Size in Micrometers (μm)				
	0,1 M	0,2 M	0,3 M	0,5 M	5 M
1 (M 1.5)	35	7.5	3	1	N/A
10 (M 2.5)	350	75	30	10	N/A
100 (M 3.5)	N/A	750	300	100	N/A
1000 (M 4.5)	N/A	N/A	N/A	1,000	7
10000 (M 5.5)	N/A	N/A	N/A	10,000	70
100,000 (M 6.5)	N/A	N/A	N/A	100,000	700

Clean Room: A room in which the concentration of airborne particles is controlled to specific limits (in the US, Federal Standard 209 E).

Coat: To cover or apply to a substrate surface a layer of a photo resist material by dipping, rolling, spraying, laminating, spinning, printing, or flowing.

Coil Set: Curvature of rolled metal along its length caused by coiling under too much tension over rolls of insufficient diameter. Coil set is similar in appearance to curl but, unlike curl, is not uniform throughout the coil.

Collimated Light: See [Light Source, Collimated](#).

Compensation: Changes made in the dimensions of the master artwork/phototool from those specified on the engineering drawing to allow for chemical machining process variables, e.g. etch allowance, etch factor and undercut during etching.

Composition: A photographic process in which patterns on two separate substrates are aligned or registered and transferred to a third substrate. Composition may be accomplished in conjunction with contact printing or camera operations. The composition usually involves intermediate phototools.

Conversion Coating: Treatment of the surface of the substrate by high temperatures or pickling to improve photo resist adhesion.

Contact Printing: A photographic process in which an image is transferred from one substrate surface by light exposure to the photosensitive side of a second substrate. The orientation of the printed image is dependent on the relative positioning of the image surface and the tone of the printed image is dependent on the photosensitive material used.

Contrast: (a) Gradient of the characteristic curve also known as γ (gamma). (b) A difference in tone between clear and emulsion on film work.

Coordinatograph: An X and Y coordinate plotting machine consisting of a fixed or rotating table and movable head, on fixed ways, that is capable of precisely locating a point on a line or surface. Coordinatographs were commonly used with cut-and-strip scribe-coat materials to generate artwork. Now they are mainly replaced by CAD production of artwork master files. Coordinatographs can also be used for accurately measuring film work or flat parts.

Copy Camera: Camera adapted for enlarging, reducing, color separating, and screening of photographic materials. Also referred to as a process camera.

Cosine Law: A law of illumination which indicates that the flux radiated or received in a given direction varies with the projected area of the receiver or emitter in a plane perpendicular to the direction of flux.

Covers (Lids): Manufactured by PCM and used to cover electronic thick film packages.

Crease: A ridge or groove in flat-rolled metal caused by improper tension control during winding. (Creases are normally intermittent, straight-line, and angled toward the edge.) Also, a crease is a line, groove, or ridge that is made by or as if by folding a pliable substance.

a pliable substance.

Cross-bow: A curvature across the full width of the strip of metal that renders it somewhat canoe-shaped or gutter-like along its length.

Cupric Chloride: A popular etchant for copper.

CTE: Coefficient of thermal expansion.

Curl: A relatively uniform curvature or sweep along the length of a metal coil, induced during rolling or by passing the metal over a small diameter roll, such that the combined tensile and bending stresses exceed the yield stress of the metal, leaving a degree of permanent curvature in the metal.

Cut and Strip: A method of producing artwork by cutting the pattern, usually on a coordinatograph, and stripping away the unwanted areas of a two-layer material. The terms "cut-and-strip" and "cut-and-peel" are synonymous.

D

Datum: A position or element in relation to which others are determined.

Datum Plane: A plane from which distances or dimensions are reckoned.

Datum Point: A point used as the basis for reckoning.

Dent: A sharp, highly local point of deformation in metal strip.

Defect: An undesirable blemish within the functional pattern or background of phototools or components commonly called flecks, voids, pinholes, spurs, notches, etc.

Definition: The fidelity of reproduction of the pattern edge relative to the original master pattern.

Densitometer: An instrument for measuring the optical density of any selected part of a film or plate.

Density (D): By definition, the $\log(1/T)$ where T is transparency. The value of D depends on the emulsion, the magnitude and nature of the exposure, the processing conditions, and the optical arrangement of the densitometer. More correctly known as optical density.

Develop: To subject photosensitive material to a chemical treatment designed to produce a usable image in matter previously modified by radiation.

produce a usable image in matter previously modified by radiation.

Diazo: A non-silver, room lighting, UV-sensitive coating, usually on a stable transparent film substrate. Diazo coatings yield mirror images with duplicate tone through contact printing, and are developed in ammonia vapor. Diazo images have high actinic density and visual transparency.

Digitizing: Any method of reducing feature locations on a flat plane to digital representation of x-y coordinates.

Dip Coating: Applying resist to the surface of the substrate by immersing it in a tank of liquid resist and slowly withdrawing.

Direct Imaging: See [Laser Direct Imaging](#).

Dropout: Parts etched without tabs.

Dry: A thermal process to reduce or eliminate water or solvent.

Dry Film Resist: Photo resist supplied in sheet laminate form as rolls. Also see [Photo resist](#).

E

Edge Waves: Buckle-like distortions that exist whenever the edge is longer than other portions of the strip, usually occurring at the immediate edge.

Electro etching: The removal of metal from a surface through the action of an electrically conductive solution and direct current according to Faraday's Laws of Electrolysis.

Electroforming: The growing of metal in an electroplating bath on a mandrel (solid/ wax/ polystyrene, etc.) according to Faraday's Laws of Electrolysis. See [Photo Electro Forming](#).

EMI: Electro-Magnetic Interference.

Embedded Particle: A foreign particle of solid substance impressed into the surface of material (see [Inclusion](#)).

Emulsion: A gelatin/polymer layer containing silver halide crystals coated onto an inert support and forming the photosensitive layer.

Emulsion Hardening: The process inherent in the developing of a photographic layer, which renders the desired image abrasion-resistant in handling.

layer, which renders the desired image abrasion-resistant in handling.

Emulsion Side: The side of a photographic film or plate, which has the photographic layer coated on it.

Encoder: Manufactured by PCM or PEF used with a light emitting/receiving diode to measure movement or distance through the apertures, linear or rotary.

Engineering Drawing: Technical drawing of the part.

Etch Allowance: The total dimensional adjustment, expressed in inches, mils or millimeters per side incorporated into the design of an artwork/phototool for a photochemically machined part to compensate for the etching process.

Etch Band Design: The method of designing artwork for the photochemically machined part whereby all shapes are outlined with a controlled line width to be etched, as opposed to non-outlining, which results in uncontrolled etching areas.

Etch Factor: The ratio of the etched depth to the lateral etch, or undercut.

Etchant: Chemical solution used in etching.

Etched Blank: The photochemically machined work piece in the flat or preformed configuration.

Etching: Chemical dissolution of material.

Evaporation Mask: Manufactured by PCM or PEF and used as a stencil when vacuum depositing.

Exothermic Reaction: A chemical reaction that creates heat.

Exposure (E): The quantity of light received per unit area of the layer. Exposure may be specified in terms of intensity, spectral composition and duration.

Eyebrow: Sometimes called "half-moon." A short, curving crease in thin strip or foil usually caused by improper handling. On photographic film this is called a cinch mark.

F

Ferric Chloride: The most common etchant used in PCM.

Fiducial: A mark enabling registration or alignment.

Filemaster: Any of the photo tooling products which may be retained for recreating or reproducing a phototool. Typically, either the artwork master or working master function as the filemaster.

Film: A photographic emulsion coated on a flexible translucent or transparent plastic base.

Film Sandwich: A sandwich composed of photomasks made with flexible film materials.

Fleck: A defect in the clear background of a phototool with a black pattern, or within the clear pattern of a phototool with a black background.

Flood Light: See [Light Source, Broad](#).

Fluidics: The science and technology of using a flow of liquid or gas (these are often produced by PCM or PEF).

Fog: See [Photographic Fog](#).

Foot-candle: Now little used. Unit of illumination equal to luminous flux density of 1 lumen per square foot of striking surface. One foot-candle equals 10.76 lux in the metric system (see [Lux](#)).

Fret: A series of etched parts tagged into a frame. Typically several frets are etched within a blank.

Functional Pattern: The photo tooling configuration required to obtain the designed part.

G

Gobos: Generally, etched discs used as illumination masks for product advertisements.

Glass Sandwich: A sandwich composed of photomasks made with rigid glass material.

Graticule: An etched/ruled grating for measurement purposes.

H

Halogen: One of the Group VII, non-metallic elements including fluorine, chlorine, bromine and iodine.

Hardening: See [Photo resist Hardening](#), [Emulsion Hardening](#), and [Metal Hardening](#).

HEPA Filter: High Efficiency Particulate Air filter. These are replaceable, extended-media dry type filters, mounted in a frame, that have a collective efficiency of 99.97 percent for a 0.3-micrometre particle size.

Hydrometer: An instrument used to measure the specific gravity of liquids. It is usually made of glass with a graduated stem, and indicates the specific gravity of a liquid by the depth to which it sinks in.

I

Illuminance (or Illumination): The result of luminous flux striking a surface. In English units, one lumen of flux falling on one square foot of area is defined as an illumination of one foot-candle. In the metric system, one lumen illuminating one square meter is the definition of one lux. This gives a direct conversion factor of $10.76 \text{ lux} = 1 \text{ foot-candle}$.

Image: A representation of the functional pattern on a substrate: (a) drafting — as part of a master drawing or layout; (b) optical — as projected on a screen; (c) photographic — as in a photomasks or in the emulsion on a film or plate; (d) photo resist — as occurs in an exposed and developed coating on a substrate.

Inclusions: Undesired materials in a solid matrix.

Infrared: Electromagnetic energy usually defined as heat in the invisible part of the spectrum beyond the 760nm range.

Intaglio: An image etched/sunk into the surface of the substrate.

Inverse Square Law: A law of illumination which states that the illumination of a surface due to a point source is proportional to the intensity of the source and inversely proportional to the square of the distance from the source to the surface.

Isotropic Etching: Etching equally in all directions.

K

Keys: See [Alignment Mark](#).

L

Labyrinth Screening Can: A complex screening can, with many compartments.

Laminating Resist: Dry film resist is applied to the work piece, and heated with pressure applied simultaneously from rollers.

Lamination: One of a series of parts or etched blanks that are stacked and bonded in registration to form a complete unit.

Lamination, Surface: Longitudinal digs, lines, or open, broken blisters on the surface of rolled metal caused by breakout of subsurface non-metallic inclusions during processing.

Laser: Light Amplification by Stimulated Emission of Radiation.

Laser Direct Imaging (LDI): Direct imaging of a photo resist with a moving laser beam, thereby eliminating the need for a phototool.

Laser Plotter: A precision optical-mechanical system for producing phototools on film or glass. A laser beam scans the surface and is turned on or off to expose (or not expose) the photographic emulsion. A PC and special software control this scanning operation.

Lateral Reversal: A mirror image of the geometric orientation of a pattern.

Layout: The graphic description of the composite patterns required to produce the functional pattern in the photo tooling or manufacturing process.

Lead Frame: Small metal strips manufactured on a frame in such a way that makes electronic interconnections easier to produce (i.e. from the silicon chip to the printed circuit board).

Legend: A format of lettering or symbols on the part, e.g. part number, component locations and patterns.

Lids: See [Covers and Lids](#).

LIGA: German acronym for X-ray Lithography, electrodeposition (Galvanofarming) and molding (Abformtechnik).

(Galvanofarming) and molding (Abformtechnik).

Light: Electromagnetic energy defined as visible energy between 380 -780nm range.

Light Source, Broad: An exposure system that uses a reflector to produce a broad diffuse source of illumination. This type of system is used to image relatively large features or flood expose surfaces.

Light Source, Collimated: An exposure system that uses special reflectors and optics to produce illumination with near parallel rays. This type of system is used to image fine features with uniform distribution of energy across the surface being exposed.

Light Source, Point: An exposure system which uses a small, intense source combined with special reflectors to produce near parallel rays similar to a collimated source. This type of system is used to image fine to medium detail with good energy distribution across the surface being exposed.

Liquid Resist: A photo resist applied to the substrate by dipping, roller coating, curtain coating or spraying. Liquid resists are most often photopolymers. In rare high volume applications casein is used (see [Photo resist](#)).

Logo: A small design used as the symbol of an organization.

Loop (Loupe): A small folding magnifying glass.

Lumen: Unit of luminous flux defined as total flux in a space angle of one steradian and emitted by a source of one candela (one candela emits 4π or 12.57 lumens).

Luminance (or Brightness): A measure of flux reflected or emitted from a surface. It has English units of foot-lamberts and metric units of candelas per square meter.

Luminous Energy: A measure of rate of flow of flux. It has units of lumen-seconds.

Luminous Flux: A measure of flow of visible light energy past any given point in space. It is defined as the amount of flux generated by a source of one candela into a solid angle of one steradian.

Lux: The metric unit (lumens per square meter) for the measure of luminous flux (also see [Illuminance](#)).

M

Marking: See [Legend](#).

Mask, Metal on Glass: An optical mask comprising a glass substrate selectively covered by a thin opaque metal layer (e.g. chromium); a type of photomasks.

Master Drawing: The technical drawing of the etched blank whose documented dimensions include all compensations for the photo chemical machining process.

Metal Hardening: A thermal, mechanical, or chemical treatment used to increase the hardness of a metal.

Micron: One-thousandth part of a millimeter. One micrometer.

Mil: One-thousandth part of one inch (U.S. term).

Mirror Image Photo-tool: When two pieces of film with their emulsions facing each other have the same image orientation.

Misalignment: Improper relative positioning of an image or images.

Molecular Dye Imaging Materials: A designation of a particular diazo material sensitometrically designed for phototool applications by the manufacturer.

Mouse Bites: A phenomenon in the edge of undercut photo resist whereby the edge fractures to cause the appearance of hemispherical "bites" out of the stencil edge.

Multilevel: Different thicknesses of metal in a substrate or different controlled depths into the surface created by Etching / PEF. This process is used extensively in stencil manufacture to deposit different thicknesses of solder paste onto the PCB for Surface Mount Technology (SMT).

N

Nanometer: A unit of measurement ($1 \text{ nm} = 10^{-9}$ meters) commonly used to define wavelength in the electromagnetic spectrum. Replaces Ångstrom; $1 \text{ Å} (10^{-10} \text{ meters}) = 0.1 \text{ nm}$.

Negative: The tone of the phototool that has translucent functional patterns; namely, the desired metal portion of the part is rendered translucent when working with negative-working photo resist.

Nanotechnology: The study, development and processing of materials, devices and systems in which structure definition on a dimensional scale $<100\text{nm}$ is essential to obtain the required functional performance.

Negative-working Resist: A resist which is polymerized (hardened) by light and which after exposure and development remains on the surface of the substrate in those areas which were beneath the transparent parts of a photomasks.

Newton's Rings: Light interference patterns signifying intimate contact between phototool and glass exposure frame.

Notch: A void; an undesirable indentation in an edge of a photographic pattern, i.e. a clear indentation in a black pattern.

O

Off-contact: Two surfaces separated slightly from each other.

Oil-canning: See [Buckle](#).

Opacity: By definition, $1/T$ where T is transparency.

Opaque: A material for retouching photographic images, generally containing graphite or iron oxide. The material can be solvent or water-soluble.

Optical Density: See [Density](#).

Orientation: A description of the manner in which the functional pattern is to be viewed. Proper orientation requires a definition of "right reading" orientation for the various photo tooling elements described as either "right reading up" or "right reading down."

ORP: Oxidation Reduction Potential. Often used as a measurement to assess the power of an etchant.

Orthochromatic: Silver emulsion spectrally sensitive to blue, green, and yellow frequencies.

Overlay: A film containing graphic matter, which is used for inspection by superimposing the film on the graphic matter.

P

Panchromatic: Silver emulsion spectrally sensitive to the entire visual portion of the frequency spectrum (red, green and blue).

Pattern: See [Functional Pattern](#).

Pattern Area: The area of designed configuration that includes the pattern and background. The bounds of the pattern area can be defined by the physical outline or by an imaginary outline formed by enclosing the pattern in a box.

PCB: Printed Circuit Board.

PCM: Photo Chemical Machining.

PEF: Photo Electro Forming.

Perpendicularity: A measure of the degree to which the angle between the X-X and Y-Y axis approaches a right angle.

pH: A number used to express degrees of acidity or alkalinity in solution.

Photo Chemical Machining: PCM. The process of using photo resist to preserve the surface of metal, while using an etchant to dissolve away bare metal from both sides, thereby manufacturing components.

Photo Chemical Machining Institute: PCMI. The trade association for the Photo Chemical Machining industry.

Photo Electro Forming (PEF): The process of using photo resist as a mold on the surface of a mandrel, while using electrolysis of an electrolyte solution to grow components in the mold.

Photoetching: Originally used to describe PCM. See Photo Chemical Machining.

Photofabrication: Originally used to describe PCM. See Photo Chemical Machining.

Photofugitive: A dye system by which the background dye lightens upon exposure to UV light.

Photographic Fog: Any plus density on negative working photographic products or a loss of density on positive working products that appear on a piece of exposed processed glass, film, or paper, but is not result of image exposure. Fog can be produced by a number of causes including safelight fog, chemical fog, dichroic fog, and fog caused by aerial oxidation.

and fog caused by aerial oxidation.

Photographic Layer: A light-sensitive coating containing silver halide which has been exposed and treated to yield a visible image of dispersed metallic silver obtained by photographic processes.

Photographic Operations: A term generically applied to the entire spectrum of procedures and techniques utilized in the preparation of phototools. This includes photo plotting, contact printing, stepping and repeating, composition, camera reduction or magnification, registration, and touch-up.

Photographic Plate: A photographic layer on "soda-lime-silica" plate glass.

Photographic Reduction Dimensions: Dimensions (e.g. the distance between lines or between two specified points) on the artwork to indicate to the photographer the extent to which the artwork is to be reduced photographically. (The value of the dimensions refers to the 1:1 scale and must be specified.)

Photogravure: A method of photoengraving in which the design etched on the metal surface is intaglio, not relief. A picture may be produced by this method (used in the printing industry).

Photolithography: The process of lithographic printing from a photographically produced plate.

Photomasks: See Phototool.

Photomasks Registration: The procedure for precise alignment of a phototool to the blank or to a mirror image phototool, when etching a panel from both sides. Punched holes and pins or optical alignment of targets are methods most commonly used.

Photo master: A general term applicable to any of the specifically defined photographic products. The artwork, artwork master, working master and phototool all are each individual tools. See Phototool.

Photometry: The measurement of visible light intensity and energy as it affects the human eye.

Photomilling: Originally used to describe PCM. The term was restricted to a surface material removal process.

Photopolymer: Polymeric material sensitive to actinic radiation.

Photo plotting: The photographic process whereby an image is generated by the motion and/or positioning of a controlled light beam by numerical control directly onto a light-sensitive material (usually emulsion).

Photo resist: A material which, when properly applied to any of a variety of substrates, becomes sensitive to portions of the electromagnetic spectrum and, when properly exposed and developed, masks portions of the substrate with a high degree of integrity.

Photo resist Hardening: The process whereby photo resist is rendered more resistant to the effects of plating and/or etching.

Photo resist Integrity: The soundness of a photo resist measured in terms such as chemical resistance, uniformity and adhesion.

Photo resist, Negative: See Negative-working Resist.

Photo resist, Positive: See Positive-working Resist.

Phototool: The working tool that is used in production for exposing the resist coated work piece.

Photo tooling: See Phototool.

Photo tooling Aids: Photographic products used to assist in inspection, i.e., as overlays, and not normally used for transferring imagery to photo resist.

Photo tooling Process: See Photographic Operations.

Phototropic: A dye system in which the background dye darkens upon exposure to UV light.

Pickle Stain: Discolored area on the surface of pickled metal due to incomplete rinsing and/or inadequate drying after pickling.

Pinhole: (a) A clear defect completely within a black pattern or in the black background of a clear pattern. (b) A small hole or holes in the surface or right through a finished PCM component.

Pins: See [Registration Pins](#).

Pit: A crater or cavity upon the surface but not penetrating completely through the material.

Point Light Source: See [Light Source Point](#).

Positive: The tone of the phototool which has opaque functional patterns; namely, the desired metal portion of the part is rendered opaque when working with positive photo resist.

Positive-working Resist: A resist which is decomposed by light and which, after exposure and development, is removed from those areas which were beneath the transparent parts of a production master.

Power of Source: The amount of luminous flux emitted from a source into a solid angle. The basic unit of power is the candle, renamed candela when defined by melting platinum.

Process Camera: See [Copy Camera](#).

R

Radiance: A measure of the output of a point source; the amount of power per unit area per solid angle defined by the unit watt/square meter-steradian.

Radiant Energy: The amount of watts reaching a given point accumulated over a given time interval, referred to as joules (watt-sec).

Radiant Flux: The amount of power incident on a given surface, expressed in watts.

Radiant Intensity (Power of Source): The amount of power from a point source generated in a solid angle, measured in units of watts/steradian.

Radiometry: The measurement of radiation in the optical spectrum, which includes ultraviolet, visible and infrared light.

Ramjets: Generally used for etching at higher speeds, these consist of larger orifice nozzles spraying close to the surface of the work piece at higher pressure.

Reciprocity Failure: Deviation from the reciprocity law. Typically, the deviation occurs at either low intensity or at short interval exposures and high intensity and/or long interval exposures.

Reciprocity Law: A general law for photo chemical reactions which states that the mass of photoproduct from such a reaction is determined simply by the total exposure involved, i.e. by the product of intensity and time, and is independent of the two factors separately.

the two factors separately.

Redox: The reduction-oxidation potential in an electrochemical reaction involving the transfer of electrons between different chemical species. See [ORP](#).

Reduction: See [Camera Reduction](#)

Reduction Marks: A set of stylized patterns in the border area of an artwork between which the "photographic reduction dimension" is defined.

Registration Pins: May be used in production for accurately positioning one piece of film to another. This is achieved by punching either, individual holes in the films, or a series of holes accurately placed through the films with a set of punches, then aligning these on pins or a pin registration bar.

Register Marks: Stylized patterns placed in the border area of the photo tooling to facilitate accurate registration.

Registration: The accuracy of relative position or concentricity of all functional patterns of any other mask of a given device, or series of masks, when the masks are exactly superimposed; the process of accomplishing the same (see [Photomasks Registration](#)).

Resist: See [Photo resist](#).

Resolution Usable: The smallest image that can be produced and subsequently processed in a given photo resist or film emulsion.

Resolving Power: The ability of a photographic system to maintain, in a developed image, the separate identity of parallel bars when their relative displacement is small.

Reversal Development: A process used with certain photographic emulsions for reversing the tone of an image from that which is accomplished with conventional developing. This process is carried out by developing the exposed silver halide, subsequently bleaching out the developed silver, and then developing the remaining silver halide after an overall second exposure.

RFI: Radio Frequency Interference.

Right Reading: An obsolete phototool definition of image orientation in which the geometric view of the images is as shown on the master drawing.

Right Reading Down: A photomasks in which the functional pattern is oriented as shown on the master drawing with the emulsion surface of the photographic film or

shown on the master drawing with the emulsion surface of the photographic film or glass plate away from the viewer.

Right Reading Up: A photomask in which the functional pattern is oriented as shown on the master drawing with the emulsion surface of the photographic film or glass plate toward the viewer.

Rotational Error: The error that occurs when functional patterns are misaligned by some angle with respect to the X and Y axes during step-and-repeat.

Runout: The sum of cumulative-pitch error when measured across a number of functional geometric patterns on a photomask.

S

Safelight: A darkroom or processing area lamp which emits light of a color that will not affect the photographic material within a reasonable handling time.

Sandwich: Phototool for double-sided PCM, comprising two pieces of mirror-imaged film.

Scratch: A cut on the surface of an object deep enough to catch a fingernail.

Screening Cans: Are used on PCBs to reduce or remove RFI and EMI.

Scribecoat: A material composed of a stable base such as glass or film with an opaque coating.

Scribing: To produce artwork by scraping the opaque coating from the scribecoat material with a blade-like cutting tool with the blade edge parallel to and resting on the plane of the base material.

Scuff: Marks on the surface of flat-rolled metal caused by surface-to-surface rubbing.

Selective Etch: Etching at unequal rates in limited areas, frequently caused by inhomogeneities in the work piece material, hot spots from unequal heat transfer or, on a microscale, selected grain faces or constituents.

SEM: Scanning Electron Microscope.

Serif: A drafting compensation in artwork to minimize the rounding of inside or outside corners.

SG: Specific Gravity.

Shielding Cans: See Screening Cans.

Sheet: See [Blank](#).

Silver Halide: Generic term for silver chloride, silver bromide, silver iodide or combinations thereof.

Smut: Fine, dark-colored, powdery material that sometimes remains on the surface of pickled or etched metal inadequately rinsed

Spin Coating: A method of putting a precise thickness of a wet resist coating on a substrate.

Spectral Sensitivity: The rate of response of a photographic material to a particular range of the electromagnetic spectrum. The values are usually expressed as a wavelength range through which some useful photographic sensitivity is obtained.

Spur: An undesirable projection from a photographic pattern, i.e. clear projection from a clear pattern or black projection from a black pattern.

Step-and-Repeat: A method of dimensionally positioning multiples of the same or intermixed functional patterns accurately within a given area on the phototool or by repetitious contact, projection printing or photo plotting.

Step-Etch: See [Multilevel](#).

Step-PEF: See [Multilevel](#).

Step Wedge: A photographic film containing areas of optical density increasing in constant increments and used for determining correct exposure levels.

Stencils: For the SMT industry, stencils are produced by PCM, Laser (cutting) and PEF, each having its own advantages. The most cost-effective is PCM, followed by Laser. The most expensive process is PEF. Best paste release from the aperture walls is by PEF, followed by Laser and then PCM.

Straight Walling: The continued etching of the part after breakthrough to reduce the exaggerated chevron-shaped profile to a straight wall profile.

Stringers: Streaks or clustered discolorations on the surfaces of alloys containing aluminum or titanium. Stringers become more readily visible after acid pickling.

Stripping: The process of removing photo resist from a substrate. Alkaline solutions and/or water miscible solvents are used to debond resist coatings by swelling and fracturing. Stripping solutions are applied by dipping or spraying. A water rinse is used to remove the residue.

Substrate: (a) The work piece. (b) A structure which underlies and supports or forms base material on which coatings are applied.

Suspension Head Assembly: Part of a device made by PCM used to read/write information on hard disk drives.

T

Tabs or Tags: Unetched portions of a substrate, which tie the etched parts together in a sheet.

Test Pattern: A pattern used for inspection or testing purposes.

Thou: An English abbreviation for one-thousandth of an inch.

Tone: The description used to identify artwork features as being opaque or clear, expressed as positive or negative.

Tooling: See [Photo tooling](#).

Tooling Pins (Holes): See [Registration pins](#).

Touch-up: A process for identifying and eliminating defects in emulsion and photo resist. Magnifiers, light tables, microscopes, knives, brushes and special inks are typically used in performing touch-up.

Trapezoidal Etch: Best described as the shape of the sand that is left on a beach after a sand filled plastic bucket has been turned upside down and removed. This shape is predominantly used in the stencil manufacturing industry for describing the cross section of an aperture that is used for depositing solder paste and its release onto a PCB that will be used for taking electronic components prior to reflow. Trapezoidal apertures are best produced for stencils by PCM, by making a mirror image double sided photo master that has one of the pieces of film with compensations on that allow an angle to be etched in the profile, thereby allowing the solder paste easy release.

Transparency (T): The ratio of transmitted radiation to that incident on a uniformly exposed and processed area that is large compared with the area of a grain in the emulsion.

emulsion.

Twaddell: An obsolete term where Degrees Twaddell is defined by $T_w^\circ = 200 (SG - 1)$.

Twist: A condition wherein a transverse axis held in the plane of the strip would rotate about the longitudinal axis when moved along the strip. Such a condition is evident in a short length of material if, when the material is freely placed on a flat surface, only three of the four corners touch that surface.

U

Undercutting: Lateral etching into a substrate under a resist coating.

Ultraviolet: Invisible electromagnetic radiation defined between 100 and 380nm.

UV: See Ultraviolet.

ULPA Filter: Ultra Low Penetration Air filters are extended media, dry filters in a rigid frame that have a minimum particle collective efficiency greater than or equal to 0.12 micrometers.

V

Void: A blemish within the photographic pattern, i.e. a black defect in a clear pattern (flecks and notches) or a clear defect in a black pattern (pinholes and spurs).

W

Wrong Reading: Obsolete terminology for defining geometric orientation of photo tooling.

X

X Axis: The horizontal or left-to-right direction in a two-dimensional system of coordinates. X-X signifies one direction followed in a step-and-repeat process (see [Step-and-Repeat](#)).

Xenon: One of the gases used to fill gas discharge lamps. The gas provides for high luminous efficiency.

XRF: X-ray Fluorescence. Used for the analysis of plating finishes, their content and thickness.

and thickness.

Y

Yellow Room: An area illuminated with yellow light for handling photo resist coated panels with minimal potential for exposing the coating. The yellow illumination is provided by special fluorescent tubes, colored sleeves which slip over conventional fluorescent tubes or yellow plastic filter materials that cover fluorescent lighting fixtures.

Y Axis: The vertical direction, perpendicular to the X-axis, in a two-dimensional system of coordinates. Y-Y signifies one direction followed in a step-and-repeat process.

Z

Z Axis: The depth direction, in a three dimensional system of coordinates.

Zahn Cup: A cup with a precisely dimensioned orifice that measures indirectly the viscosity of the resist.