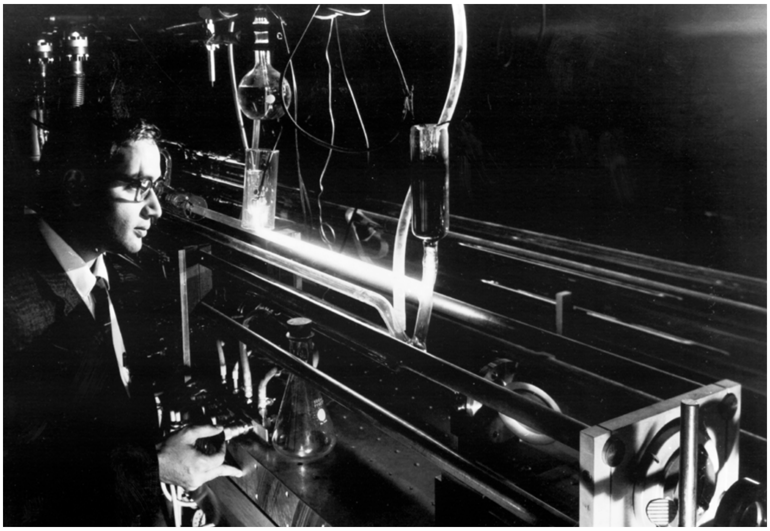
then

Industrial Laser Processing

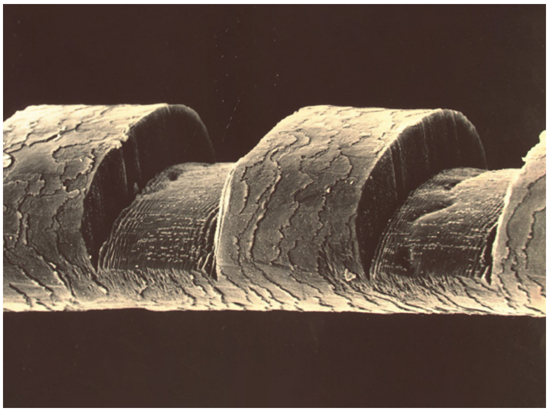
The small heat-affected zone of laser pulses, and their potential to etch tiny features without damaging the surrounding material, drove interest in laser micromachining.



Kumar Patel with one of the first CO_2 lasers. (Reused with permission of Nokia Corp. and AT&T Archives)

1960s: Cutting through steel

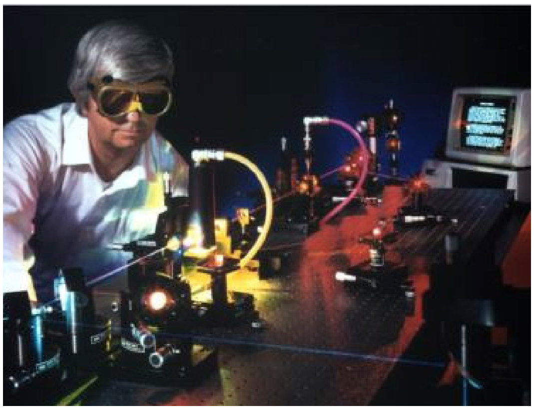
OSA Fellow Kumar Patel, Bell Labs, USA, invented CO_2 lasers in 1964—and by 1967 their powers could exceed 1000 watts. Just three years after this invention, Peter Houldcroft at The Welding Institute (TWI), U.K., used oxygen-assisted gas with a concentrated CO_2 laser beam to cut through a 1-mm-thick sheet of steel. This achievement marked the first commercial application of laser materials processing and demonstrated the usefulness of CO_2 lasers for industrial applications and laser cutting.



Excimer-laser-etched human hair circa 1982. (IBM T.J. Watson Research Center)

1982: Excimer laser etching

Researchers have studied using pulsed light to shape and remove materials since the laser's invention. However, it wasn't until 1982 that reports of polymers etched by UV excimer lasers spurred a widespread investigation into laser micromachining applications. The Japanese and U.S. teams showed that excimer lasers could be effective for UV photoetching of thermoplastic materials. The findings effectively catalyzed a micromachining revolution.



Bill Clark with a colliding-pulse mode-locked dye laser. (Clark-MXR)

1990s: Toward the femtosecond

With the invention of chirped pulse amplification (CPA) by Gerard Mourou and Donna Strickland in 1986, laser pulses reached new intensities using more compact systems. After Mourou joined forces with Bill Clark, the U.S. company Clark-MXR produced the first modularized CPA specifically designed for micromachining—the CPA-2000 Series. This source enabled the first live demonstration of industrial femtosecond laser micromachining in 1997.

now

Ultrashort-Pulse Micromachining

Today, lasers are used to precisely drill, weld, etch and cut various materials for sectors ranging from aerospace to medical devices and renewable energy.

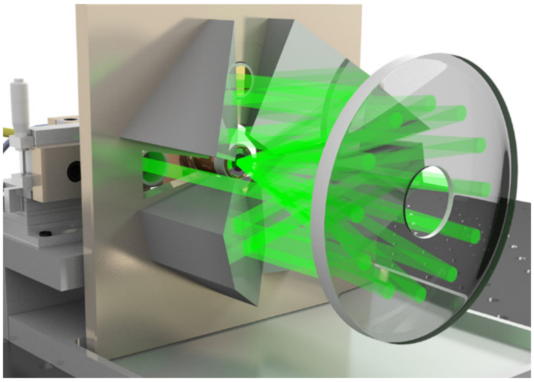
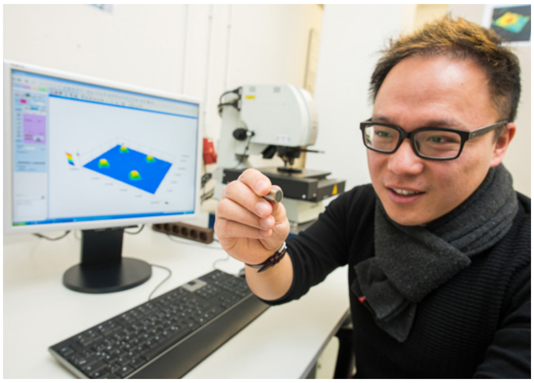


Illustration of a thin-disk laser head. (© M. Saraceno, martin@saraceno.info)

2019: Thin-disk advances

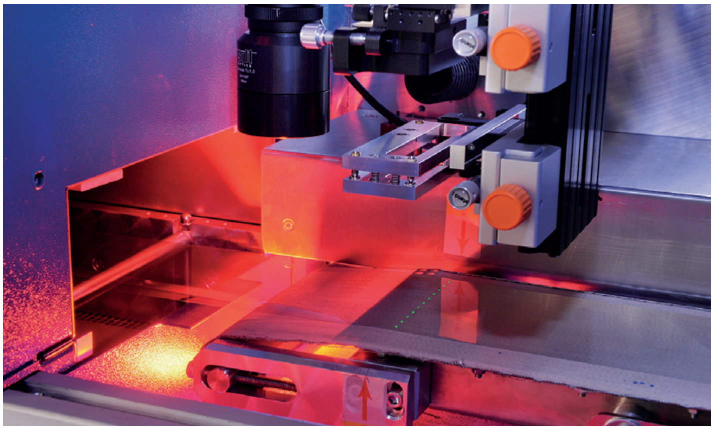
Swiss physicists have demonstrated a sub-picosecond thin-disk laser oscillator, which delivered a record-high 350-W average output power with 940-fs-long pulses, 39 mJ and an 8.88-MHz repetition rate. Combining the high average output power of thin-disk lasers with the high repetition rates of oscillators, the source could potentially pave the way for more powerful lasers for precision machining of materials.



Shiqi Fang with one of the tailor-made abrasive tools. (© Oliver Dietze)

2020: Back to the grind

Researchers in Germany reportedly have developed a laser-based technique for constructing tailor-made abrasive tools with microstructured surfaces. The microstructures, which are as wide as a human hair, allow them to develop precise grinding tools made from cemented carbides. The lasers etch the structures into the carbide in incredibly precise patterns to create micrometer-scale grinding surfaces.



Laser scribing of solar cells with 11 laser beams. (Fraunhofer ILT, Aachen, Germany)

2019–2020: Photovoltaic processing

Femtosecond laser processing has been a boon to the solar-energy sector. A multinational team recently developed a precise, fast laser-processing method for halide perovskites—producing high-quality nanostructures with controlled characteristics using femtosecond pulses. Researchers in Germany, meanwhile, have devised a laser-scribing method that guides 11 beams on the surface of an organic photovoltaic cell while the film moves, selectively ablating the nanometer-thick layers without damaging them.

Shorter pulses, smaller components

Looking ahead, as laser pulses get ever-shorter and more stable and as the demand for miniaturization continues to grow, laser micromachining and nanofabrication techniques will become even more important. Shorter pulses and better positioning systems in the future could extend laser micromachining to more sectors, and widespread implementation of technology trends like 5G and the Internet of Things (IoT) will require microscopic sensors and gadgets that will demand precision processing.