ENNOVI™

CUTTING TOOL ENGINEERING®

Media outlet: Cutting Tool Engineering

Date of publication: March 30, 2026

How Reel-to-Reel Photochemical Processing Supports Complex, High-Performance Part Design

By Mark Bowden, General Manager and Plant Manager at ENNOVI (formerly known as Interplex)

Precision manufacturing is evolving rapidly, and engineers now face two main challenges: miniaturization and the creation of more complex geometries. As components in cars, medical devices, and electronics get smaller, traditional methods like stamping and machining often reach their limits. When designs need tiny channels, fine meshes or smooth edges on thin metal, mechanical methods can cause stress, deformation or high tooling costs that slow innovation. To address these challenges, many manufacturers now use photochemical etching, a process that uses controlled chemicals to shape metal with high precision.

The Evolution of Micro-Manufacturing

Chemical etching, sometimes called industrial etching or photochemical machining (PCM), removes material with temperature-controlled chemicals to create specific shapes and patterns. This method enables the production of detailed designs that stamping cannot achieve while preserving the metal's original properties. Because it avoids the stress of punch-and-die methods, etching keeps parts flat, stress and burr-free, which is essential for high-performance applications where even tiny flaws can cause problems.

Chemical etching can be done on sheets or panels, but the most advanced version is reel-to-reel photochemical etching. This method uses a continuous metal reel and offers clear advantages over batch processing. Reel-to-reel processing combines multiple steps into a single continuous system, significantly reducing manual handling and the risk of defects.

Reel-to-reel etching is well-suited to automation because the parts remain attached to a continuous strip. This allows them to proceed directly to other automated steps, such as forming, plating, molding and assembly. This setup lowers manufacturing costs and keeps parts aligned for later steps. Also, continuous operation helps the equipment remain stable, which means tighter tolerances and more consistent results than stop-and-start sheet processing.

Inside the Process: From Cleaning to Etching

Making a high-quality etched part starts with careful preparation. A reel of thin metal, usually between 0.02mm and 0.5mm thick, passes through a cleaning line. This step is important because any dirt or residue can affect how well the photoresist sticks, which could cause defects. The metal is cleaned in several stages, including chemical and electrolytic cleaning, water rinses, acid activation, and final hot-air drying to ensure a spotless surface.

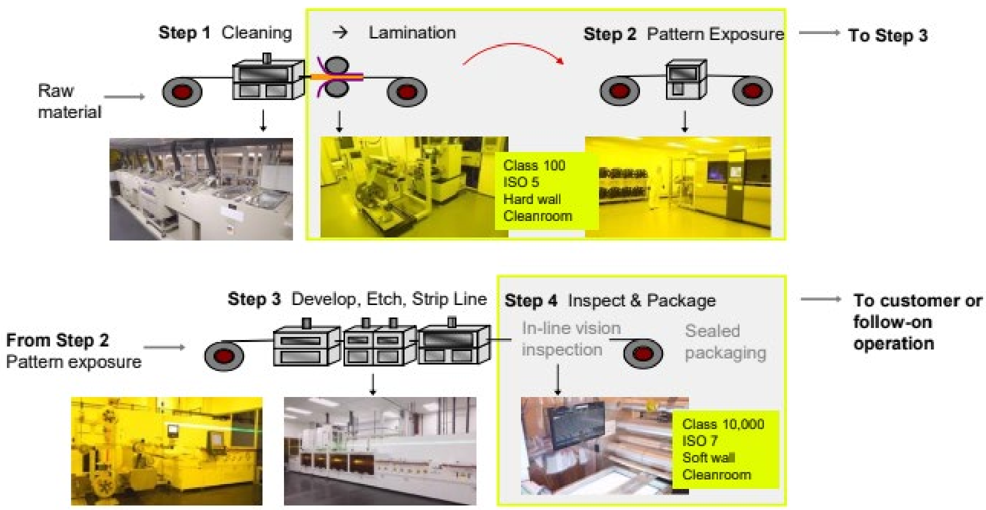

Figure 1. Overview of ENNOVI's reel-to-reel etch process flow

After cleaning, the metal is transferred to an ISO 5 Class 100 cleanroom for lamination. A dry photosensitive film, also known as a photoresist film, is applied to both sides of the metal simultaneously under heat and pressure. This photoresist acts as a protective layer that shapes the part. Next, the metal is placed between two glass photomasks, which hold the negative image of the part. High-intensity ultraviolet light then flashes through the masks, hardening the photoresist where it needs to stay. Using glass photomasks in this setup keeps alignment within 5 microns, which is needed for today’s tiny components.

After exposure, the metal is developed in a solution that removes the unexposed photoresist, revealing the bare metal for etching. The strip then moves into the etching chambers, where chemicals are sprayed onto both sides at once. Advanced systems, such as those used by ENNOVI, employ titanium chambers that withstand high temperatures and pressures to deliver better results. The process removes excess metal to achieve the final shape. At the end, the remaining photoresist is removed, and the parts are rinsed, dried and inspected.

Unlocking “Unstampable” Geometrics and Micro-Features
Engineers often choose chemical etching because it can make features that stamping cannot. Since it uses liquid chemicals instead of mechanical punches, it is not limited by the same physical restrictions. This means it can create holes, slots and webs almost equal to the material’s thickness, as well as complex shapes like hexagons or ovals that would be too expensive to produce with a die.

Figure 2: High-volume ‘unstampable’ products can be produced economically using chemical etching

One special feature of this process is "half-etching," in which material is removed from only one side of the metal to a set depth. This enables manufacturers to create detailed 3D features such as grooves, microchannels for fluid flow, and pockets for parts. It is also used to make tabs that hold the part during processing, but can be broken off easily later. Half-etching produces sharp edges and tips, such as those required for medical needles, without requiring additional grinding or sharpening.

Making micro-channels with half-etching also enables new solutions for thermal management and fluid control. For example, engineers can build complex manifolds by bonding layers of different metals, each with its own etched channels. This method enables the fabrication of liquid-cooled heat sinks for powerful AI chips or tiny fuel nozzles, with internal geometries that cannot be fabricated from a solid block.

Precision Control and Cleanroom Manufacturing

To achieve tolerances as tight as ±5μm, the process needs strict control. Top etching facilities perform key steps such as lamination and exposure in ISO 5 (Class 100) cleanrooms. This high level of air purity, with approximately 300 air changes per hour, keeps dust off the photoresist and prevents defects. Even the end of the etching line, where finished parts exit, is often in ISO 7 (Class 10,000) cleanrooms to keep parts clean during packaging.

Modern etching lines use computerized systems to monitor over 160 variables in real time. Parameters such as etchant temperature, spray pressure, conveyor speed, and chemical levels are continuously adjusted to maintain consistency. In-line automated optical inspection (AOI) systems scan thousands of features per minute to ensure every part of the strip meets required tolerances. This mix of clean environments and digital process control ensures repeatable results, which is vital for automotive and medical device manufacturers that need zero defects.

Accelerating Development with Low Tooling Costs

Traditionally, moving from a prototype to a production-ready stamped part can take months and cost tens of thousands of dollars in tooling. If the design changes, the die must be modified or replaced, which adds additional time and cost. Chemical etching changes this. The tooling here consists of high-resolution glass photomasks, which can be fabricated quickly and typically cost less than $6,000.

This low cost makes it easy for engineering teams to test and change designs quickly. A project can go from idea to production-ready parts in under six weeks. For new or untested products with uncertain demand, etching is a low-risk way to get to market. Manufacturers can produce prototypes using the same reel-to-reel process as mass production, ensuring test data is accurate. If demand grows, the process can scale up easily. Sometimes, companies switch to stamping for very high volumes, but etching often stays the best choice because it is flexible and precise.

Diverse Material Applications

Chemical etching is also very versatile in the types of metals it can handle. It works with many materials, including stainless steels (300 and 400 series), copper and nickel alloys, and special metals such as Invar® and Kovar®. Since the process does not alter the metal's hardness or magnetic properties, it is well-suited for pre-hardened spring steels and magnetic alloys that are difficult to stamp without damage.

This material flexibility enables chemical etching in many important applications. In cars, etched filters are replacing woven-wire mesh in systems such as variable valve timing and transmissions. These filters are strong, one-piece parts that do not fray and can have custom hole shapes to improve fluid flow and filtration.

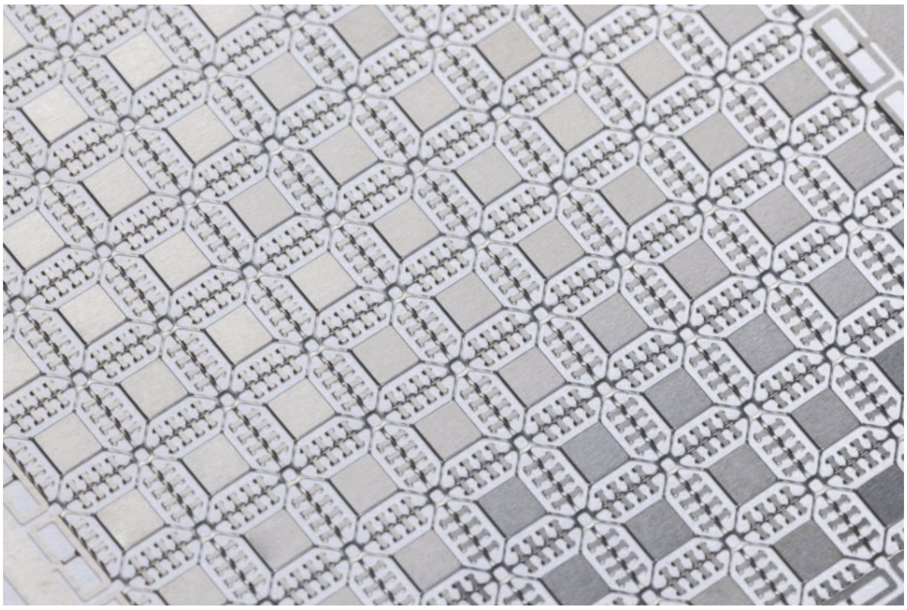

Figure 3: IC lead frames and QFN packages take advantage of ENNOVI's half-etch capability

In medical devices, etching is used to make grids, electrical contacts and very sharp needles for glucose monitors. The burr-free finish is important for patient comfort and device reliability, reducing the need for additional processing. Chemical etching is also used in high-tech fields to make precise lead frames for chips and detailed nozzle plates for industrial printers, where features are measured in microns.

Conclusion

Chemical etching has grown from a niche prototyping method into a key manufacturing solution for high-performance metal parts. With the efficiency of reel-to-reel processing, clean ISO-certified environments, and the design freedom of photochemical machining, engineers can now make parts that traditional methods cannot. Whether making tiny fluid channels, precise filters or burr-free medical sharps, this technology combines speed, accuracy and scalability. As devices get smaller and more complex, chemical etching will become even more important in precision manufacturing.

About the Author

Mark Bowden is the General Manager at ENNOVI Etch Logic. With nearly two decades of early experience in the spring and stamping industry, he joined ENNOVI (formerly known as Interplex) 25 years ago and has since helped build its Etching division into a thriving business unit. His expertise in Sales Engineering and Estimation continues to guide innovation in precision photo-chemical etching and advanced packaging solutions.
https://www.linkedin.com/in/mark-bowden-05619115/