Introduction to Photo Chemical Machining

A Guide Presented by Conard Corporation

CONARD CORPORATION
Precision Photochemical Manufacturing Since 1965

What is Photo Chemical Machining?

The photo chemical machining process goes by many names, including photo chemical machining, photo chemical etching, chemical milling, chemical etching, photo etching, even the abbreviation “PCM.” All of these names describe the same process.

The photo chemical machining process is a means of fabricating thin gauge metal parts. The metal thickness rages from .001” to .080” depending on the type of metal.

In the photo chemical machining process a stencil, called a “photo tool,” is used to expose multiple images of the parts to be made on both sides of a sheet of raw material that has been coated with a light sensitive and acid resistant material, called “resist.”

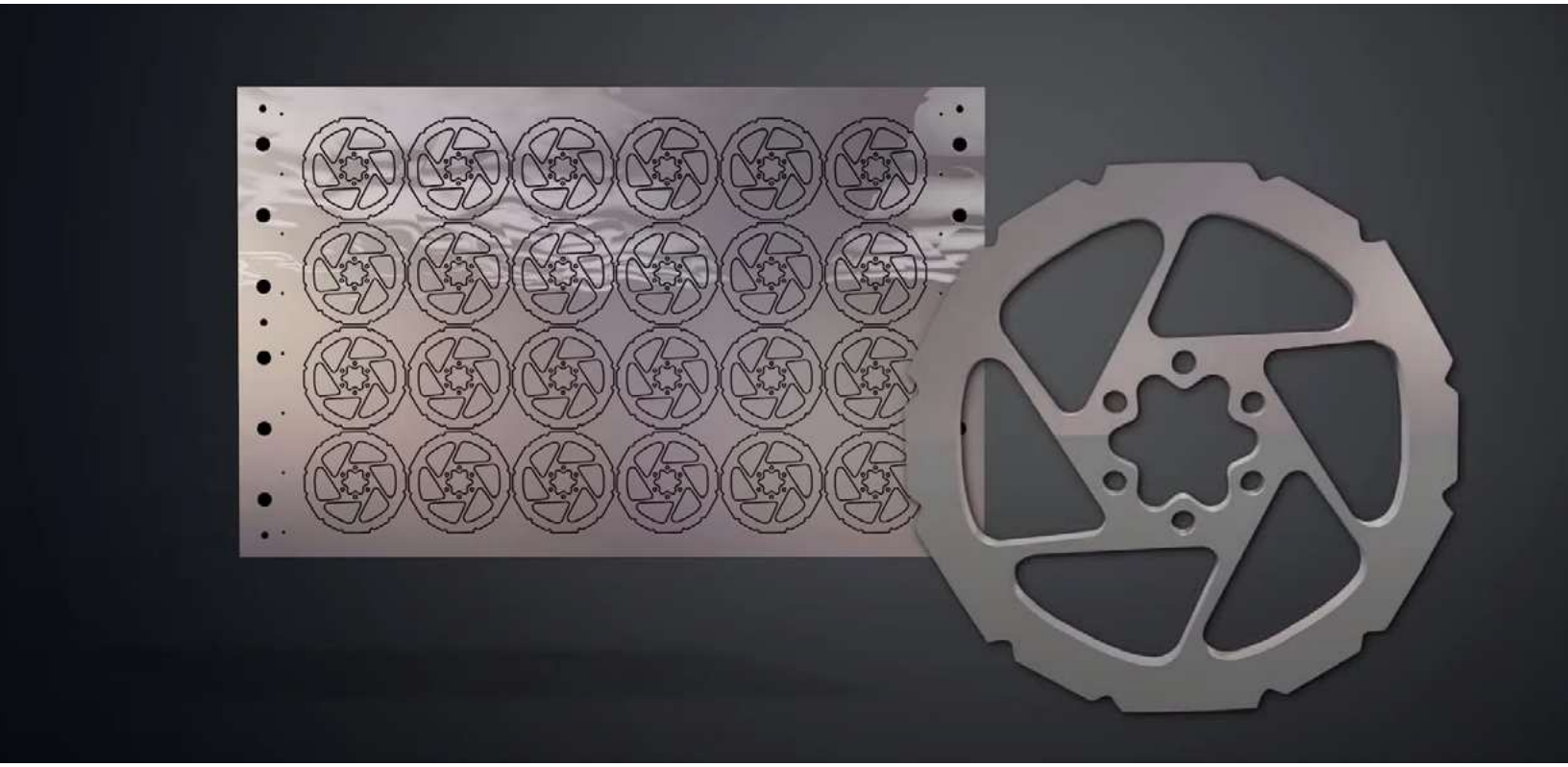
After the images of the parts have been developed, and the uncured “resist” is washed away, the metal around the part is dissolved using an etching chemistry.

Ten Simple Steps of Photo Chemical Machining

1. 2-CAD files are use to generate a Gerber file for plotting (DXF or DWG format preferred).
2. The Gerber File is output to a high-resolution photo-plotter and mylar phototools are developed and registered.
3. Metal is measured and sheared from coils.
4. Metal sheets are scrubbed, cleaned and rinsed.
5. Clean, dry metal is laminated with photopolymer film in a safe-light clean room.
6. The phototool and the laminate metal are precisely positioned in a vacuum frame UV exposure unit.
7. The exposed sheets are developed to remove the unexposed photopolymer, leaving bare metal to be etched.
8. The heated etching acid is sprayed at the metal from both sides, dissolving the unneeded metal areas. The metal sheets are rinsed four times.
9. The photopolymer is stripped using a heated solution of caustic and water. The parts are rinsed multiple times and dried in a turbo dryer. The clean, dry parts are delivered to our Quality Inspection department.
10. The parts are thoroughly inspected in accordance with our Quality Management System and to the customer's specifications. Conforming parts are packaged and shipped.

Why Photo Chemical Machining?

The resulting metal from the photo chemical process has no burrs or deformations of the raw material that can occur with other processes, such as stamping, punching, waterjet or laser cutting.



Inexpensive & Effective Tools

Photo chemical machining provides a fast, flexible and relatively inexpensive way to produce a wide variety of precision metal parts. Phototools replace conventional steel tools and dies. These tools can be generated in a matter of hours and rapidly and inexpensively regenerated to accommodate revisions to parts. The length in time from production of conventional tools compared to phototools can be reduced from weeks to days.

The phototool, which operates like a stencil, is the foundation of accuracy with light being its only working exposure, ensuring that there is no “tool wear” that needs to be monitored. Phototools are produced on a heavy gauge and dimensionally stable mylar using an 8000- dpi photoplotter. The locational tolerances for part features typically meet the nominal dimensions of the specification.

Fast & Easy to Produce

The photo chemical process can create quantities from handfuls to 100,000s.

From initial tooling to finished parts, the entire photo chemical machining cycle can be completed in 3 to 5 days. Given a normal backlog, typical lead times for new parts are 3- 4 weeks. Often, repeat orders can be processed more quickly, especially if the raw material is in stock. Prototype orders may be done in 2 weeks. Additional time is required to accommodate secondary operations such as plating, forming, heat-treating, silk screening, assembly, or the addition of surface components.

Photo chemical machining has similarities to a printing process in that the part designs can be immensely intricate without having an impact on the tooling or production process. Photo chemical machining can produce complex parts that would be either impossible or impractical to produce by stamping or laser cutting. The etching process produces parts that are free of burrs and mechanical stress.

Raw materials are thoroughly cleaned before imaging, after etching, after stripping, and before and after any subsequent metal finishing processes.

Photo Chemical Machining is Effective for Many Kinds of Metal:

Aluminum	Brass	Chromium	Copper, Oxygen Free
Copper, Rolled	Copper, Electrolytic	Beryllium Copper	OFHC Copper
Inconel®	Monel®	Nickel	Nickel Silver
Nichrome®	Ni Span C	Permanickel®	Phosphor Bronze
Carbon Steel	Electrical Steel	Stainless Steel, 300 & 400 Series	PH15-7 Stainless Steel
PH17-7 Stainless Steel	Custom 455®	Spring Steel	90-10 Copper Nickel
Kovar®	Rodar®	Nicoseal®	Therlo®
Sealmet 29-17®	Glass Sealing 42®	142 Alloy®	Glass Sealing 46®
146 Alloy®	Glass Sealing 49®	Alloy 4750®	Glass Sealing 52®
152 Alloy®	Glass Sealing 42-6®	Sylvania No. 4®	44-50 Nickel Iron
High Permeability 49®	Hipernik®	High Permeability 45®	Hymu 80®
4-79 Permalloy®	Hymu800®	Hipernon®	Supermalloy®
5-79 Permalloy	Invar 36®	TC-30®	Molybdenum
Conetic AA®	Metal on Polyamide	Metal on Kapton®	Metal on Rubber
Metal on Ceramic	Titanium		

Etching As An Alternative To Other Processes

Etching is a better alternative than stamping, laser cutting, punching or wire EDM.

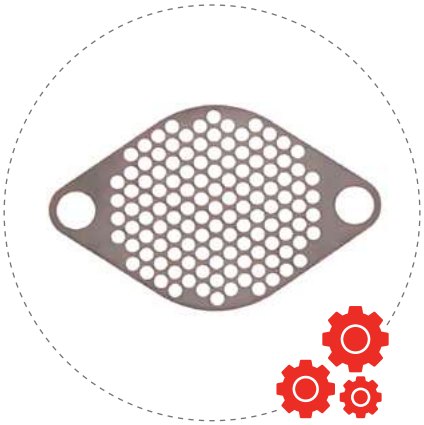
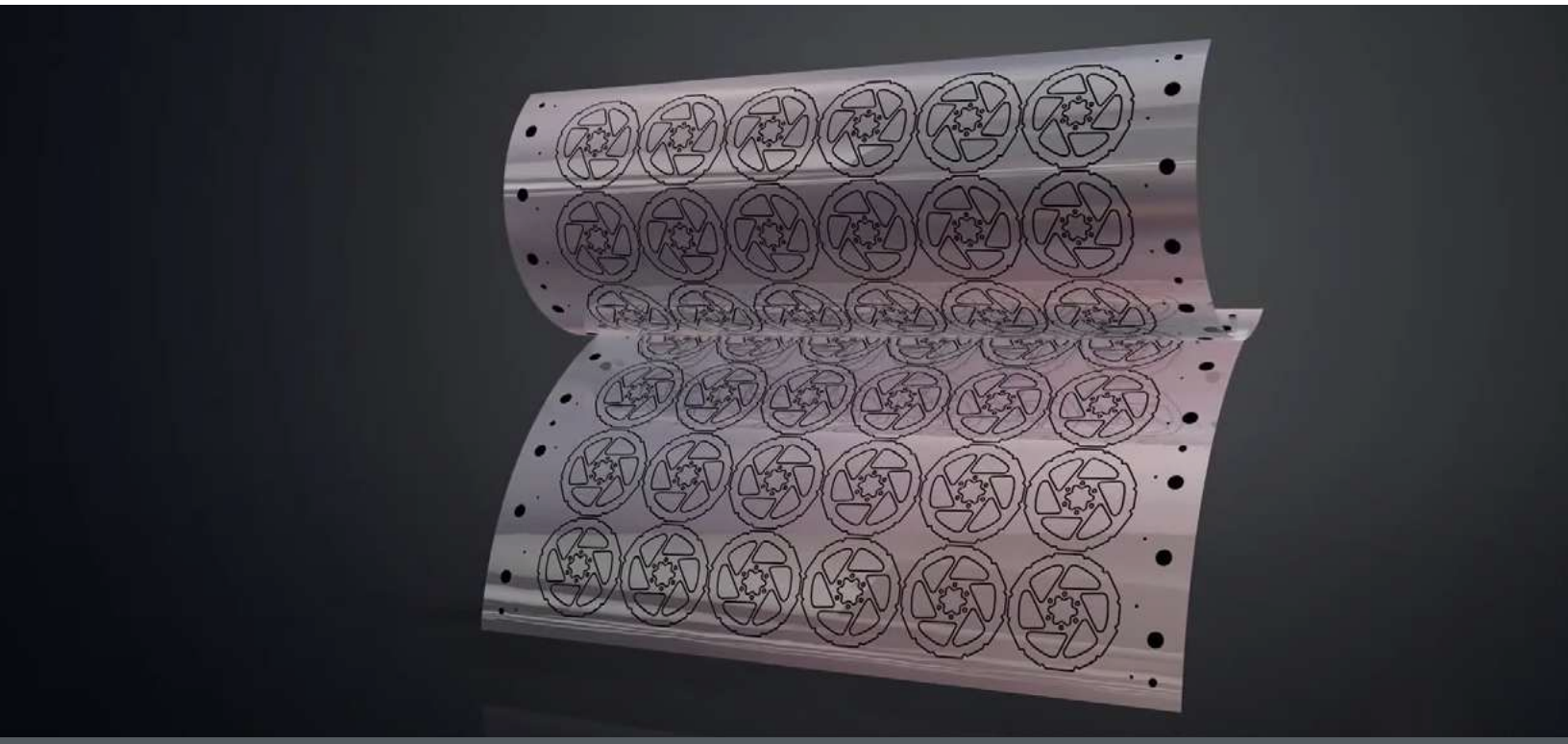


Photo chemical machining imparts no mechanical stresses on metal substrates. Where stamping, punching and die cutting impart shearing deformation and laser and water-jet cutting can leave ablative deformation, photo chemical machining simply dissolves the unneeded metal, leaving a flat and burr-free part.

Photo chemical machining is frequently the process of choice because the tooling is inexpensive and can be produced very quickly, the parts are very precise and consistent, and the process is particularly effective when the shape of the part is complex and/or the part contains many holes or internal cut-outs.

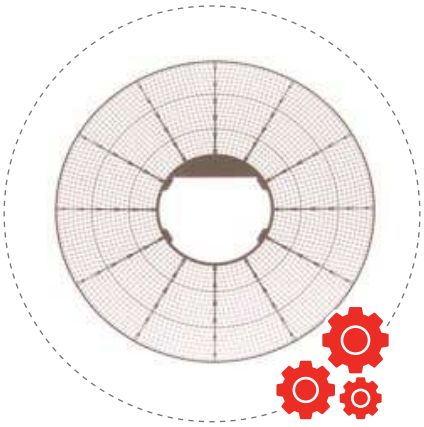


Industries Served

Applications for etched components range from aerospace, medical, and electronics to Christmas tree ornaments and scale models of railroads, villages and ships.

Aerospace Industry

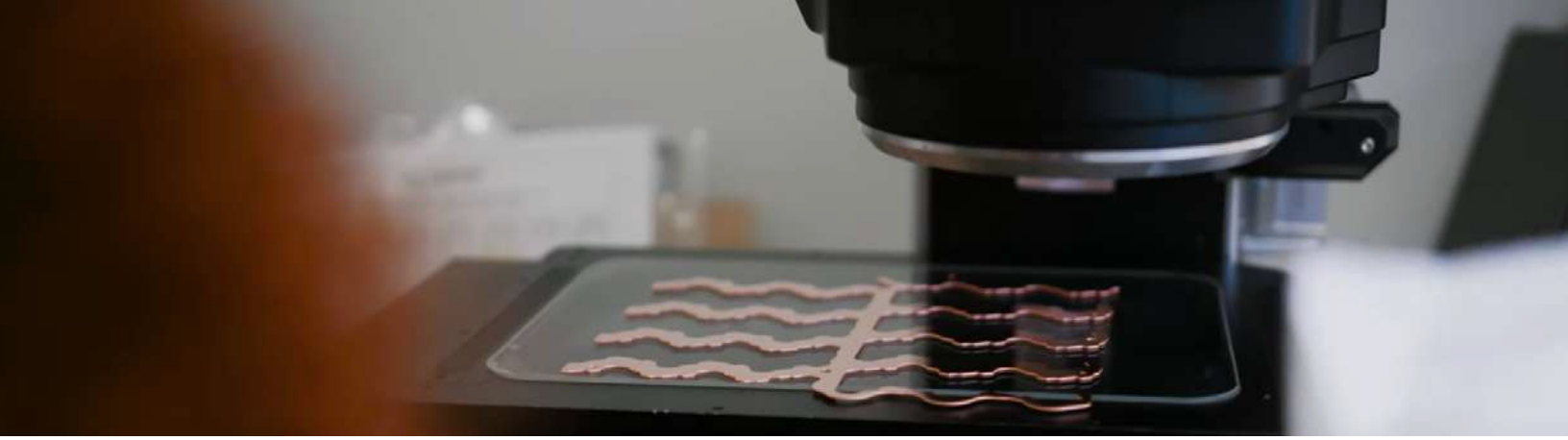
Photo chemical machining is used to produce components for many types of aerospace applications from airframe stiffeners and heat sinks to satellite batteries.



The ability to produce complex parts that are free of burrs and distortion in very thin gauges of metal is a key advantage of photo chemical etching.

Many aerospace components are produced in aluminum to save weight. Photo etching aluminum is challenging because it is a very reactive metal that readily oxidizes. (Aluminum hydroxide is a component of solid rocket fuel!)

Richard Huttinger, a metallurgist, developed a proprietary method for precision chemical milling of aluminum for jet engine components. Photo chemical machining is exempt from NADCAP because the process does not alter any of the properties of the metal.



Commercial & Military

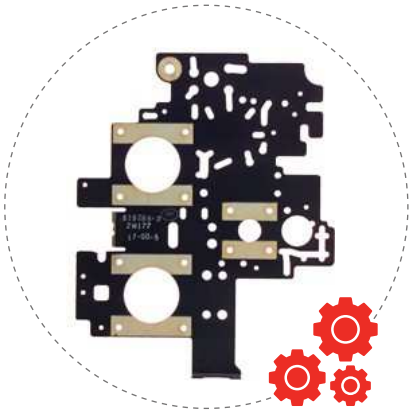
Photo chemical machining can produce photo-etched copper and aluminum circuit board heatsinks for commercial and military applications. Component-side heatsinks are photo chemical machined, precision drilled, conversion coated, dielectric epoxy coated and silk- screened. Where required, parts such as brackets, stiffeners and solder terminals can also be produced.

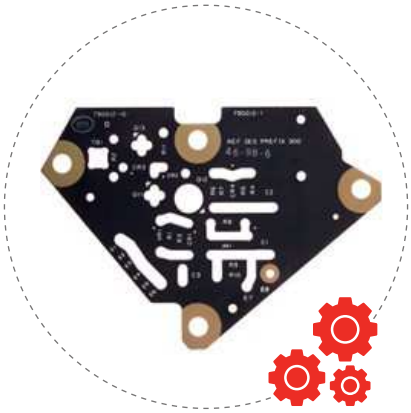
Heatsinks and other photo etched parts can be found in electronic engine controls, guidance and navigation systems and environmental systems of military and commercial aircraft, weapon systems, some U.S. Navy ships and NASA's Space Shuttle fleet.

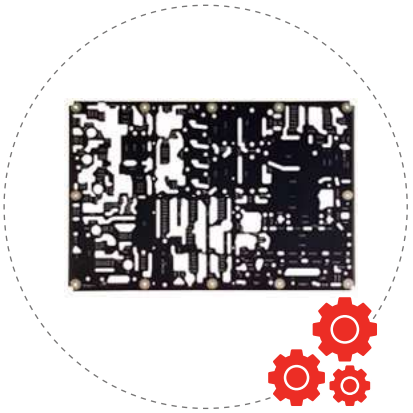
Photo chemical etching is a very effective solution for producing heat transfer and dissipation components that are used in applications including LED lighting, chilling systems, RF and microwave power circuits, as well as printed circuit boards.

Flexible heaters are produced from metal-clad insulating substrates into which the resistor heating element pattern is chemically etched. Resistor element alloys include stainless steel, copper and some nickel-copper alloys. Substrates may be may from rubber, silicone or polyamide materials.

Heatsinks vary greatly in size, shape and complexity.





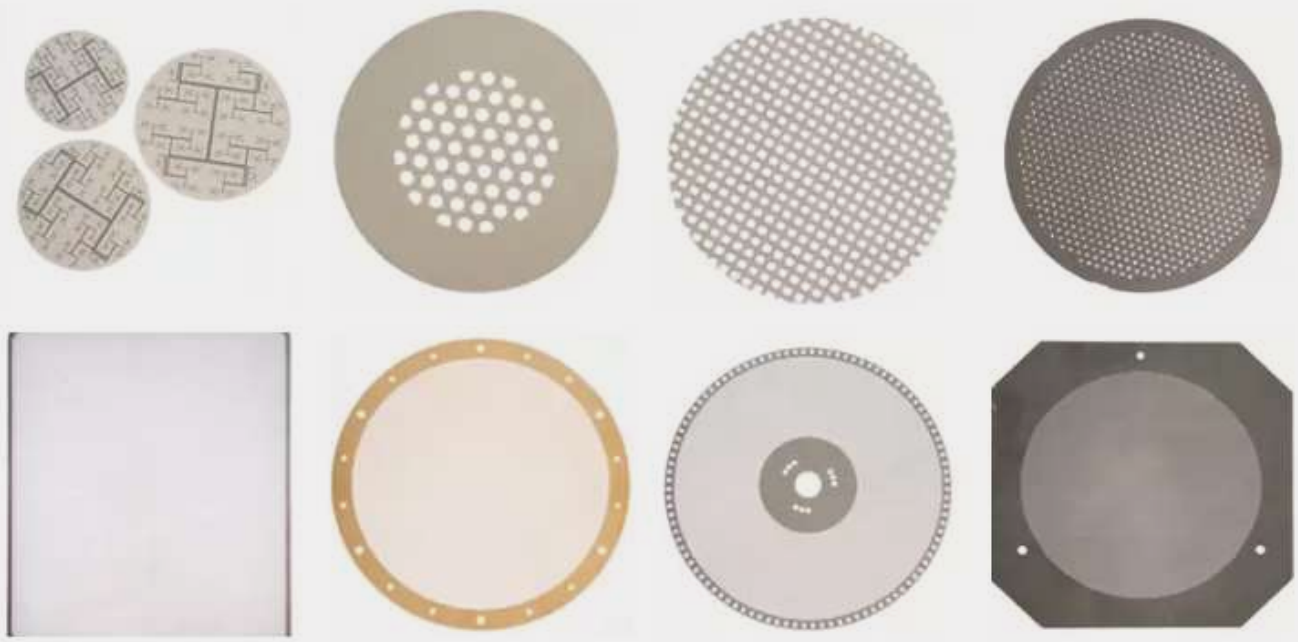


Industrial & Architectural Industry

Photo chemical etching is an ideal process for metal grids, screens, meshes, filters, separators, microfilters, grilles, lighting diffusers and other perforated metal applications.

The photo etching process produces consistent, burr-free holes as small as .004” in .002” thick material. As a general rule, minimum hole size is 110% of the thickness of the material, e.g. on .010” material, the smallest hole would be .011.”Unlike mechanical perforating methods such as punching, stamping or laser cutting, photo chemical machining of metal leaves the material free of burrs and induced mechanical or thermal stress or deformation.

Metal meshes can be photo etched in a wide variety of alloys including steel, nickel, copper, brass, aluminum and more. Holes can be made in a variety of shapes and sizes at no additional cost in tooling. Photo etched meshes, grids, filters and screens are used in many types of industrial, decorative and architectural applications. In many cases, chemical etching of metal meshes, grids, screens and filters provide better value and performance than woven or punched products.



Applications

Battery Plates

Rechargeable nickel metal hydride (NiMH) batteries are constructed using nickel as the positive node. The nickel electrodes, or cathodes, are grids or screens of varying configurations that are readily produced by photo etching. NiMH batteries are rapidly replacing NiCad because they do not contain toxic cadmium and offer better life cycle performance.

Deposition Masks

Very fine features can be created in stainless, moly and other alloys to allow pattern deposition for a number of electronics applications.

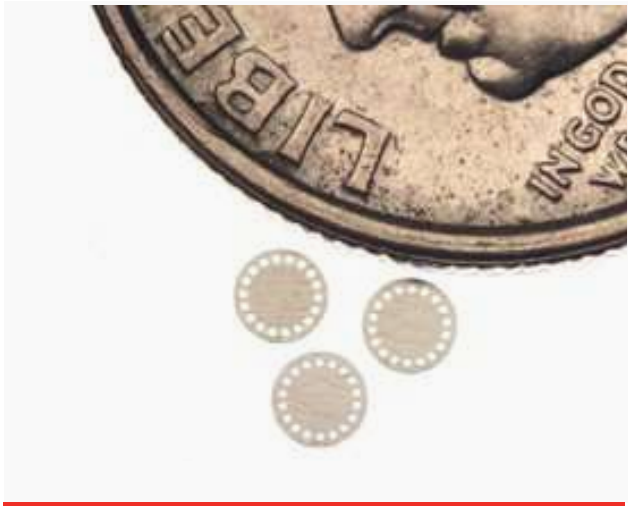
Filtration

Applications range from heavy gauge metal effluent filtration to extremely fine thin gauge filters and diaphragms for liquids and gasses in a variety of alloys including steel, copper, aluminum, nickel and molybdenum.

Mechanical

Photo chemical etching is exceptionally well suited to producing mechanical components such as shims, spacers, gaskets, pointers, dials, clips, diaphragms, springs, pressure membranes and many other applications.

Stainless Steel Shaft Locking Washers

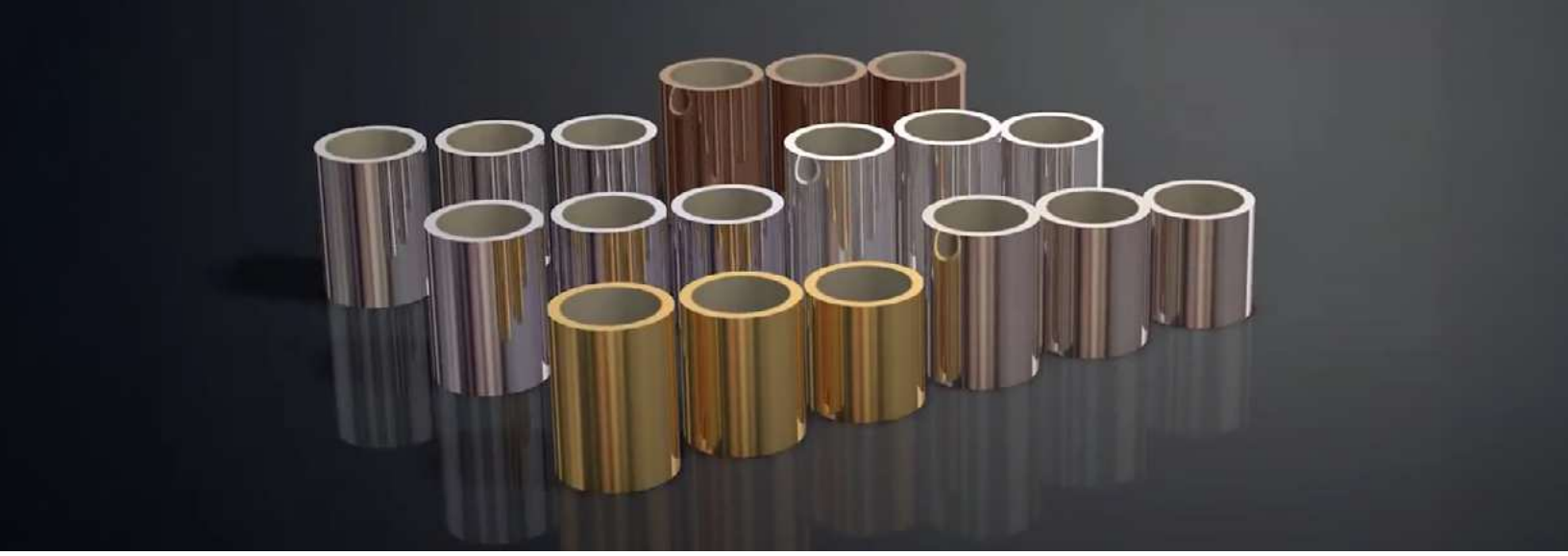


Stainless Steel Encoders 1/10 of an inch in diameter

Items with complex geometries (odd shapes, lots of holes, etc) are often far more cost effective to produce by photo chemical machining than by stamping, punching, laser cutting, or wire EDM.

In photo chemical machining, the part “emerges” from the metal all at once as the etchant simultaneously etches through all unmasked areas of the plate. CNC punching, laser and EDM affect only a small localized area at a time and the more complex the part, the more time it takes. From the simplest geometries to the most complex, chemical machining is a very cost effective solution for precision metal parts.

In photo etching, dimensional tolerances can be held as close as +/- 10% of the material thickness. Locational tolerances are to drawing nominals because there is no tool wear and the phototool is created directly from CAD data.



Medical and Dental Industry

Photo chemical machining is an ideal fabrication method for surgical and dental parts because it can produce very fine features and burr-free parts.

Many types of microsurgery blades are readily produced by photo etching as the inherent sidewall effect eliminates the need for further honing.

Photo chemical etching is also used to produce a variety of flexible sensors, detectors, and circuits that have medical applications.

High temp and high yield autoclavable stainless alloys. Photo etching is capable of producing very tiny parts at high precision.

Specialty Surgical Blades

Tissue Retractors for Ophthalmic Surgery

What is Half-Etching?

Half-etching allows the creation of features on one side of a part. Uses for half-etching include fold lines, channels, burst seams, part or serial numbers, instructions, decorative needs, patterning and graphics.

Etching Basics

- Minimum hole/slot dimension= 115% of material thickness
  Minimum radius = metal thickness
- Minimum land area = metal thickness

Tolerances

- Tightest dimensional tolerances are +/-10% of material thickness for metals under .010 ". For greater productivity and lower cost,+/- 15-20% is desirable.
- Locational tolerances are typically+/- .001"

Alloys and Gauges

- Ferrous alloys: up to .040 thick
  Cobalt content up to 27%
  Copper alloys: up to .063 thick
- Including brass, phosphor bronze, beryllium copper, copper nickel aluminum alloys: up to .080 thick
- Molybdenum: up to .040 thick
  Nickel alloys to .040

About Conard Corporation

Conard was founded in 1965 in Glastonbury, CT and has continuously specialized in Photo Chemical Machining (PCM) or chemical etching. The founder, Richard C. Huttinger, was a metallurgist and engineer who had previously worked for both Boeing and Pratt & Whitney. Huttinger developed a process to chemically mill the surface of forged aluminum propeller hubs for Pratt & Whitney. This process was more efficient and cost effective than conventional milling in the days before CNC machining was widely available.

Conard's early expertise in etching aluminum came to the attention of a major aerospace avionics company. Military and commercial avionics systems needed flat aluminum heatsinks to cool printed circuit boards. The heatsinks required detailed cutouts around each component. Photo etching was a cost-saving ideal solution, and flat heatsinks remain a significant part of our business today.

Conard is a Green Circle Award recipient from the Connecticut Department of Environmental Protection for consistently meeting and exceeding our environmental requirements. Conard has achieved registration under the AS9100/ISO9001 standards, in order to assure both existing and new customers that we are qualified to meet your requirements.

Conard has assisted hundreds of companies in developing applications for photo etching. We provide engineering and design support, rapid turnaround of prototypes, and engage in special development projects to help customers solve complex problems.

Contact Us

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