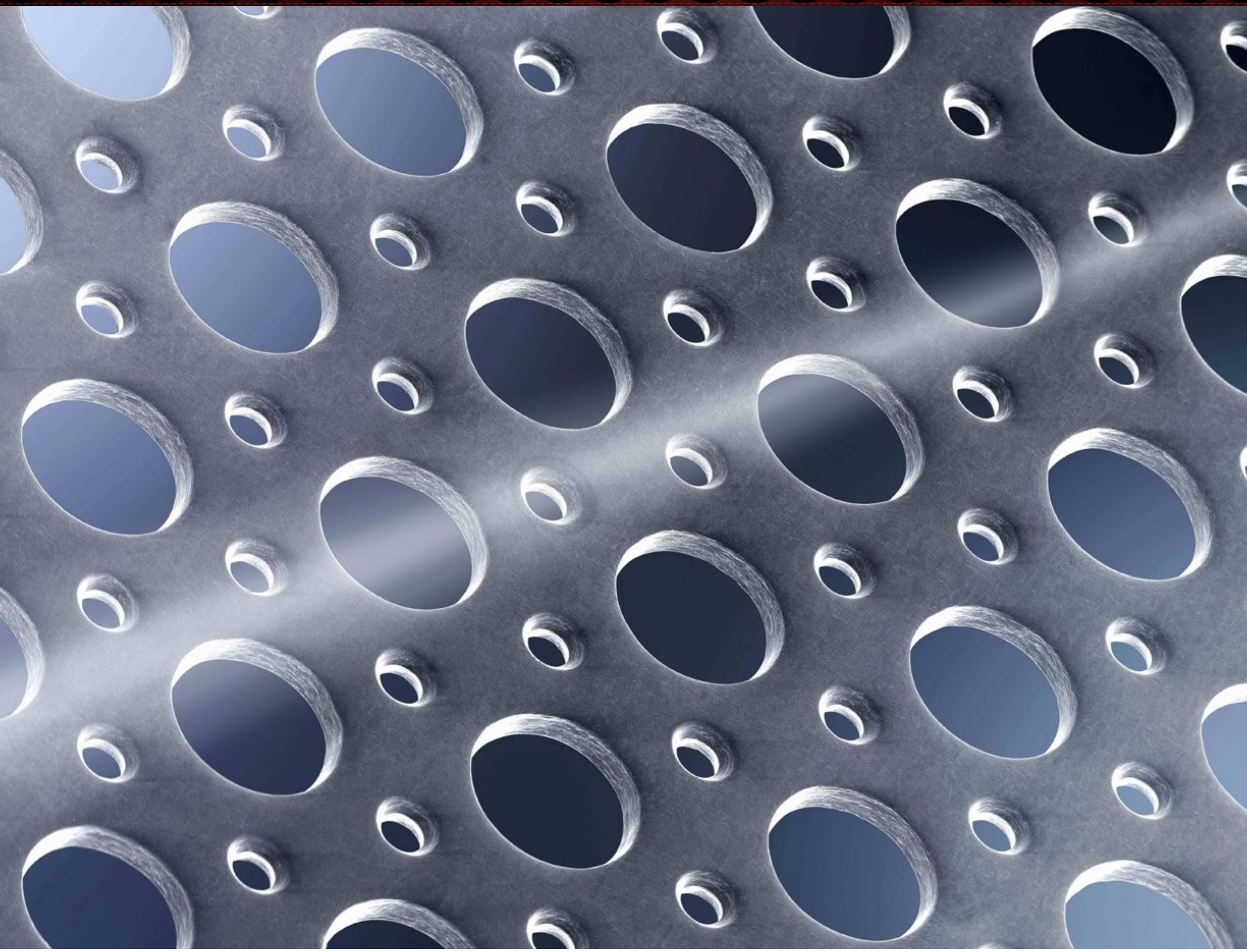
Design Considerations for Photo Etching

A Guide Presented by Conard Corporation



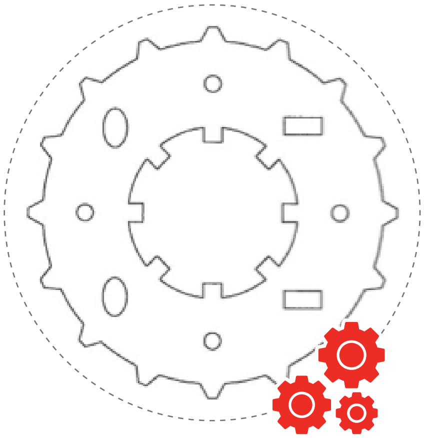
CONARD CORPORATION

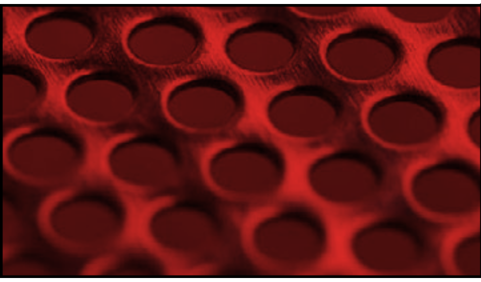
Precision Photochemical Manufacturing Since 1965

Design Considerations for Photo Etching

Educating designers and engineers about the capabilities of the photo chemical etching process is our constant task. Conceptually, it's alien to people who picture stamping and punch presses and laser, water, and plasma cutters for creating metal parts. Each process has its pluses and minuses, and in some aspects the capabilities have some overlap.

Using photo etching, the test part shown here is no more difficult or costly to make than a simple washer.





Etch Factor Compensation

Like other metal fabricating technologies, photo chemical etching requires adjustments of the nominal dimensions in order for the parts to come out the right size. In other processes, this may be referred to as tooling offset or a similar expression.

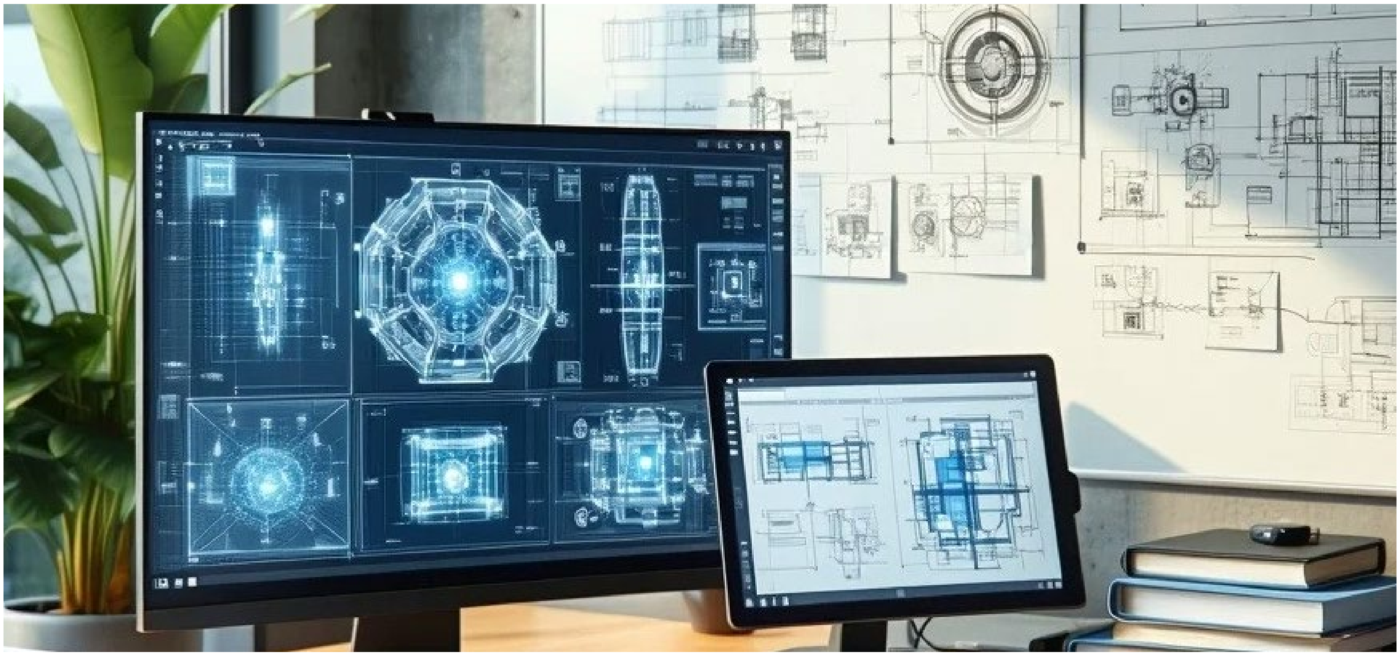
We refer to this adjustment as the “etch factor” and the process of applying the adjustment to the various dimensions of the parts as “compensation.” If we did not compensate dimensions, the outsides of parts would be too small and the insides of parts would be too big. In some cases, where the metal is thin enough and the dimensional tolerances are generous enough, it may not be strictly necessary to apply the etch factor; however in most cases, we do.

Just as the tolerance band and minimum feature sizes in photo etching are driven by metal thickness, so too is the etch factor. In its simplest expression, and assuming a 50/50 etch, the etch factor is thickness/2.

Let’s take the basic case of a washer. We will call the outside diameter 1” and the inside diameter .5 inches. If the selected metal is .010” thick, then we need to adjust the OD to be half the metal thickness larger, or 1.005”. And, similarly, the ID needs to become .005” smaller or 0.495” on the phototool. Continuing this example, if the metal thickness is.020”, then the compensated dimensions would be 1.010” and .490”, respectively.

Keeping in mind that the clear areas on the phototool represent the actual part, we also apply an “etch band” to the areas to be etched. Depending on the metal thickness and the parts, the etch band that is printed in black on the phototool may be from .020” to .050” wide. If a part has large areas of internal cut-outs, we may put an etch band around the cut out and let it fall out, rather than put all of that metal into solution.

Even though we start with the customer’s nominal data in the CAD file, the output on the phototool itself represents the process factors that are needed to produce the parts correctly as well as avoid putting metal into solution unnecessarily.



The 50/50 etch represents the majority of etching applications, and this method is the typical strategy. There are situations where the standard methods must be modified to suit an alternative etching ratio.

In the cases where an asymmetrical etching ratio (e.g., 60/40, 70/30, etc) is desirable, each side of the phototool must be compensated separately. In these cases, the etch factor is based on the fractional thickness of the metal, as if it were being etched from one side. So, in the example case of a 70/30 etch on .020” material, the 70% side (.020” x .7 = .014”) is treated as the equivalent of etching .028 material 50/50 from two sides. Therefore, the compensation would be .028/2 or .014. The same rationale applies to the minor side, treating .006 from one side as if it were .012 from two sides, or .006”.

Although most applications can be served effectively with formulaic solutions for compensation, there are a growing number of designs, especially with regard to semiconductor packaging, that bring additional complexities to the process of compensating for the etch factors. This is particularly true for the so-called “flat, no lead” microleadframes. The “FN” style leadframes, whether “quad” (QFN) or “dual” (DFN), require an heuristic approach to compensation, since the parts involve both partial and full thickness etching in different areas. What may be predicted by calculation, may not prove out in process. This leads to “measure, modify and make again.”

Metal Thickness and Tolerances

Another factor is the material thickness. Most stamping and CNC punching tend to avoid working with very thin materials because of material handling. Plasma and laser cutters are typically not very “thin” friendly due to the heat involved. Water jets avoid the heat problem, but the pressure can be a problem of shredding very thin metals. Although photo etching is practical for a wide variety of thicknesses, its greatest advantage is with the very thin materials, down to .0005”, although the typical range is from .001” to .032”.

Dimensional accuracy is also an important consideration. Fine blanking is the highest precision option in stamping and can achieve dimensional tolerances of as little as +/-1% of metal thickness, to a practical limit of about +/-.0003”. But the tooling can be very expensive. Photo etching typically runs about +/-15% of metal thickness, which still easily accommodates +/-.005” tolerances on materials up to .032” thick. Plasma cutters are reported to hold tolerances to +/-.015”, and lasers +/-.005”.

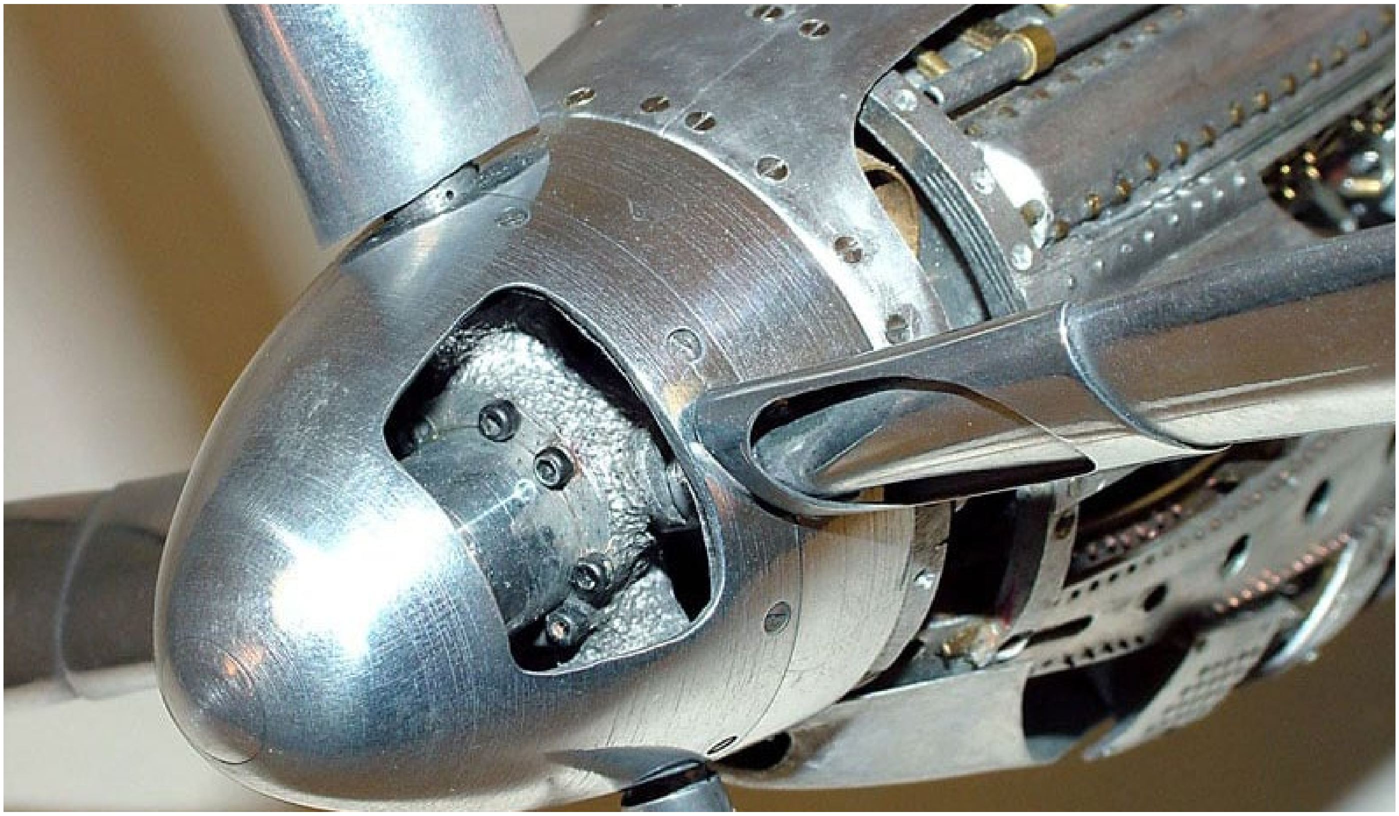
Maintaining Metal Integrity

Alteration of metal characteristics can be problematic in stamping and punching, as cold working can occur at the shearing points. Some alloys can be annealed afterwards, but many, like 300 series stainless steels, cannot be. Laser and plasma cutters impart intense heat and the metal adjacent to the kerf lines may be subject to embrittlement or other thermal distortions. Photo etching, which runs about as hot as your dishwasher (about 130F), poses no threat of inducing thermal or mechanical distortions.

Feature Size and Sidewall Characteristics

In photo etching, the metal thickness is the key determinant of feature sizes, minimum radius and dimensional tolerances. Through holes or slots must be at least 110% of the metal thickness. Minimum land area between through features should not be less than the metal thickness. And, in general, minimum radius is approximately equal to metal thickness.

Another feature of chemical etching is the sidewall. The etching process occurs from both sides of the sheet, and as the etch depth increases the side wall slopes away from the etch line at the rate of .00025” per .001” of depth. This creates a slightly hexagonal cross section with a small feature we call the “feather” at the breakthrough point.



Design Freedom and Flexibility

Simplifying complexity is perhaps one of photo etching's greatest advantages. The process is utterly indifferent to odd shapes, multitudes of holes or other less ordinary features. Photo etching can produce part geometries that would be extremely difficult, if even possible, with stamping or punching. Laser and plasma cutting are more flexible in this regard; however, every feature and every hole must be addressed in a linear way, as if tracing with a pencil.

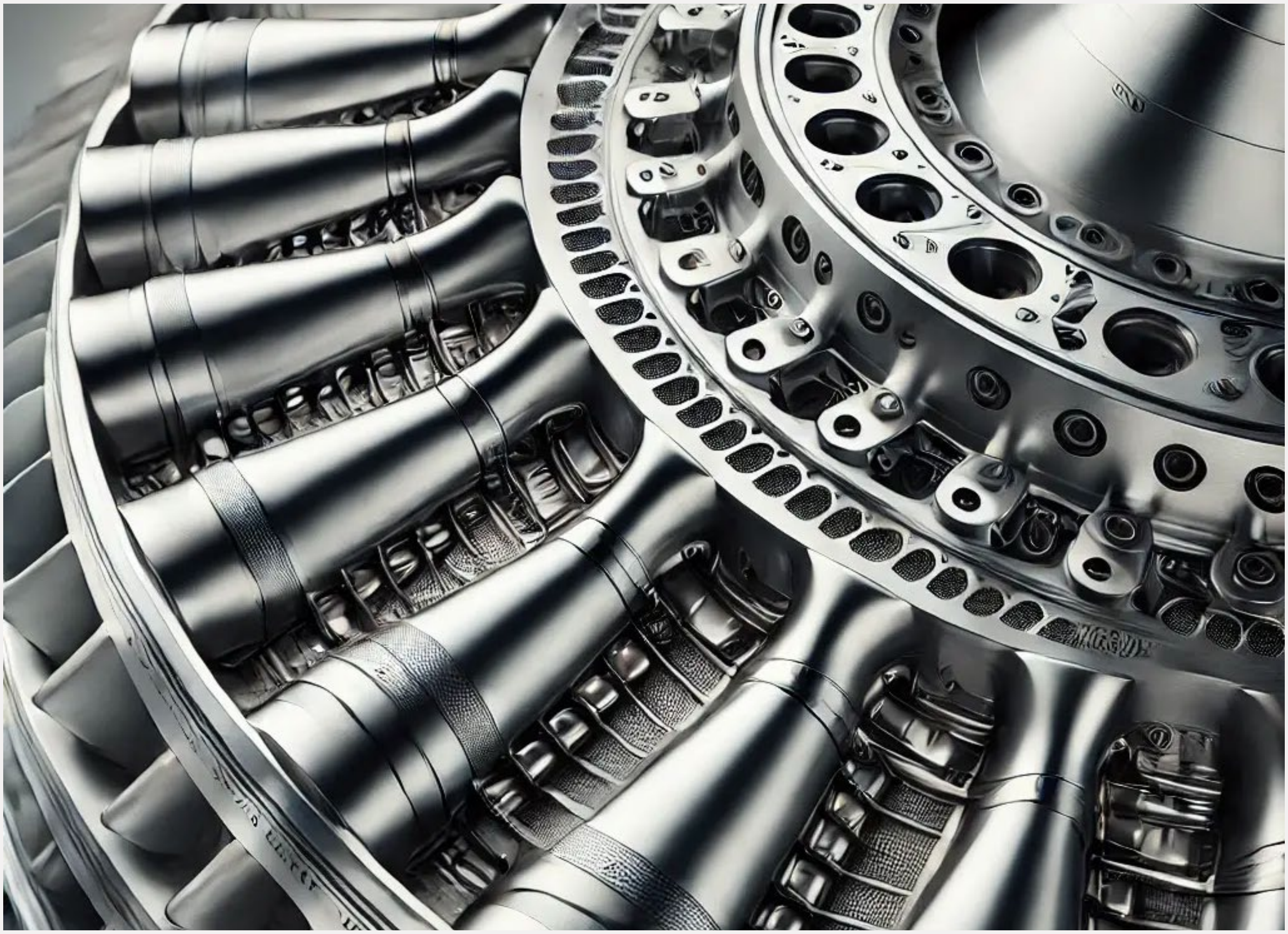
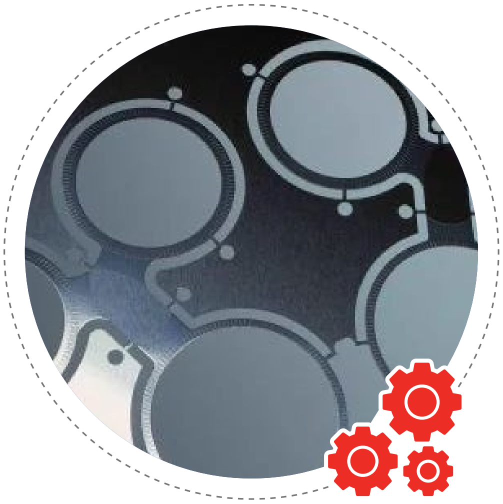


Photo Etching ABCs

2-Minute Video of the Photo Etching Process



The basics of the process include creating the photomask, which today is derived from CAD data and output on film from a laser photoplotter. This is known as the phototool. The metal to be etched is carefully cleaned and coated on both sides with a polymer film called photo resist. When applied, the photoresist film is unexposed and this must be done in a yellow safe-light environment.

The coated metal and the phototool come together in the imaging process where the black regions on the phototool prevent the exposure of the resist under intense UV light. The unexposed resist is washed away in a developing solution, leaving bare metal in the areas to be etched.

In the etching process, the exposed photoresist is strong enough to withstand the effects of the ferric chloride etchant. But the unprotected metal is dissolved right up to the edge of the resist. The etchant is sprayed at both sides of the sheet until cut through is achieved. After etching, the resist is washed away in a different solution.

Photo Etching Versus...

So, just by thinking about the processes, you can easily see the differences. Stamping and punching are sort of "brute force" processes, shearing the metal using powerful presses. Plasma, laser and EDM rely on intense energy, literally burning their way through metal. Waterjet is sort of the "hot knife through butter" option, but you definitely wouldn't want to get in the way of a pressurized stream of water that can cut through an inch of steel!

Photo etching, in contrast, would be like running a sheet of metal through your dishwasher and then taking out a sheet of parts.

So, what can you do you with chemical etching? You can make very thin metal parts, as thin as .0005" (yes, five ten-thousandths). You can make fairly thick parts: up to .040" in ferrous alloys, .065" in copper alloys, and .080" in aluminum. You can make parts with funny shapes and lots of holes and it doesn't cost any extra. You can make some very little parts, as small as .020" diameter. And, you can make some fairly big parts, up to 24" x 56".

Chemical etching is used for fabricating metal parts for many different industrial applications including sensors, shields, retainers, flat springs, strain gauges, filters, screens, grids, shims, gaskets and more. For electronics, etching is used to produce a host of metal components used in RF, microwave and wireless applications, as well as lids and leadframes for semiconductor packaging. Photo etched direct bond copper is increasingly used in power electronic applications, particularly in wireless devices. It is also used to produce a host of electrical contacts, bus bars and other electrical interconnect devices. Decorative etching is widely used for giftware, jewelry, scale models, architectural, and ornamentation for apparel.

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 turn around of prototypes; and engage in special development projects to help customers solve complex problem.

Contact Us

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