

CHEMICAL ETCHING
CAPABILITIES & DESIGN GUIDE

**DELIVERING PRECISION
MANUFACTURING FOR FINE-
FEATURED METAL PARTS**

ENNOVITM

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1.0 Overview

ENNOVI has a long history as a pioneering leader in advanced photochemical machining, offering a suite of chemical etching capabilities designed for industries where precision, repeatability, and design freedom are non-negotiable.

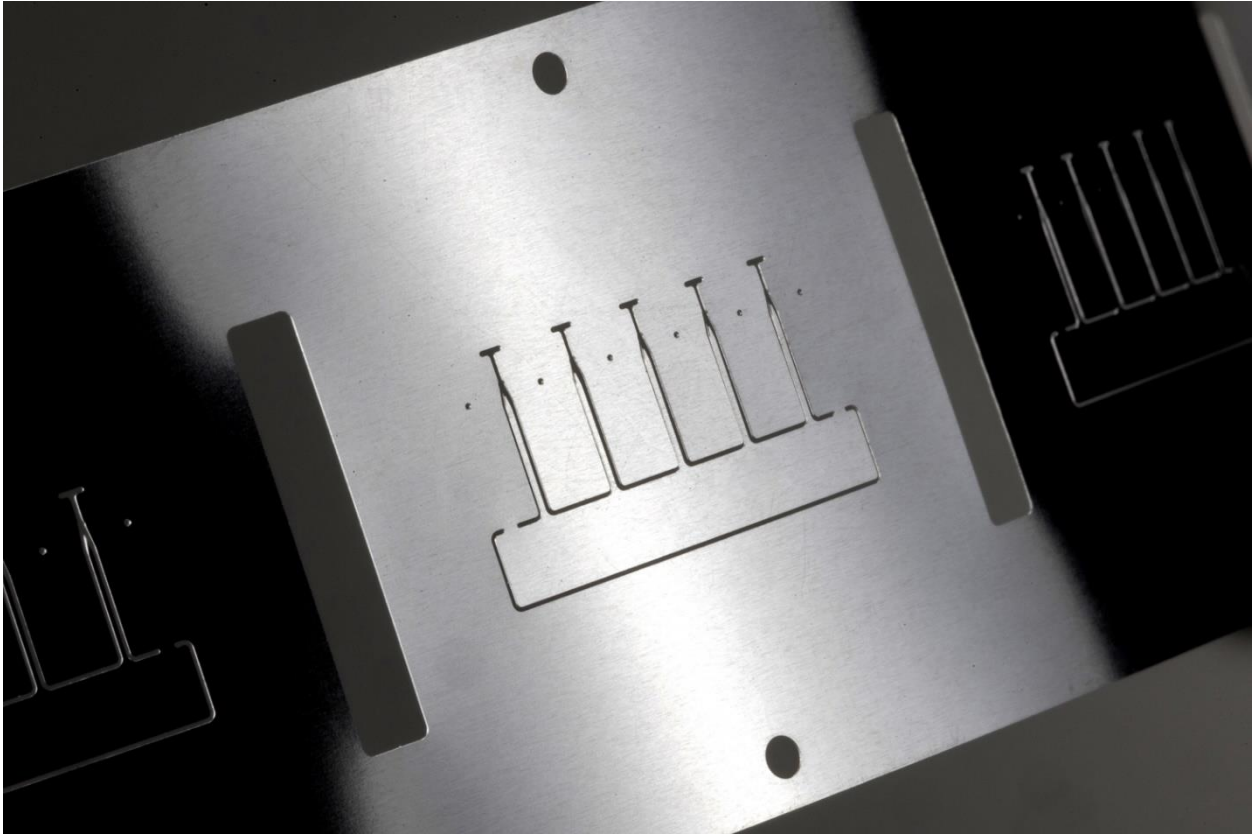


Figure 1 – Fine-featured metal components produced using ENNOVI's reel-to-reel photochemical etching process.

Using an approach that blends proprietary reel-to-reel processing, rigorous process control, and deep materials expertise to deliver intricate metal components at scale, without the limitations of traditional stamping or laser cutting.

2.0 Overview of ENNOVI Reel-to-Reel Process

ENNOVI uses a reel to reel photochemical etching process, sometimes called chemical stamping or photochemical machining, to produce intricate thin metal parts on a continuous strip.

This approach supports strip widths up to 288 mm, metal thicknesses from 0.02 mm to 0.50 mm, and reel lengths up to 300 meters, enabling both prototyping and production on the same platform. The end-to-end, turnkey process combines cleaning, lamination with photoresist, high precision pattern exposure, etching, inspection, and sealed cleanroom packaging into an integrated, in line flow.

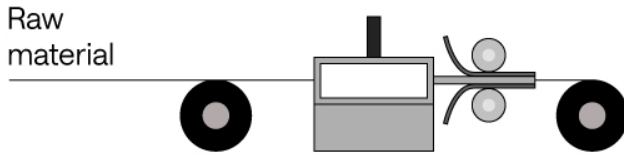
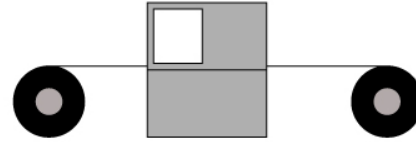
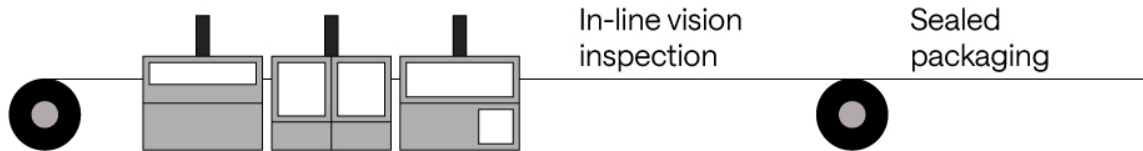
Step 1. Cleaning & Lamination**Step 2. Pattern Exposure****Step 3. Develop, Etch, Strip Line****Step 4. Inspect & Package**

Figure 2 – ENNOVI's reel-to-reel photochemical etching process integrates cleaning, imaging, etching, inspection, and packaging in a single controlled flow.

2.1. Core strengths and technical performance

ENNOVI's chemical etching process uses photosensitive films and controlled chemical corrosion to remove metal with extreme accuracy. This subtractive method enables the creation of complex geometries that would be difficult or impossible to achieve with mechanical tooling.

Key benefits include:

- + **Precision and repeatability:** The reel-to-reel approach holds very tight tolerances for small feature sizes, with selectable tolerances down to about $\pm 5 \mu\text{m}$ and highly consistent results across long runs.
- + **Burr-free, stress-free parts:** Because material is removed chemically rather than mechanically, edges are burr-free and base material properties, including hardness and temper, are preserved, which is difficult to achieve with conventional stamping.
- + **Complex geometry options:** ENNOVI's proven phototools allow almost unlimited 2D geometries and finely pitched features, including "unstampable" shapes, ultra-fine slots and holes, and sophisticated half-etch patterns that create 3D features such as channels, retention pockets, and blade edges.
- + **Cleanliness and quality:** Etching and exposure occur in ISO 5 cleanrooms, with the product outputs moving into ISO 7 cleanrooms for inspection and sealed packaging, resulting in metallurgically clean parts suited to high-reliability environments.

- + **Rapid time-to-market:** Photo masks replace hard tooling, enabling fast design iterations and lower prototyping costs.



Figure 3 – Photochemical etching enables tight tolerances, consistent fine features, and burr free edges without mechanical stress.

2.2. Materials and Process Design Envelope

ENNOVI's etching facilities routinely process a wide range of alloys, including stainless steels (300 and 400 series), spring steels, copper and copper alloys, brass, phosphor bronze, Be copper, Invar, Kovar, nickel and nickel alloys, and other low expansion and high permeability alloys.

Typical design rules link feature sizes and tolerances directly to stock thickness: overall tolerances are about $\pm 10\%$ of thickness t , and minimum opening sizes (holes, slots, gaps) are commonly specified around $1.2 \times t$ to maintain edge quality and process robustness.

Strip width can be used as a cost lever; filling more of the available ~ 288 mm width with nested parts reduces cost per piece because line runtime dominates cost more than strip width does.

Key Specifications:

Capability	Specification
Minimum thickness	0.0008" (0.0203 mm)
Maximum thickness	0.0200" (0.508 mm)
Minimum feature size	1.1 × material thickness
Maximum part width	12" (300 mm)
Maximum part/reel length	1,000' (300 m)

ENNOVI's fully computerized control system manages 160+ chemical and process variables in real time, ensuring uniformity and repeatability across every batch.

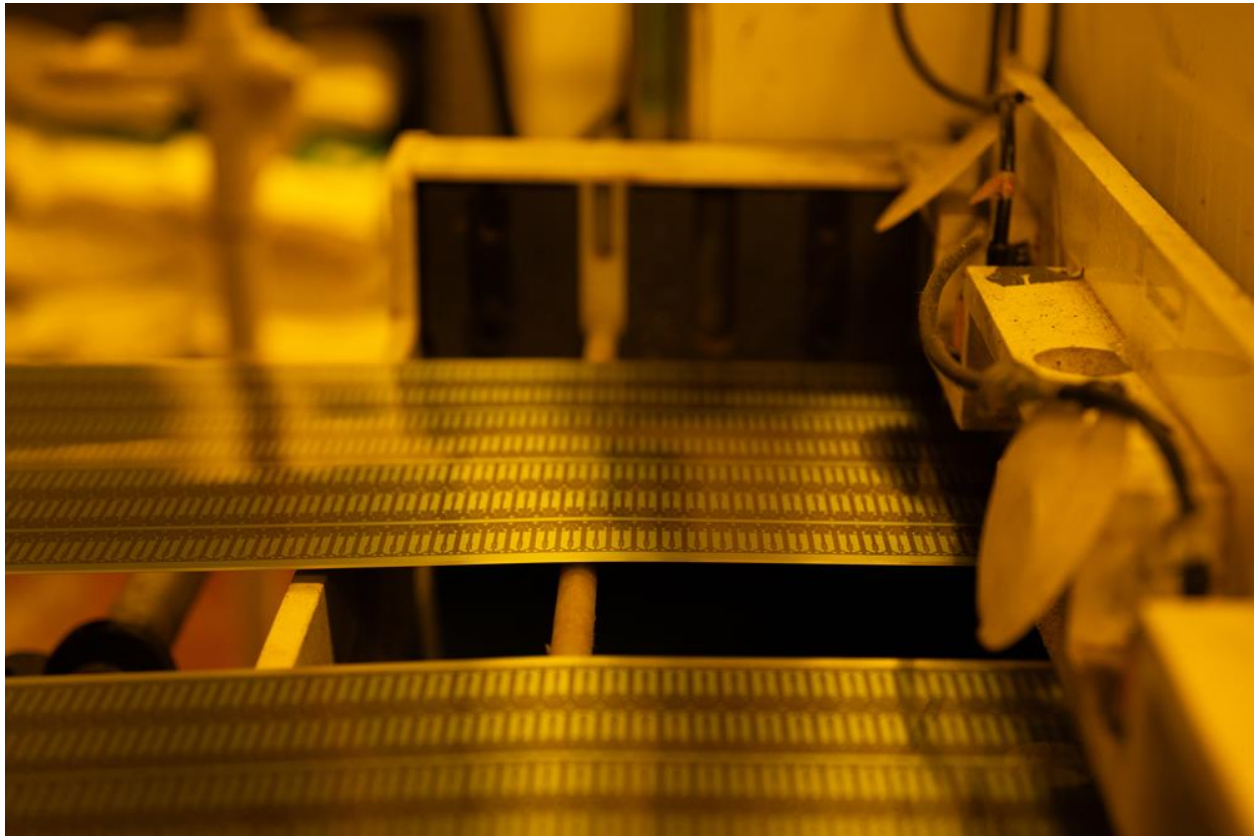


Figure 4 – Lamination and exposure are performed in ISO certified cleanrooms with inline vision systems monitoring key quality parameters.

3.0 Why Chemical Etching Matters in Modern Manufacturing

Chemical etching has become a preferred method for producing thin-metal components with complex geometries. Compared to stamping or laser cutting, it offers:

- + Lower tooling costs
- + Faster prototyping
- + No heat-affected zones
- + No mechanical stress
- + Simultaneous etching of multiple features without added cost

This makes it especially attractive for high-density designs such as filters, screens, sieves, and lead-frames, where traditional machining is cost-prohibitive or technically limiting.

3.1 Advantages Over Alternative Processes

Compared with panel/sheet etching, ENNOVI's proprietary reel to reel lines reduce manual handling by combining many processing steps in line, stabilizing conditions over long runs, and supporting in line vision inspection, improving yields in production.

Versus stamping, chemical etching offers much lower and complexity independent tooling costs, faster time to market (production ready parts in under six weeks), along with the ability to realize much finer, denser features without burrs.

Customers can also adopt hybrid strategies: using etching for complex, fine feature blanks and then feeding those blanks into progressive stamping, molding, plating, or assembly lines, which is especially powerful during early program phases.

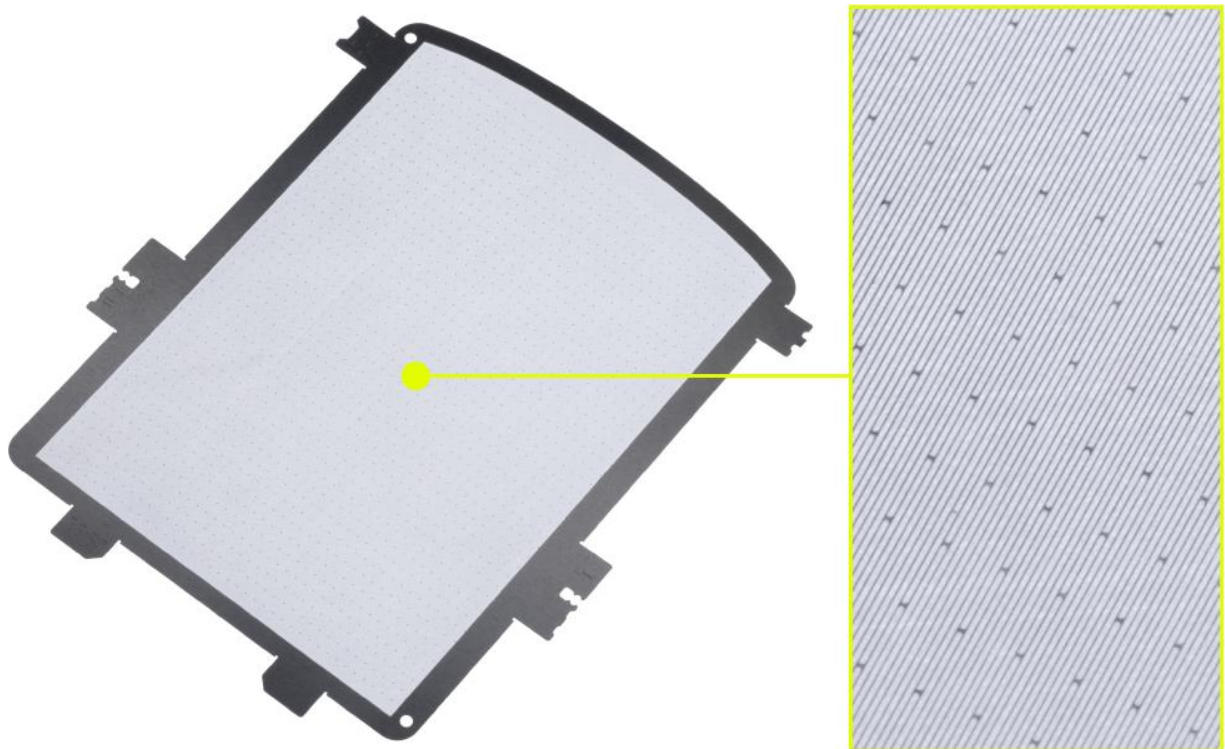


Figure 5 – Chemical etching enables finer features such as fuel injector filter screens and oil control valve filters and other mesh filters.

4.0 Applications Across High Performance Industries

ENNOVI's chemical etching supports components that require ultra fine features, tight tolerances, and high repeatability — making it ideal for:

- + Micro components
- + Mesh filters
- + Medical sharps
- + Print heads

These parts often include intricate apertures, ultra fine pitches, and complex 3D profiles that benefit from the design freedom provided by chemical etching.

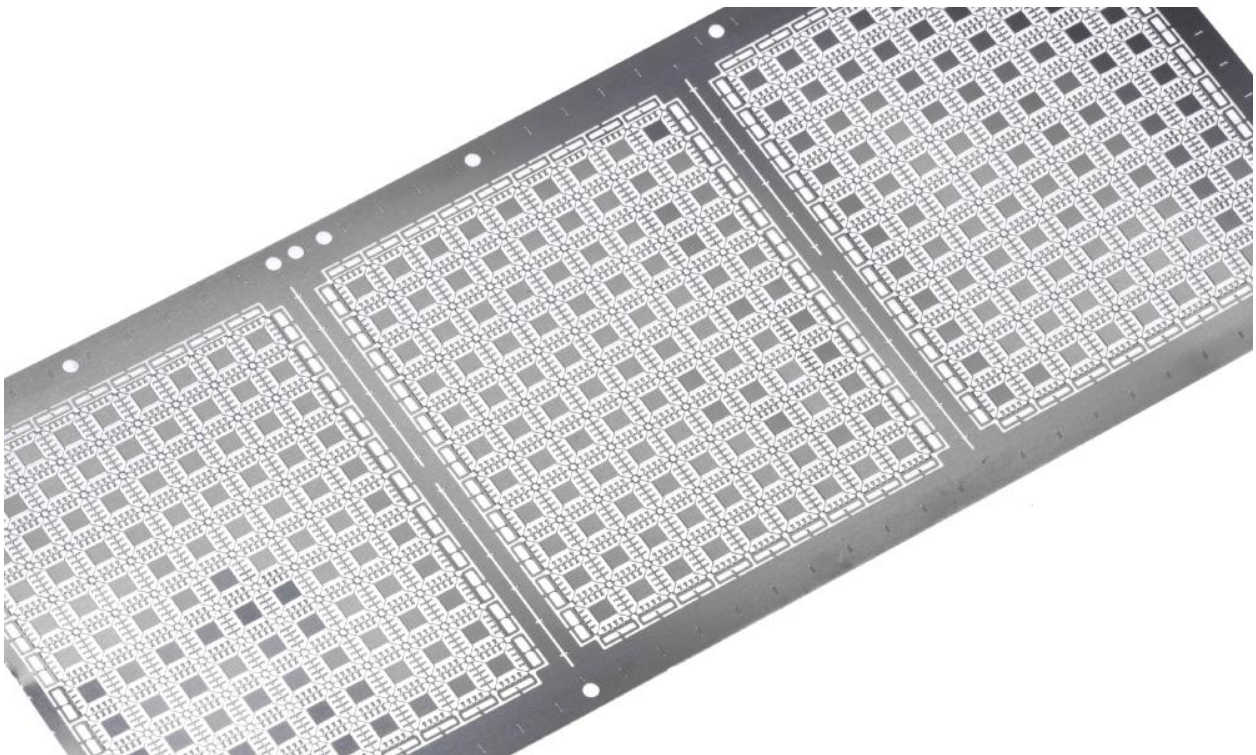


Figure 6 – Example of a semiconductor QFN lead-frame made using the chemical etching process.

4.1 High value applications

ENNOVI's chemical etching underpins advanced solutions across automotive, medical, filtration, and micro-component markets.

In automotive powertrain and mobility, etched filters and bands support variable valve timing and valve-body oil filtration, while high-precision components such as springs and sensor parts benefit from burr-free edges and tight tolerances.

In medical and life-science applications, ENNOVI supplies very high-volume etched sharps for continuous glucose monitoring and other devices, leveraging cleanroom processing and the ability to form and mold etched reels into finished assemblies.

Half-etched micro-channels are increasingly used to build stacked manifolds for fluid control, inkjet and other printheads, atomization systems, and liquid-cooled heat sinks for large AI chips, where fine, repeatable channels improve thermal performance and flow behavior.

The same capabilities support lead-frames and QFN packages with half-etched retention features for robust over-molding, as well as micro-components and “unstampable” geometries that require ultra-fine traces or apertures.

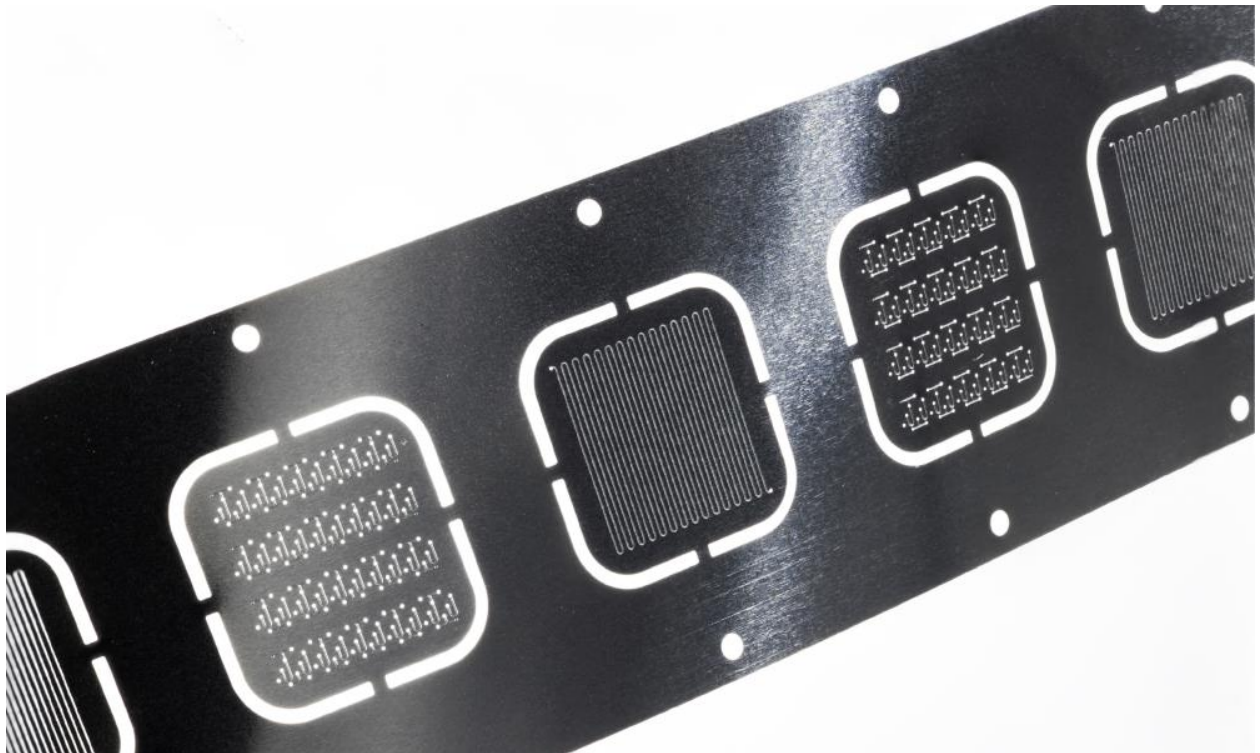


Figure 7 – Half-etching enables functional 3D features such as microchannels and retention pockets.

5.0 Quality, scalability, and collaboration

ENNOVI’s etching operations run under ISO 9001:2015, IATF 16949:2016, and ISO 14001:2015 certifications, backed by in line vision systems, a flat line process control system monitoring over 160 parameters in real time, and high throughput automated optical inspection.

Reel to reel lines are engineered to support both rapid prototyping and sustained high volume output, enabling customers to qualify designs quickly and then scale without changing core processes.

Because chemical etching sits within a broader ENNOVI capabilities stack—including design services, plating, molding, stamping, and other advanced manufacturing processes with global presence and localized support, customers can collaborate end to end, from early design and design for etching guidance through to finished, assembled, and tested products for automotive, medical, and other high reliability sectors.



Figure 8 – Automated process control systems monitor over 160 parameters in real time.

6.0 Summary

ENNOVI's combination of advanced photochemical processes, proprietary reel to reel systems, and rigorous process control positions them as a high performance partner for manufacturers seeking:

- + Consistent quality at scale
- + Rapid iteration cycles
- + Complex geometries without tooling constraints
- + Burr free, stress free metal components

In industries where microns matter, ENNOVI delivers precision chemical etching processes that provide rapid prototyping and smooth production scaling; enabling engineers and product teams to push the boundaries of what's possible in metal component design.