Raydiance
Precision Like No Other

White Paper

Catalogue of Precision

Material gallery of one step micro machined features

Introduction

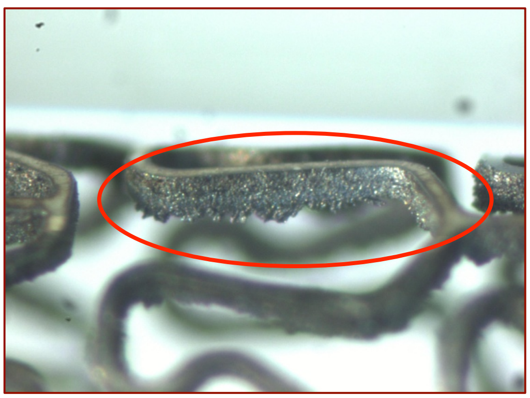
Raydiance micro machining solutions are changing the technology and economics of precision manufacturing. Using femtosecond technology based on a fiber architecture and with integrated pulse management, Raydiance has developed an industrial grade femtosecond laser platform. Raydiance solutions remove material from precision parts without generating any heat, which would otherwise damage the part and require multiple post process steps to reverse the thermal damage. This heatless machining produces finished parts in a single process, dramatically reducing the time and cost of manufacturing, while also improving the quality and consistency of the part. This paper features an overview of Raydiance machining capabilities and a few examples of the precision possible with heatless, single step micro machining.

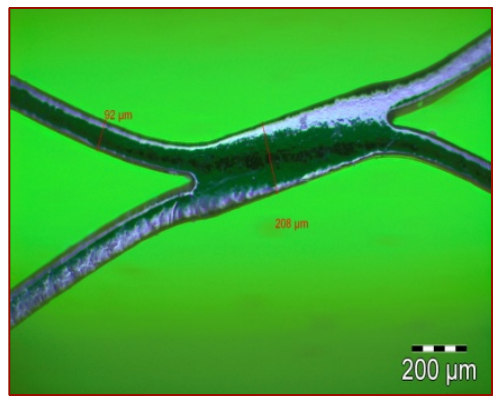
Challenges and Solutions

More and more, manufacturing challenges center on precision. Achieving manufacturing precision increases in importance as products continue to get smaller, lighter, and thinner. In many cases, product designs are ahead of the capabilities of legacy equipment available to manufacture them. In this case, precision, or lack of it, stalls new products and new revenue streams.

Take for example gas direct fuel injectors. The ability to laser machine extremely precise holes in fuel injector nozzles enables fuel efficiency improvements on the order of 30 percent. The problem? Legacy electronic magnetic discharge (EDM) and mechanical drills could not achieve the precision needed to make the parts. Raydiance's R-Drill Solution was designed specifically to address this need—drilling finished parts in a few seconds.

Or consider the manufacturing of vascular stents. Precisely cutting the metal or polymer designs—tiny webs that must be structurally strong and clean—has been notoriously costly and difficult. With traditional methods, a stent is cut and then sent through multiple post processing steps to achieve the required precision. A turnkey stent cutting solution developed by Raydiance cuts finished stents in a single process, and eliminates the chemical and mechanical re-work steps from the manufacturing process. It is a solution representing real production savings, as well as significantly improved device integrity.





Figures 1 & 2: *At left is a vascular stent processed with a nanosecond laser. The heat affected zone (circled) must be re-worked with three additional processing steps: manual honing and two chemical etch processes. The stent at right was machined with the R-Cut Solution. After machining, there was no honing, chemical etching or other re-work required. The part was taken directly to the final electro-polishing step.*

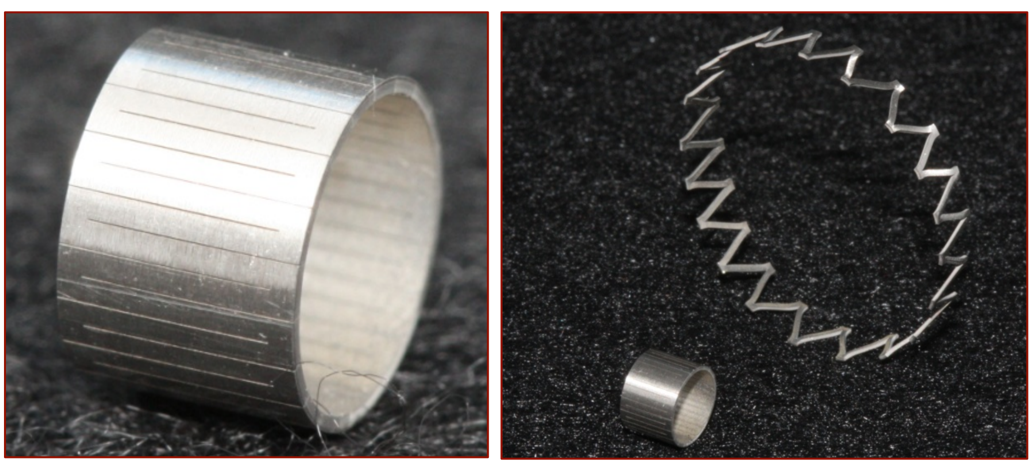
Precision machining needs to do more than make a product—it needs to make it faster, better, and at a lower cost.

Raydiance is in business to solve the world's most complex precision manufacturing problems by delivering full machining solutions enabled by femtosecond laser technology. Raydiance solutions bring together the value of no heat, no touch machining with application software to meet specific manufacturing specifications. These precision solutions—femtosecond technology, specialty beam management hardware and specific application software to orchestrate the process—can be plugged into any workstation to machine any material to any geometry or dimension in a single step.

A Catalog of Precision

The following pages are a catalog of features machined by Raydiance solutions in two materials commonly used in industrial applications: 316L stainless steel and titanium. The catalog includes visible and SEM images of precision features—through-cuts, holes, and trenches—features used in industrial applications such as fuel injector spray nozzles, turbine blades cooling holes, burst pressure disks, and implantable medical devices. These images provide an overview of the machining precision in a single step—as none of the parts has undergone any post processing or rework—with industrial grade femtosecond laser technology.

Through-Cuts: Stainless Steel Tubing - 250 μm Wall



Figures 3 & 4: *Macroscopic images of stainless steel tubing (250 μm wall) machined with the R-Cut Solution and then mechanically expanded (right).*

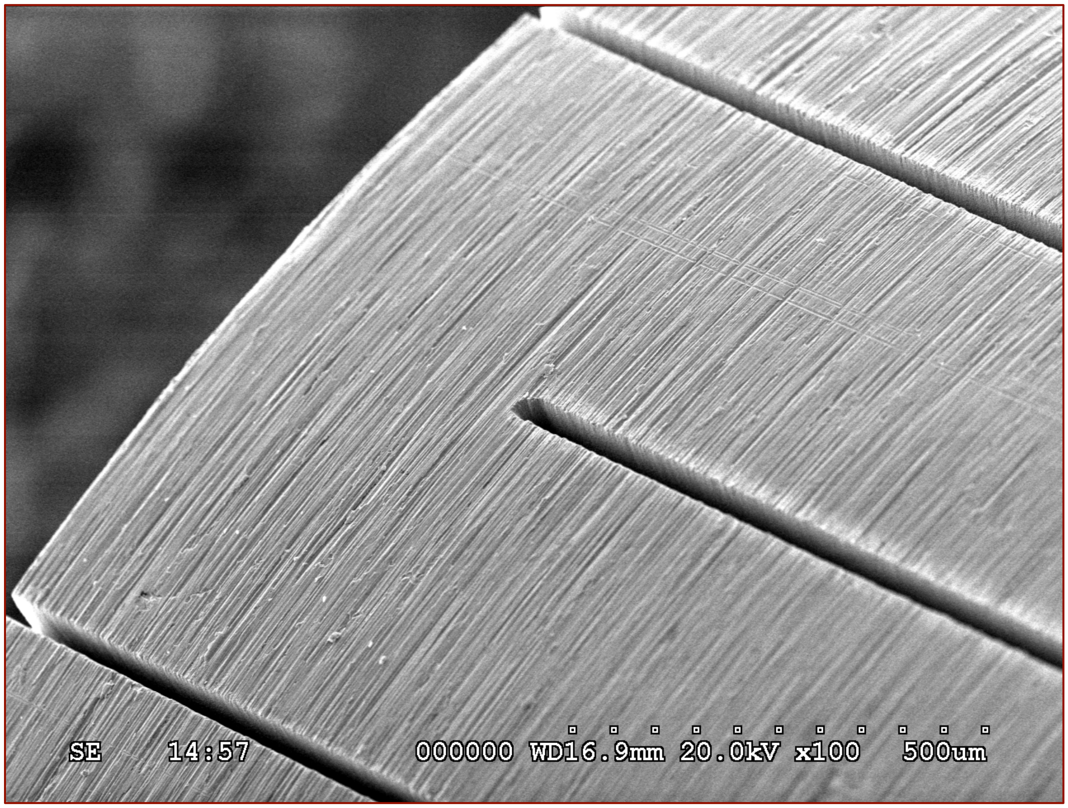
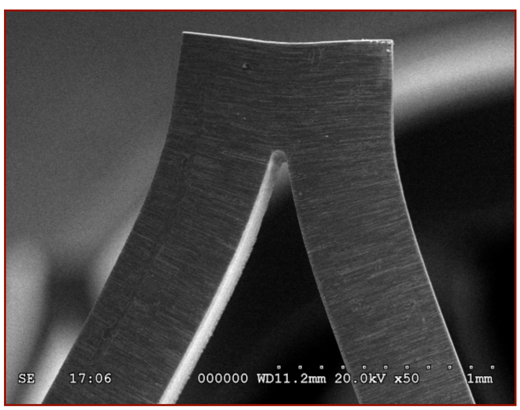
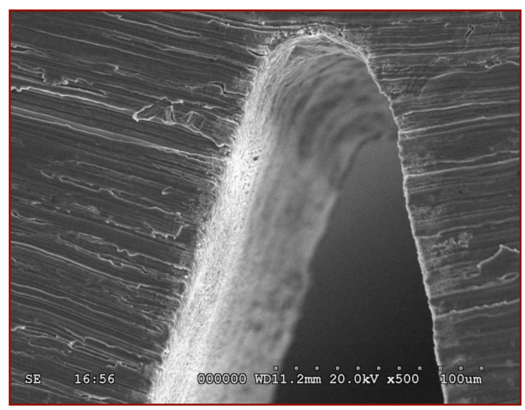


Figure 5: *SEM image of the through-cuts in stainless steel.*





Figures 6 & 7: *SEM images of the feature junction after expansion of cut stainless steel tube. Note the edge quality and absence of any thermal effects.*

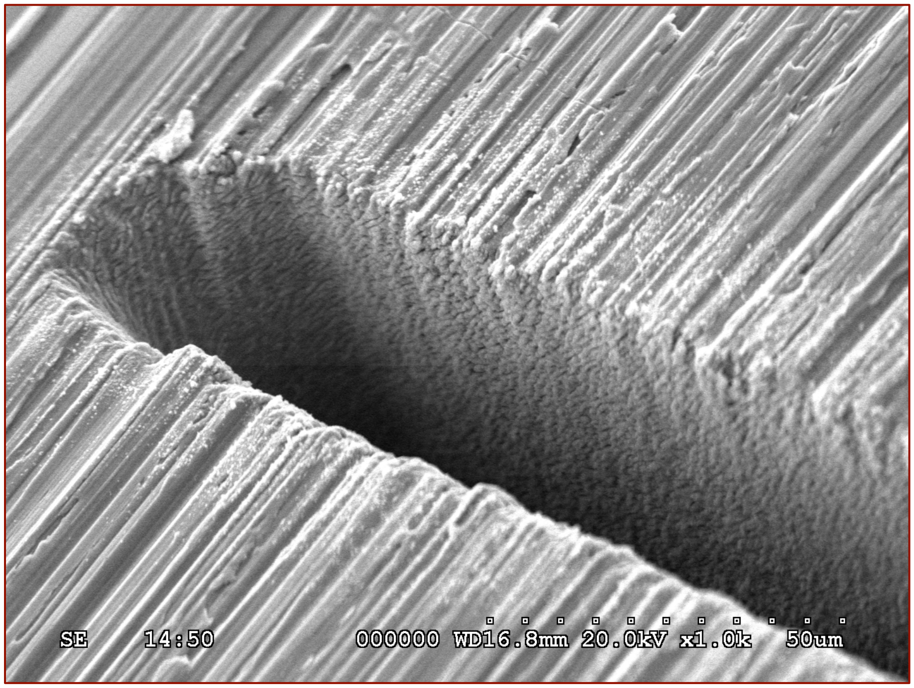


***Figure 8**: SEM image of through-cut showing edge and surface quality.*

Holes: 250 µm Stainless Steel (230 µm diameter)

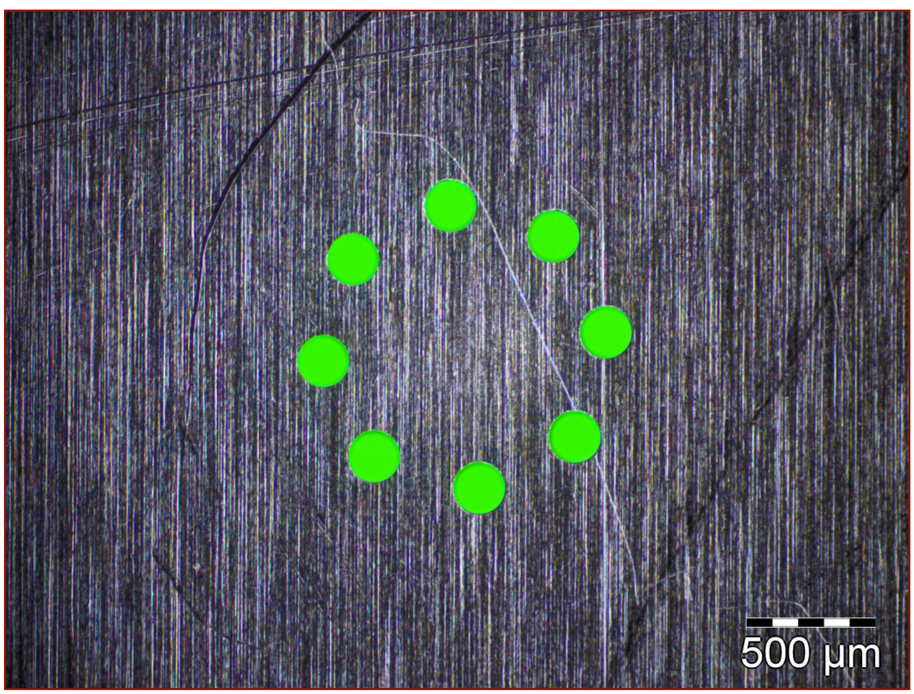


***Figure 9**: Hole array in 316L stainless steel. (Green coloring is backlighting.)*

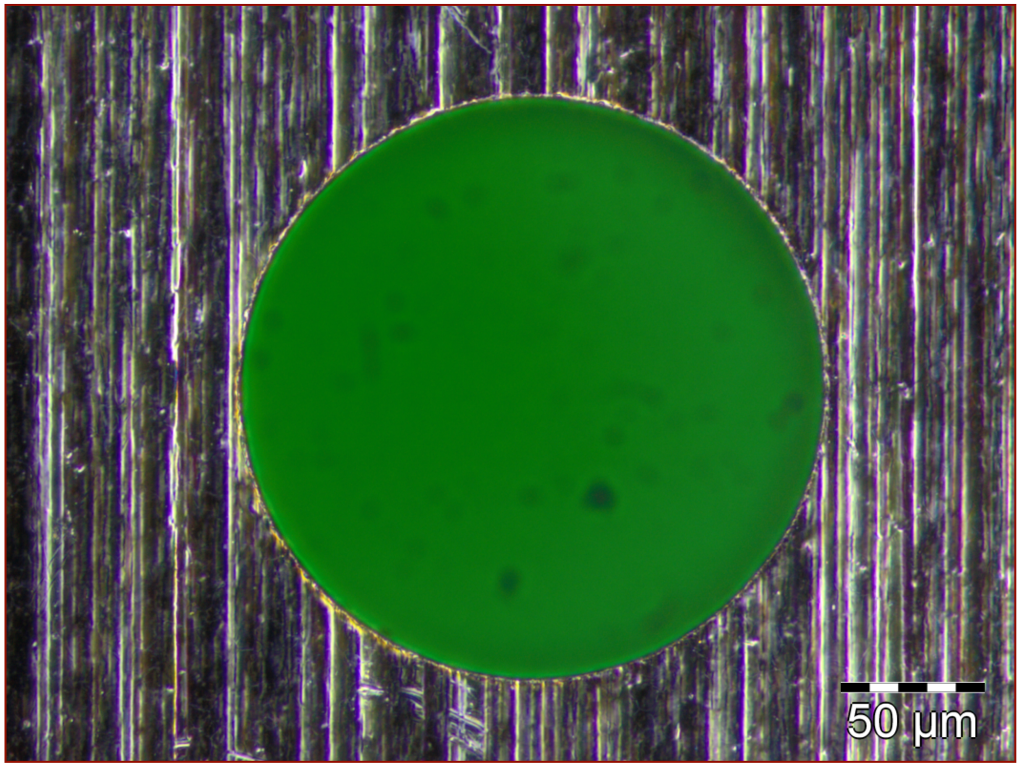
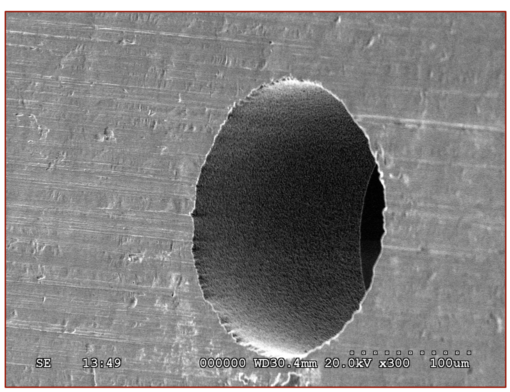
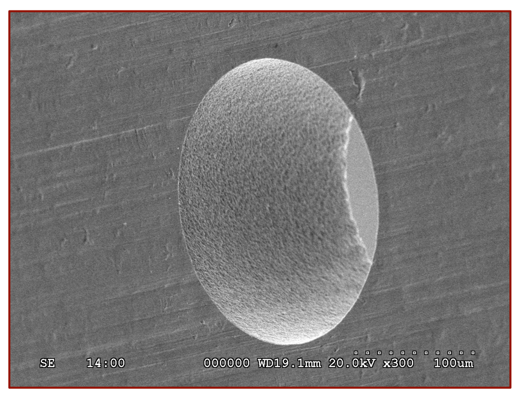


Figure 10: *Visible image of hole machined in 250 µm stainless steel.*





Figures 11 & 12: *Entrance side (left) of 230 µm hole machined in 250 µm stainless steel (316L). The exit hole is shown at right.*

Holes: 250 µm Titanium – Zero, Positive and Negative Taper

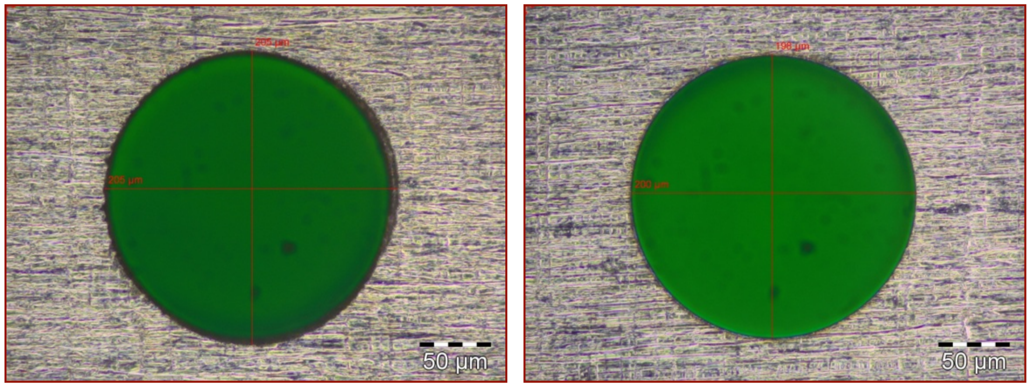


Figure 13 & 14*: 200 micron hole in titanium with zero taper. Entrance hole is at left, exit at right.*

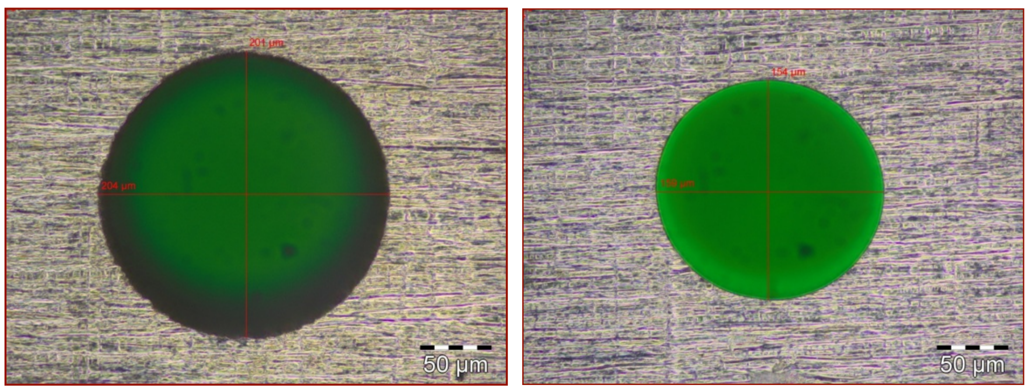


Figure 14 & 15*: 200 micron positive taper hole. The exit hole (right) diameter is approximately 156 microns.*

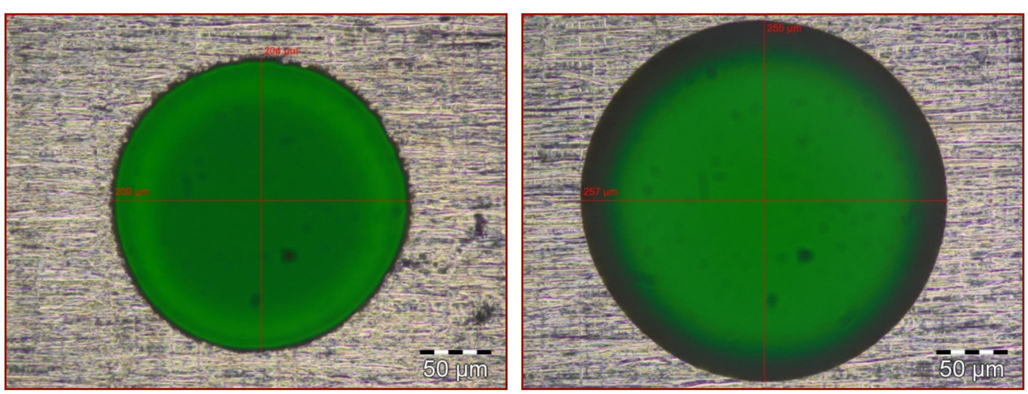


Figure 15 & 16*: 200 micron negative taper hole. The exit hole (right) diameter is approximately 256 microns.*

Trenches: Stainless Steel (350 µm wide, 100 µm deep)

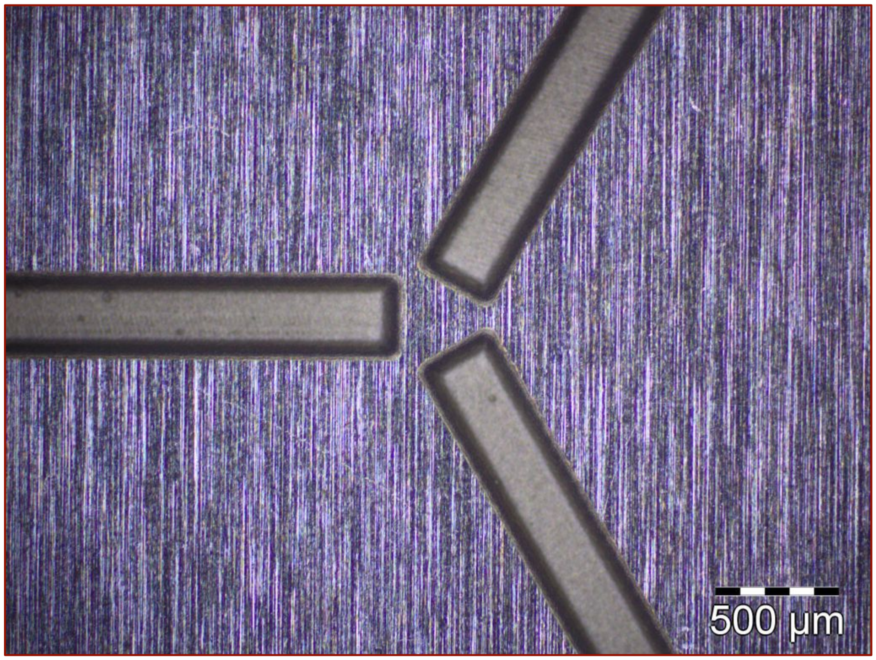


Figure 17*: Visible image at 50x showing junction of three 100 µm deep trenches, each 350 µm wide at the surface.*

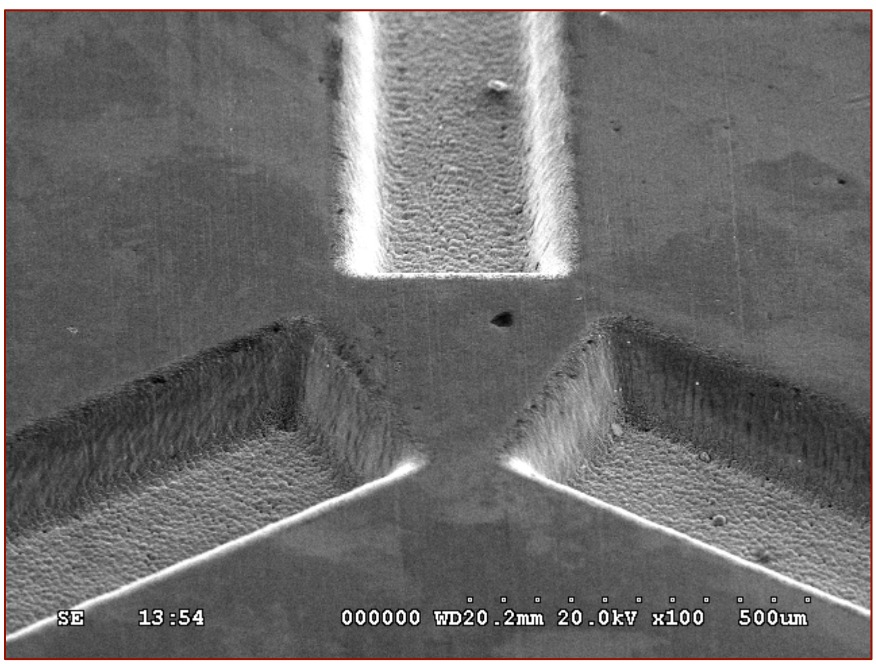


Figure 18*: SEM image of 100 µm deep trenches in stainless steel.*

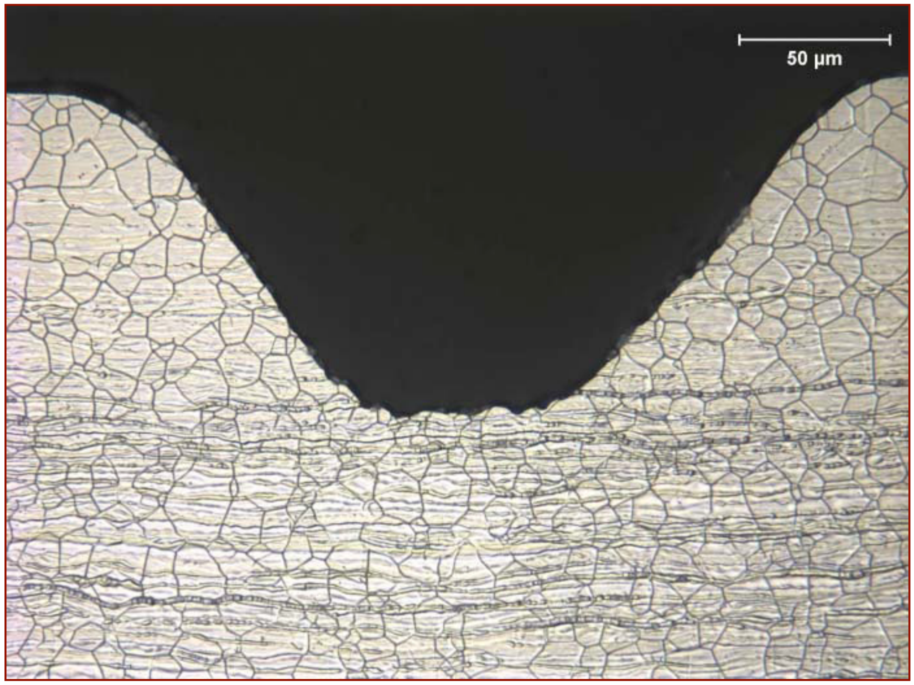


***Figure 19**: Above is a cross-section of the Raydiance-machined trench. (Acid etched, 400x). The ablation caused no change to the grain structure.*

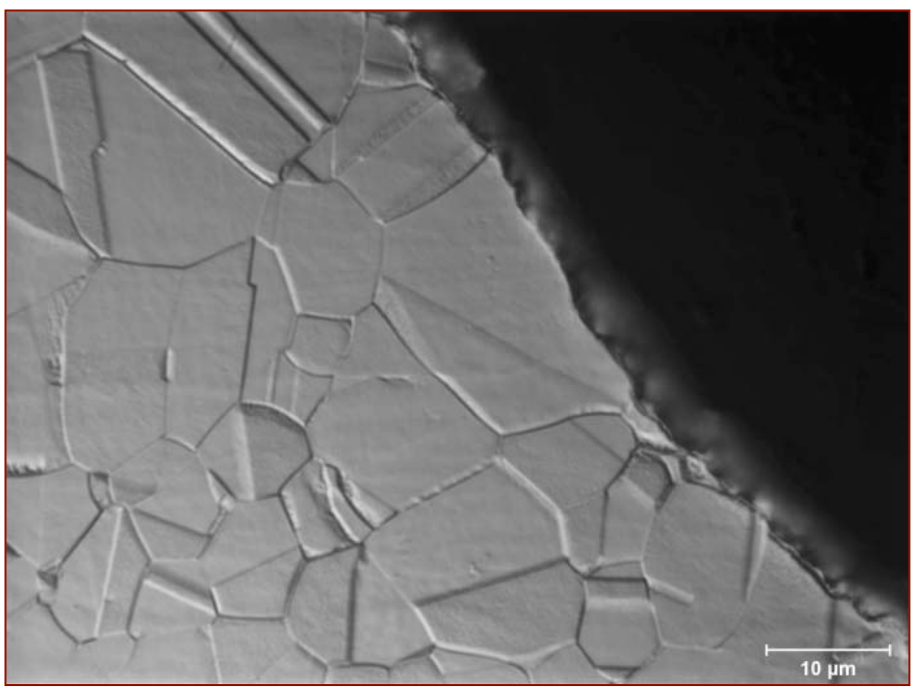


***Figure 20**: The ablated edge of the trench is shown at 1600x magnification. There are no apparent thermal effects of the machining.*

Summary

Raydiance industrial femtosecond laser solutions deliver uncompromising precision—precision that delivers unprecedented value to micro manufacturers. By creating finished parts machined to exact specifications in a single, side effect-free process, manufacturers virtually eliminate operating expenses previously required to post process parts made with earlier technologies. Raydiance solutions are at work on factory floors around the world, delivering this value and proving the advantages of femtosecond heatless material removal.