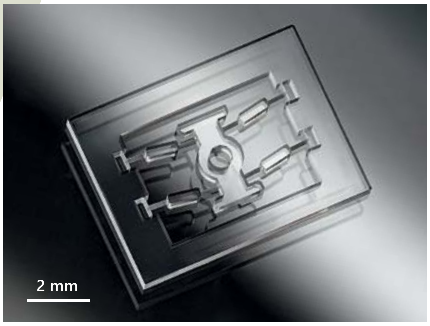
Material processing examples
Made with **FemtoLux 30** laser

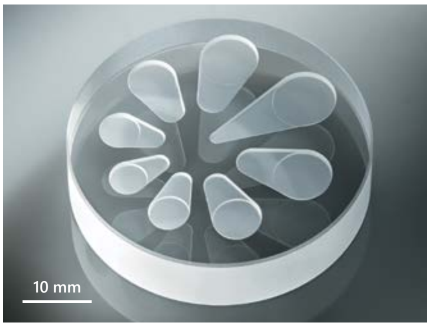


SLE of fused silica. Courtesy of Femtika.

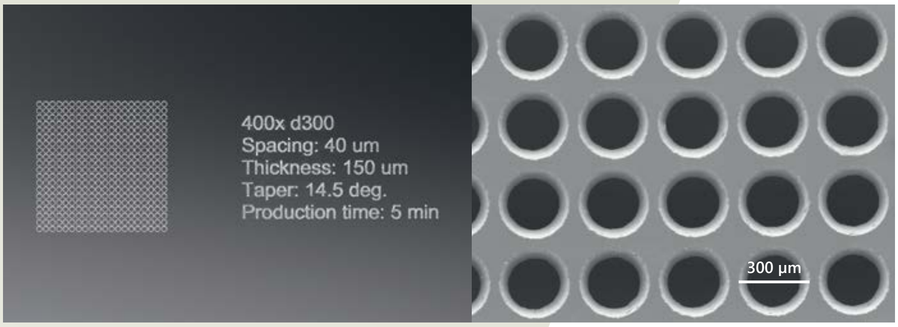
Transparent materials

Transparent materials, such as glass/sapphire are fascinating materials with remarkable properties that have made it a favorite among researchers and engineers for decades. Its robustness, chemical resistance, transparency, and affordability have made it an ideal candidate for a multitude of applications, ranging from microfluidic devices and optical components to electronic devices.

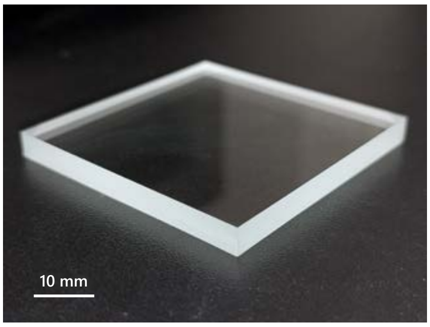
The femtosecond laser micromachining technique has brought transparent materials processing to the next level. Complex structures can now be precisely fabricated by selectively removing material through drilling, cutting, milling, etching and scribing.



UVFS milling. Courtesy of FTMC.



Borosilicate drilling. Courtesy of FTMC.



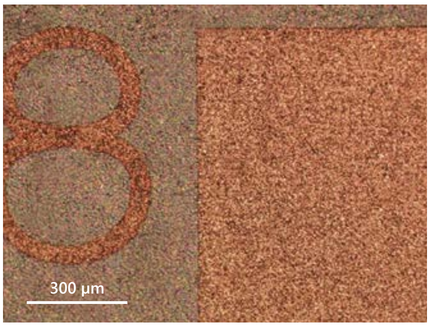
Laser-based Bessel beam scribing of soda-lime glass. Courtesy of FTMC.

Polymers

Polymers are revolutionizing various industries with their exceptional properties, including flexibility, durability, and ease of processing. These versatile materials find application in a wide range of fields, from aerospace and biomedicine to electronics.

Polymer processing with femtosecond lasers has opened up new avenues for precision fabrication of complex structures by selectively removing polymer with high precision and minimal thermal effects.

Femtosecond laser processing can also be used for photo-polymerization, a process where monomers or prepolymers are selectively polymerized to create complex 3D structures with sub-micron resolution, high accuracy, and repeatability.



Insulation layer removal from PCB. Courtesy of FTMC.

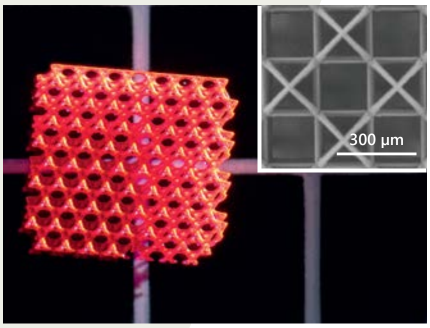


Photo-polymerization. Courtesy of Femtika.

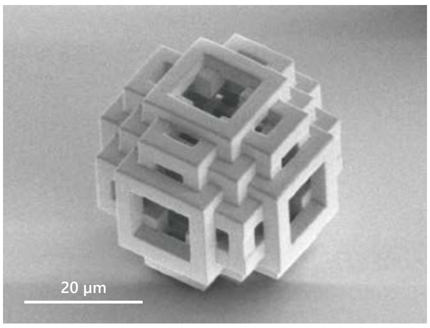
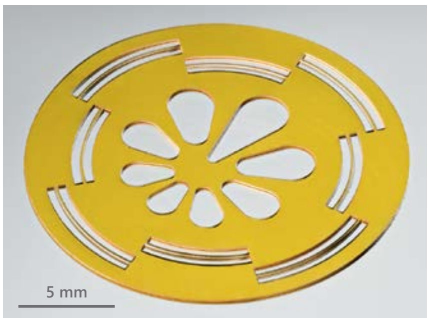


Photo-polymerization. Courtesy of WOP.



Polymide cutting. Courtesy of FTMC.

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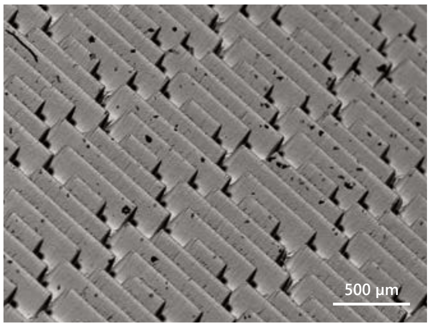
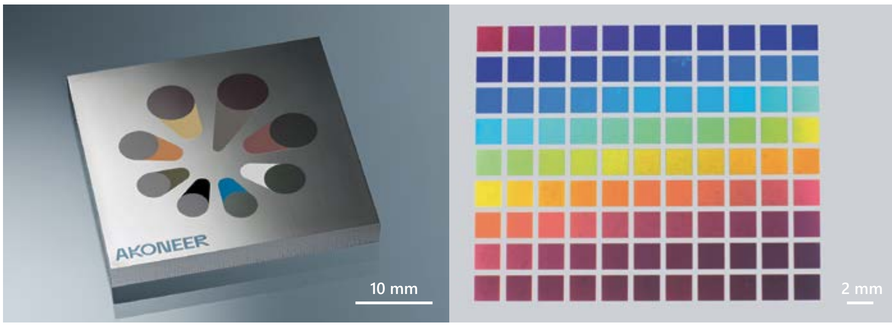
Metals



"Shark skin" surface structuring. Courtesy of FTMC.

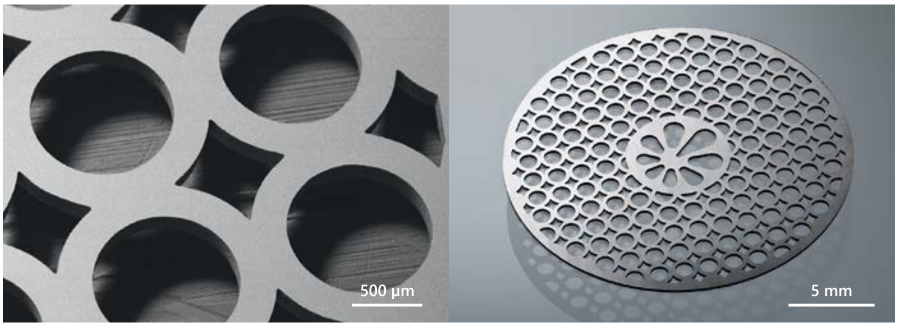
Metals, particularly stainless steel, has become an integral part of modern engineering and manufacturing thanks to its mechanical, chemical, and aesthetic properties. Its versatility has led to its use in diverse fields such as aerospace, automotive, architecture, and medical equipment.

Femtosecond laser technology has revolutionized metal micromachining, offering an exciting array of possibilities for creating visually stunning and intricately precise structures with minimal heat affected zones. Femtosecond lasers enable the production of complex shapes and features, while also providing the capability to perform black/white marking and coloring without the need for chemical additives.

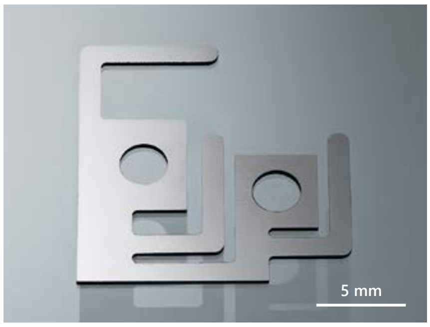


Stainless steel (left) and titanium film (right) coloring with GHz burst feature. Courtesy of Akoneer.

Highly-resistant black marking. Courtesy of FTMC.

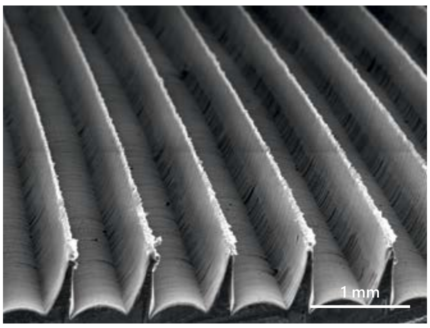


Stainless steel cutting. Courtesy of FTMC.

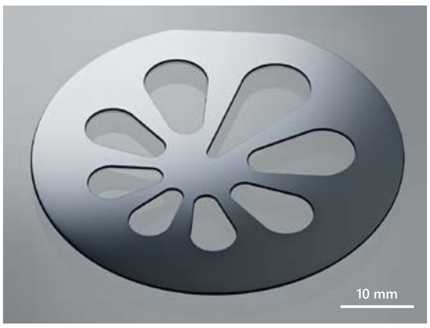


Stainless steel cutting. Courtesy of FTMC.

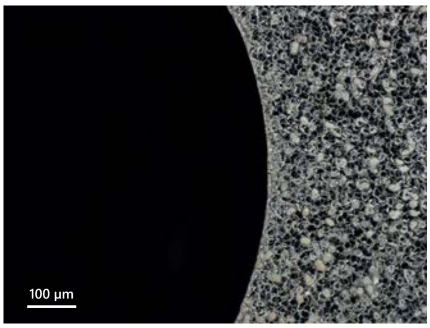
Other materials



Teflon (PTFE) milling. Courtesy of FTMC.



Crystalline silicon cutting. Courtesy of FTMC.



Crystalline silicon cutting. Courtesy of FTMC.

fs Industrial Femtosecond Lasers

FemtoLux 30

Reliability Redefined

A reliable & versatile tool for micromachining

/ Glass, sapphire and ceramics micro processing

/ Microelectronics manufacturing

/ Glass intra volume structuring

/ Micro processing of different polymers and metals

/ LCD, LED, OLED drilling, cutting and repair

Zero maintenance

2 years of total warranty

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30 W Femtosecond Industrial Laser

FemtoLux 30

Designed from the get-go for maximum reliability, seamless integration and non-stop 24/7/365 zero maintenance operation with innovative "dry" cooling.

The FemtoLux 30 femtosecond laser has a tunable pulse duration from <350 fs to 1 ps and can operate in a broad AOM controlled range of pulse repetition rates from a single shot to 4 MHz.

The maximum pulse energy is more than 100 μJ operating with single pulses and can reach more than 450 μJ in burst mode, ensuring higher ablation rates and processing throughput for different materials.

The FemtoLux 30 beam parameters will meet the requirements of the most demanding materials and micro-machining applications.

Innovative laser control electronics ensure simple control of the FemtoLux 30 laser by external controllers that could run on different platforms, be it Windows, Linux or others using REST API commands.

This makes easy integration and reduces the time and human resources required to integrate this laser into any laser micromachining equipment.

Seamless User Experience

Easy integration – remote control using REST API via RS232 and LAN.

Reduced integration time – demo electronics is available for laser control programming in advance.

Easy and quick installation – no water, fully disconnectable laser head. Can be installed by the end-user.

Easy troubleshooting – integrated detectors and constant system status logging.

No periodic maintenance required.

Features

Typical max output power
30 W at 1030 nm,
11 W at 515 nm,
6 W at 343 nm

Typical max output energies
> 100 μJ at 1030 nm,
> 55 μJ at 515 nm,
> 30 μJ at 343 nm

High energy version available (**1 mJ** at 10 kHz)

MHz, GHz, MHz+GHz burst modes

> 450 μJ in a burst mode

< 350 fs – 1 ps

Single shot to 4 MHz (AOM controlled)

Pulse-on-demand (PoD), with jitter as low as 20 ns (peak-to-peak)

<0.5% RMS power long term stability over 100 hours

M^2 < 1.2

Beam circularity > 0.85

Zero maintenance

Dry cooling (no water used)

2 years of total warranty

At 1030 nm	At 515 nm	At 343 nm
30 W	11 W	6 W
>100 μJ	>55 μJ	>30 μJ

Learn more about FemtoLux 30
www.ekspla.com

"Dry" Cooling

Direct Refrigerant Cooling System

The FemtoLux 30 laser employs an innovative cooling system and sets new reliability standards among industrial femtosecond lasers. No additional bulky and heavy water chiller is needed.

The chiller requires periodic maintenance – cooling system draining and rinsing and water and particle filter replacement. Moreover, water leakage can cause damage to the laser head and other equipment. Instead of using water for transferring heat from a laser head, the FemtoLux 30 laser uses an innovative Direct Refrigerant Cooling method.

The refrigerant agent circulates from a PSU-integrated compressor and condenser, to a cooling plate via armored flexible lines.

The entire cooling circuit is permanently hermetically sealed and requires no maintenance.

See **FemtoLux 30** introduction video showing "dry cooling" advantages

Benefits

Military-grade reliability

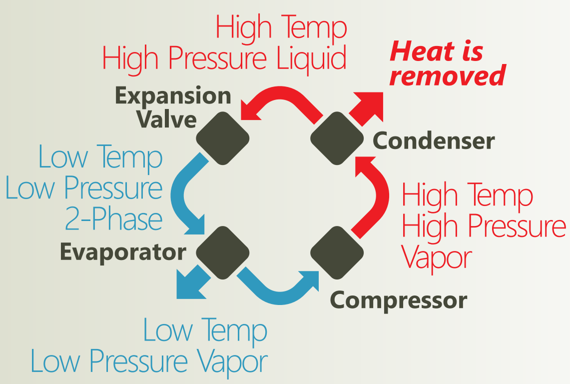
Permanently hermetically sealed system **>90,000 hour MTBF**

No maintenance

High cooling efficiency

>45% lower power consumption compared to water cooling equipment

Compact and light



Compressor picture.
Courtesy of Aspen Systems Inc.

Simple & Reliable Cooling Plate Attachment

The cooling plate is detachable from the laser head for more convenient laser installation. The laser cooling equipment is integrated with the laser power supply unit into a single 4U rack-mounted housing with a total weight of 15 kg.

Detachable cooling plate

Integrated cooling equipment with the laser power supply

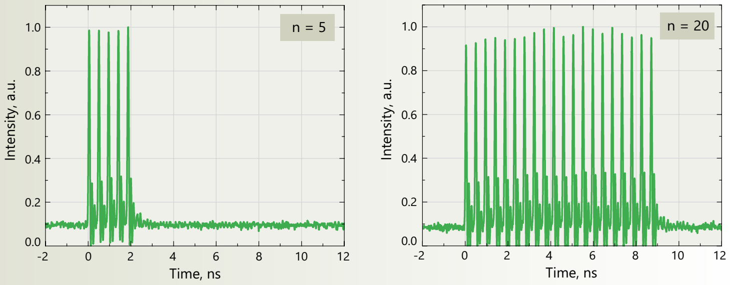
Simple and reliable cooling plate attachment

GHz Burst Option

Patent-Pending Method for Ultra-High Rate Bursts

Short GHz burst

Fig 1. Measured 2.2 GHz intra-burst PRR burst of pulses containing a different number of pulses of equal amplitudes at 31.5 W average output power



Long GHz burst

Fig 2. Measured 2.2 GHz pre-shaped bursts of 1000 pulses at 233 kHz burst repetition rate for the desired rectangular-like burst shape

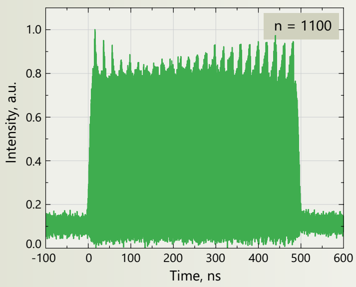
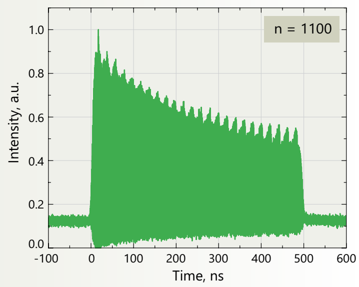


Fig 3. Measured 2.2 GHz non-pre-shaped bursts of 1100 pulses at 233 kHz burst repetition rate



MHz + GHz burst mode

Fig 4. Measured 4 bursts of 50 MHz BRR containing 4 pulses of 2.5 GHz intra-burst PRR

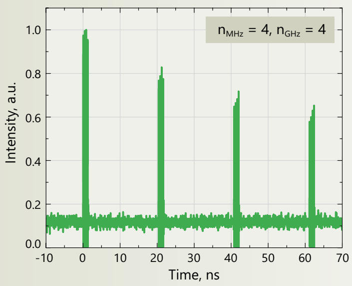
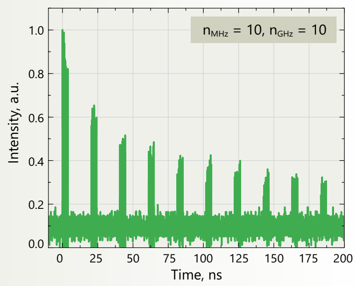


Fig 5. Measured 10 bursts of 50 MHz BRR containing 10 pulses of 2.5 GHz intra-burst PRR



Benefits

The Femtolux 30 laser can operate in the **single-pulse** mode, **MHz burst** mode, **GHz burst** mode, and **MHz + GHz burst** mode.

The burst formation technique based on the use of the AFL is a very versatile method as it allows to overcome many limitations encountered by other fiber- and/or solid-state-based techniques.

Any desired intra-burst PRR can be achieved independently from the initial PRR of the master oscillator

Identical pulse separation inside the GHz bursts is maintained

Short- and long-burst formation modes can be provided.

/ A short burst is up to about 10 ns burst width (from 2 to tens of pulses in the GHz burst).

/ A long burst is from ~20 ns up to a few hundred ns in burst width (from tens to thousands of pulses in the GHz burst)

MHz+GHz burst mode

An adjustable amplitude envelope of the GHz bursts is provided

No pre/post pulses in GHz burst. Pure GHz bursts

Ultrashort pulse duration is maintained inside the bursts

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A new versatile patent-pending method to form ultra-high repetition rate bursts of ultrashort laser pulses.

The developed method is based on the use of an all-in-fiber active fiber loop (AFL). A detailed description of the invention can be found on:

[1] Andrejus Michailovas, and Tadas Bartulevičius. 2021 Int. patent application published under the Patent Cooperation Treaty (PCT) WO2021059003A1.

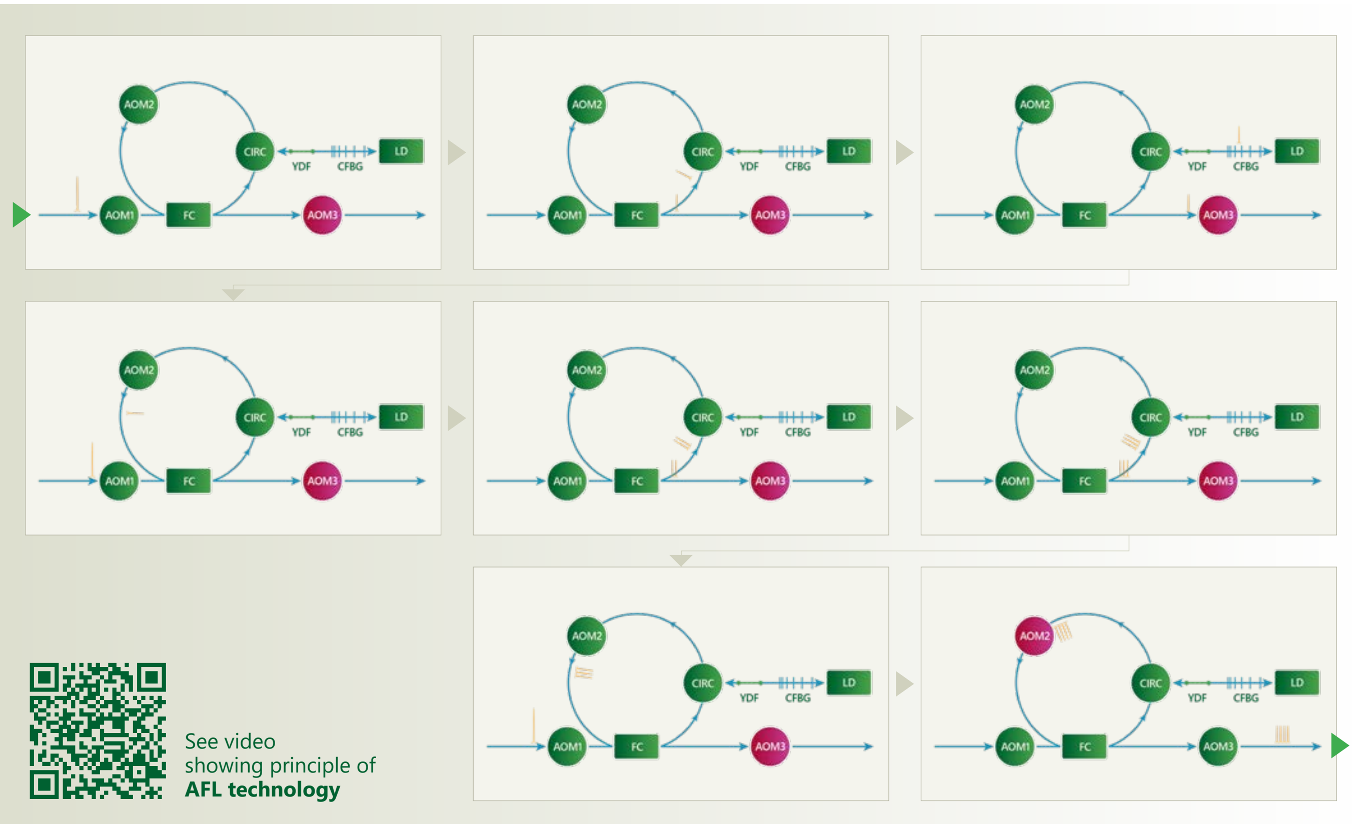
[2] Tadas Bartulevičius, Mykolas Lipnickas, Virginija Petrauskienė, Karolis Madeikis, and Andrejus Michailovas, (2022), "30 W-average-power femtosecond NIR laser operating in a flexible GHz-burst-regime," Opt. Express 30, 36849-36862.

Specifications

Parameter	Value	
Burst repetition rate	200 – 650 kHz	
Intra-burst pulse repetition rate [1]	2 GHz	
GHz burst mode	**short**	**long**
Number of pulses [2]	2 – 22	44 – 1100
Shape	square, rising, falling	falling, pre-shaped [3]
MHz + GHz burst mode		
Burst repetition rate	100 – 650 kHz	
Number of pulses in MHz burst	2 – 10	
Number of pulses in GHz burst	2 – 22	

[1] Custom intra-pulse PRR is available upon a request.
[2] Depends on the intra-pulse PRR.
[3] For more information, please inquire sales@ekspla.com.

Principle of AFL Technology



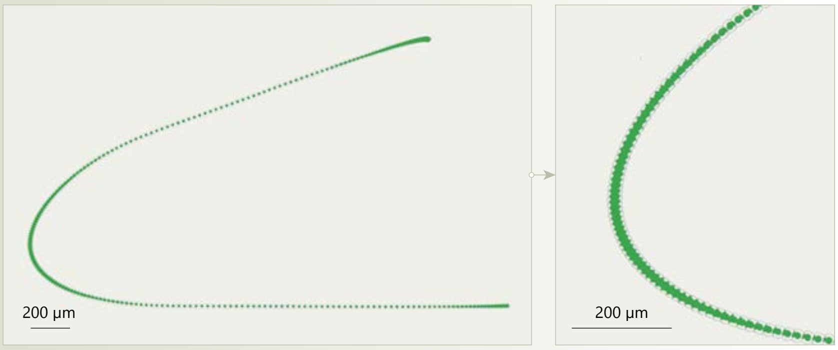
See video showing principle of **AFL technology**

Pulse-on-Demand (PoD)

Traditional laser triggering techniques struggle to maintain equally spaced pulses at high speeds (Fig.1, 2). Pulse-on-demand feature tackles this challenge and enables high-speed micromachining (Fig. 3).

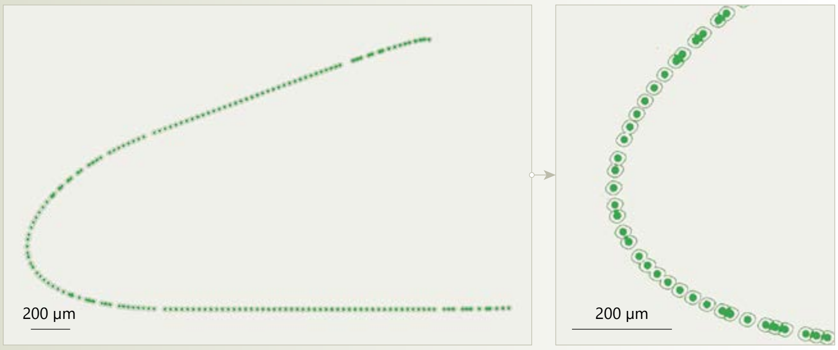
Time based laser triggering

Fig 1. Complex shape scanned with time based laser triggering mode with a pulse repetition of 200 kHz and scanning speed of 6 m/s. The scanning started from the top right to the bottom right area. Overlapping pulses result in an overheated area.



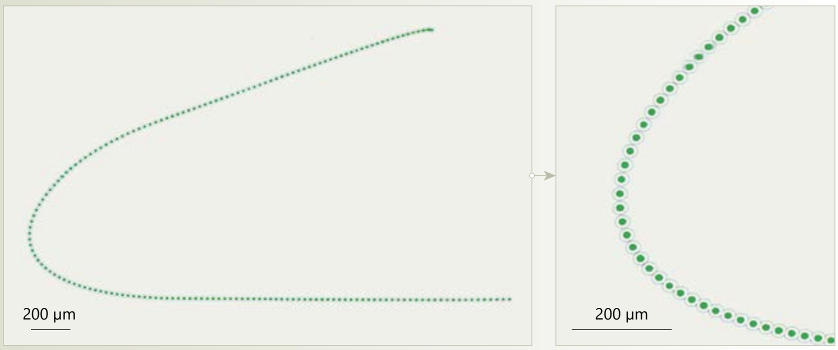
Position based laser triggering

Fig 2. Complex shape scanned with position based laser triggering mode with a pitch of 30 µm and scanning speed of 6 m/s. The scanning started from the top right to the bottom right area. Jitter of tens of µs results in random pulse spacing.



Pulse-on-demand (PoD)

Fig 3. Complex shape scanned with pulse-on-demand (PoD) and position based laser triggering mode with a pitch of 30 µm and scanning speed of 6 m/s. The scanning started from the top right to the bottom right area. PoD feature preserves equidistant pulse spacing at high speeds.



Benefits

Jitter lower than 20 ns ensures consistent and equidistant pulse spacing for high-speed micromachining

Adjustable repetition rate for processing complex geometries

Faster processing speeds, increased productivity

PoD feature enables the laser to fire a pulse only when required, rather than at a constant rate, enabling precise control over the laser's output and resulting in higher efficiency, accuracy and quality.

This capability is especially valuable in various micromachining applications where a high processing speed, constant energy, and accuracy are essential. To follow complex curvature at high speed and to maintain equidistant spacing it is necessary to ensure that the repetition rate of the pulses is adjusted. To achieve these requirements, it is necessary to ensure that the repetition rate of the pulses is adjusted to follow complex curvature at high speed and to maintain equidistant spacing. One may try to use position based laser triggering but, due to laser system limitations, the jitter will be from several µs to tens of µs, which will result in random spacing of the pulses. On the other hand, the usage of time based laser triggering results in overheat areas, due to excessive overlap of pulses. The FemtoLux 30 laser has the pulse-on-demand feature with jitter as low as 20 ns (peak-to-peak), and it can therefore tackle all the challenges and maximize process efficiency, precision and quality at high speed.

Specifications [1]

Model		FemtoLux 30
Main specifications		
Central wavelength	fundamental	1030 nm
	with second harmonic option	515 nm
	with third harmonic option	343 nm
Pulse repetition rate (PRR) [2]		200 kHz – 4 MHz
Pulse repetition frequency (PRF) after frequency divider		PRF = PRR / N, N=1, 2, 3, ... , 65000; single shot
Average output power	at 1030 nm	> 27 W (typical 30 W)
	at 515 nm	> 11 W [3]
	at 343 nm	> 6 W [3]
Pulse energy	at 1030 nm	> 100 µJ or 1 mJ [4]
	at 515 nm	> 55 µJ [3]
	at 343 nm	> 30 µJ [3]
Number of pulses in MHz burst [5]		2 – 10
Total energy in burst mode		> 450 µJ [6]
Power long term stability (Std. dev.) [7]		< 0.5 %
Pulse energy stability (Std. dev.) [8]		< 1 %
Pulse duration (FWHM)		tunable, < 350 fs [9] – 1 ps [10]
Beam quality		M^2 < 1.2 (typical < 1.1)
Beam circularity, far field		> 0.85
Beam divergence (full angle)		< 1 mrad
Beam pointing thermal stability		< 20 µrad/°C
Beam diameter ($1/e^2$) at 20 cm distance from laser aperture at 1030 nm		2.5 ± 0.4 mm
Triggering mode		internal / external
Pulse output control		frequency divider, pulse picker, burst mode, packet triggering, power attenuation, pulse-on-demand [11]
Control interfaces		RS232 / LAN
Length of the umbilical cord		3 m, detachable. Custom length option available
Laser head cooling type		dry (direct refrigerant cooling through detachable cooling plate)
Physical characteristics		
Laser head (W × L × H)		429 × 569 × 130 mm
Power supply unit (W × L × H)		449 × 376 × 177 mm
Operating requirements		
Mains requirements		100 – 240 V AC, single phase, 50/60 Hz
Maximal power rating		800 W
Operating ambient temperature		18 – 27 °C
Relative humidity		10 – 80 % (non-condensing)
Air contamination level		ISO 9 (room air) or better

1) Due to continuous improvement, all specifications are subject to change without notice. Parameters marked typical are not specifications. They are indications of typical performance and will vary with each unit we manufacture. All parameters are specified for a shortest pulse duration. Unless stated otherwise, all specifications are measured at 1030 nm and for basic system without options.

2) When frequency divider is set to transmit every pulse. Fully controllable by integrated AOM.

3) At 200 kHz.

4) Other combinations of energy and repetition rate available.

5) Oscillator frequency ~50 MHz, ~20 ns separation between pulses.

6) > 450 µJ in MHz burst mode or MHz+GHz burst mode at 100 kHz PRR. > 90 µJ energy in GHz burst mode.

7) Over 100 h after warm-up under constant environmental conditions.

8) Under constant environmental conditions.

9) At PRR > 500 kHz. At PRR < 500 kHz shortest pulse duration is < 400 fs.

10) Custom pulse duration by request. For example – fixed 50 fs available.

11) Jitter < 20 ns. Trigger-to-pulse delay < 1 µs.

DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT

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Performance

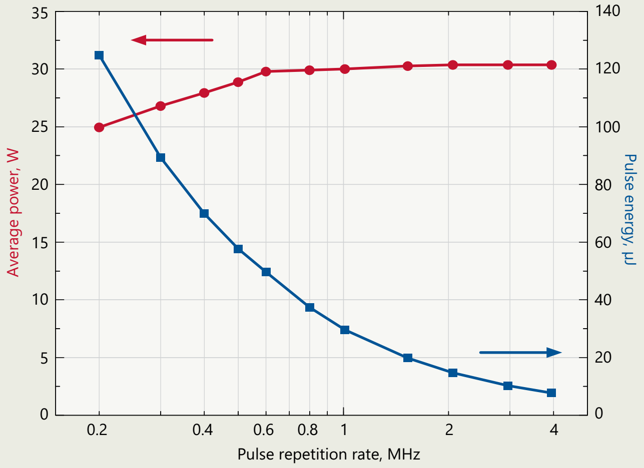

Fig 1. Typical dependence of output power and pulse energy of FemtoLux 30 laser at 1030 nm on pulse repetition rate

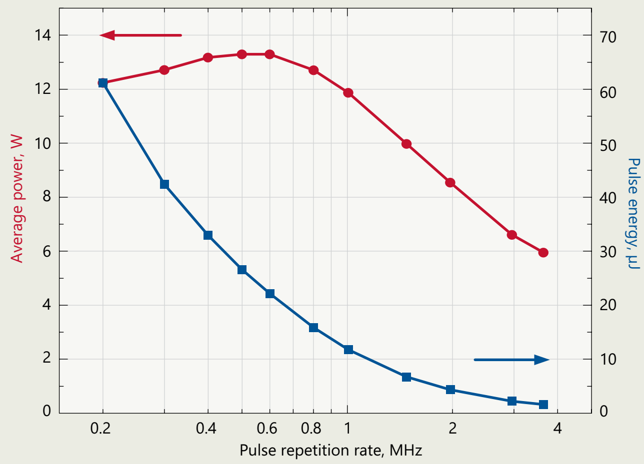

Fig 2. Typical dependence of output power and pulse energy of FemtoLux 30 laser at 515 nm on pulse repetition rate

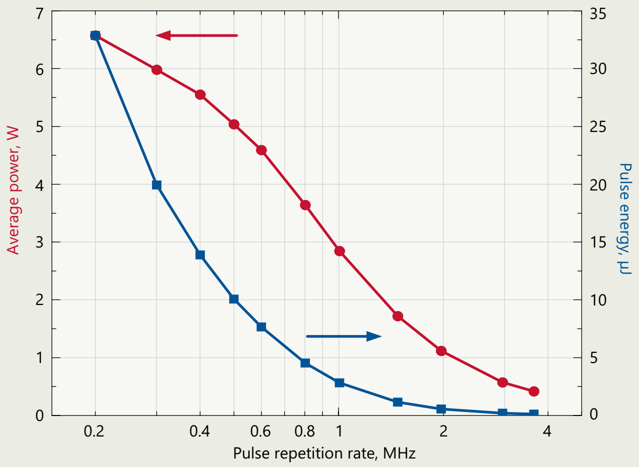

Fig 3. Typical dependence of output power and pulse energy of FemtoLux 30 laser at 343 nm on pulse repetition rate

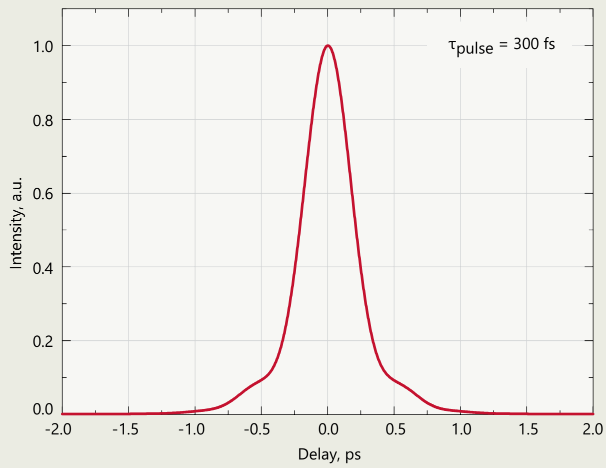

Fig 4. Typical FemtoLux 30 laser (at 1030 nm) output pulse autocorrelation function

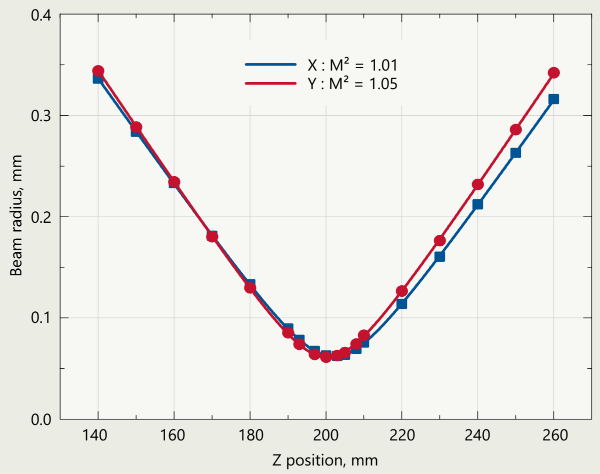

Fig 5. Typical M^2 measurement of FemtoLux 30 laser at 1030 nm

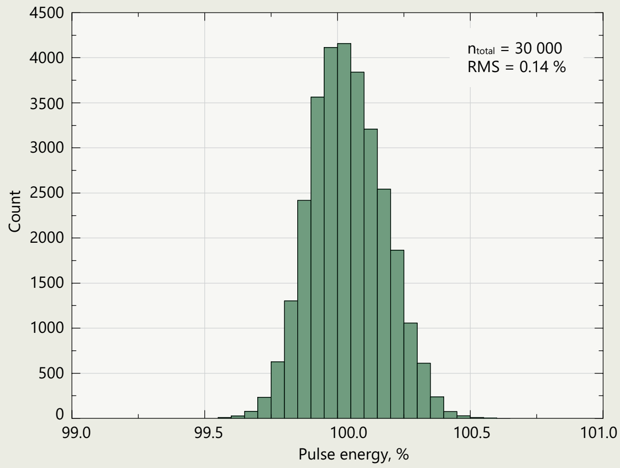

Fig 6. Typical pulse-to-pulse energy stability of FemtoLux 30 laser at 200 kHz over 30 000 pulses. RMS was calculated by using a set of mean values of 10 consecutive laser shots

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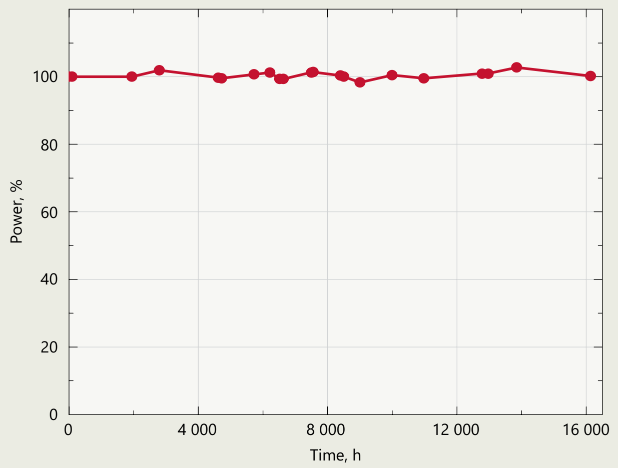

Fig 7. Long-term average power stability of the FemtoLux 30 laser at 1030 nm under constant environmental conditions over an extended duration of 16,000 hours

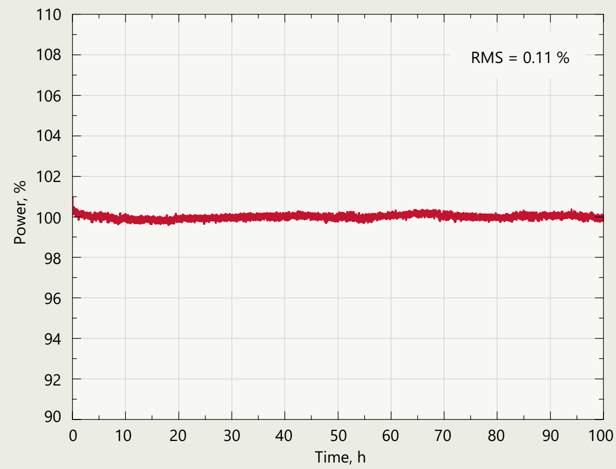

Fig 8. Typical long term average power stability of FemtoLux 30 laser at 1030 nm under constant environmental conditions

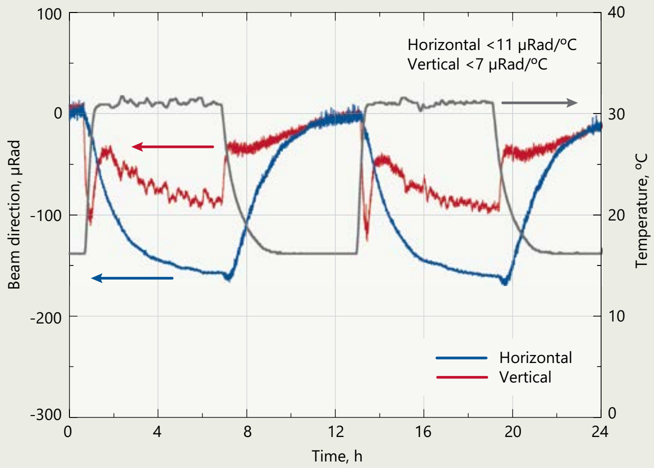

Fig 9. Typical beam direction stability of FemtoLux 30 under harsh environmental conditions

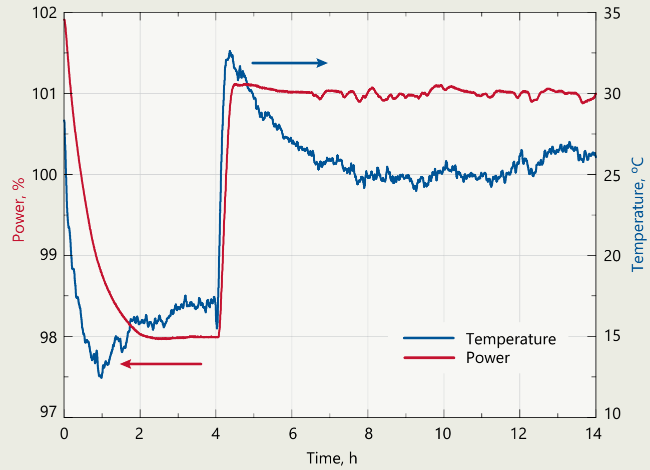

Fig 10. Average output power dependance of FemtoLux 30 laser on ambient temperature at 1030 nm

FemtoLux 30 with harmonics module and power supply

Drawings

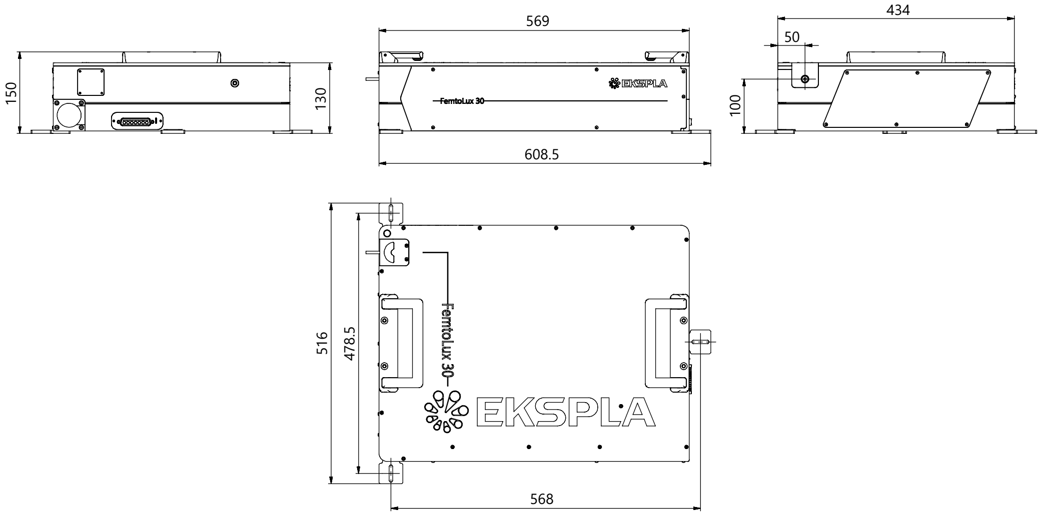

Fig 11. FemtoLux 30 laser head outline drawing

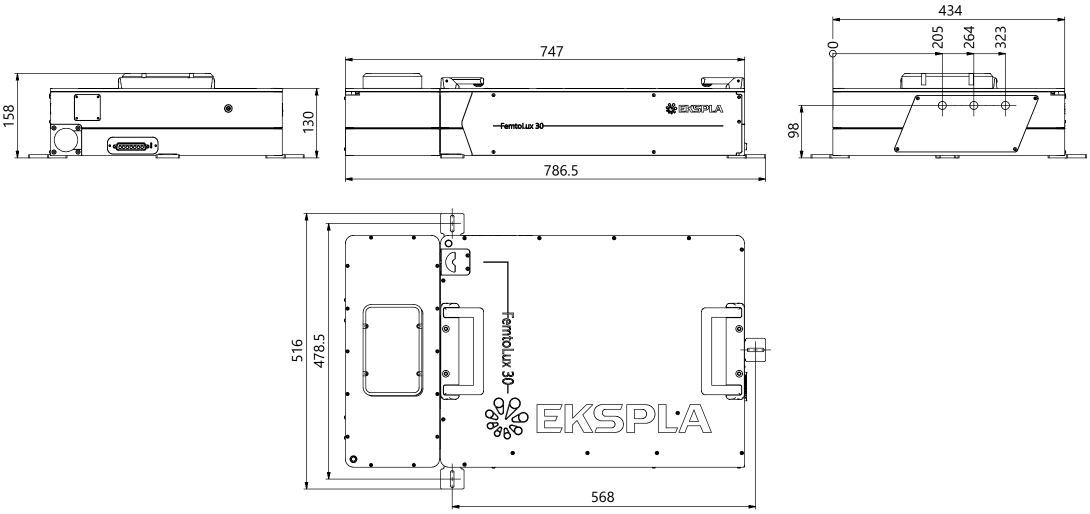

Fig 12. FemtoLux 30 with harmonics module. Laser head outline drawing

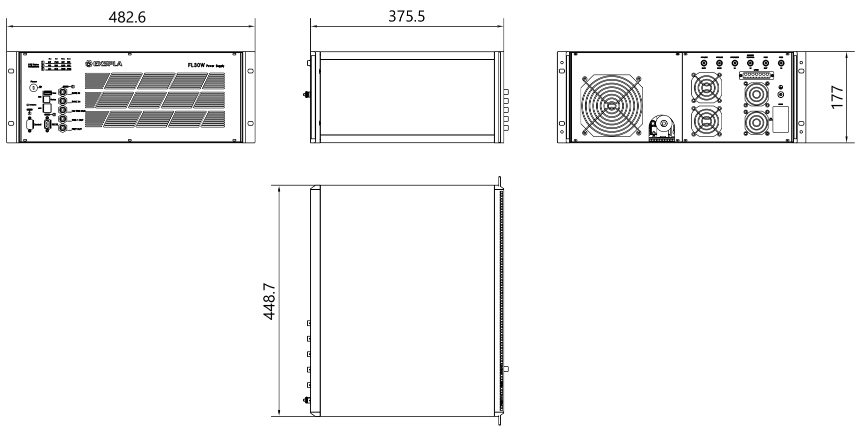

Fig 13. Power supply outline drawing

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