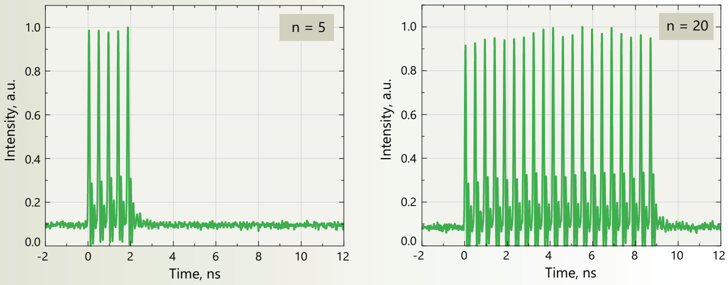
GHz Burst Option

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

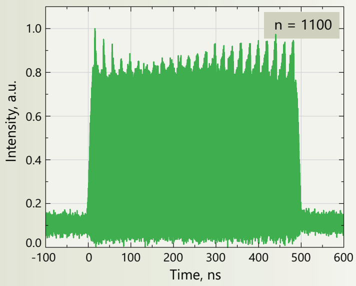
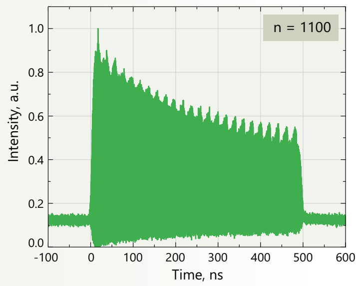


Fig 3. Measured 2.2 GHz non-pre-shaped bursts of 1100 pulses at 233 kHz burst repetition rate



MHz + GHz burst mode

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

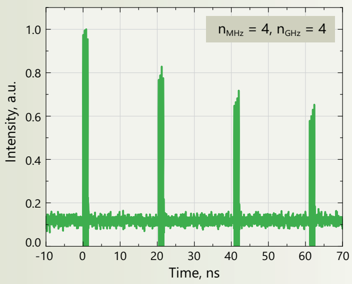
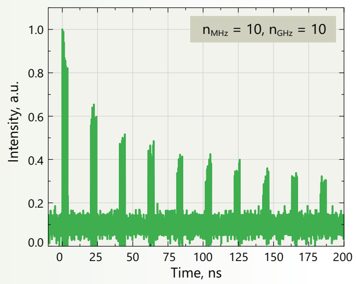


Fig 5. Measured 10 bursts of 50 MHz BRR containing 10 pulses of 2.5 GHz intra-burst PRR



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

Savanoriu Av. 237, LT-02300 Vilnius, Lithuania | ph. +370 5 2649629 | e-mail: sales@ekspla.com | **www.ekspla.com**

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.

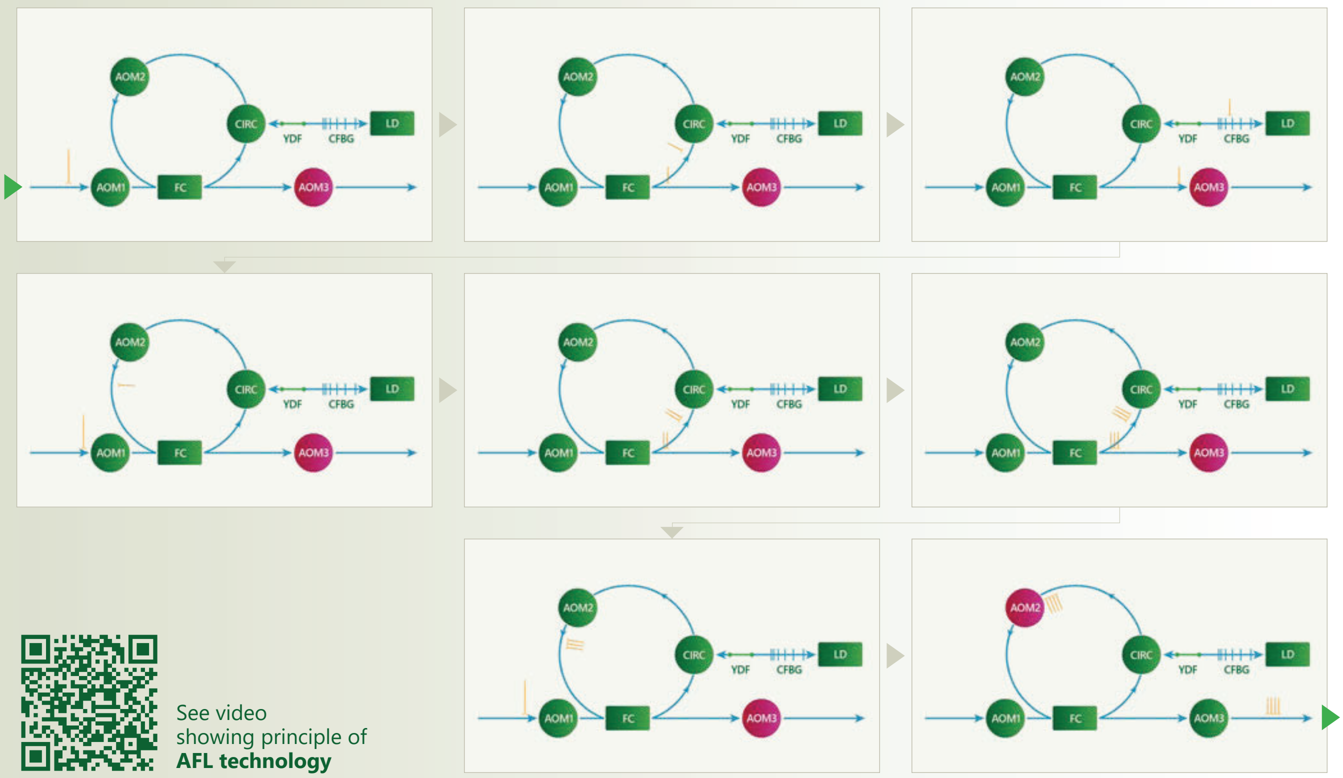
[2] Tadas Bartulevičius, Mykolas Lipnickas, Virginija Petrauskienė, Karolis Madeikis, and Andrejus Michailovas, (2022), "30 W-average-power femtosecond NIR laser operating in a flexible GHz-burst-regime," Opt. Express 30, 36849-36862.

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



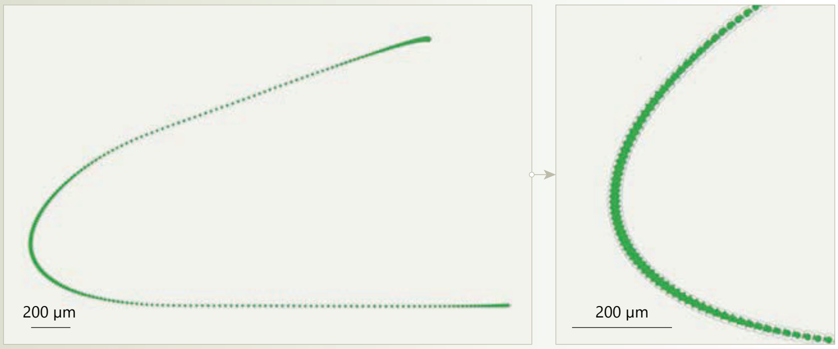
See video showing principle of **AFL technology**

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).

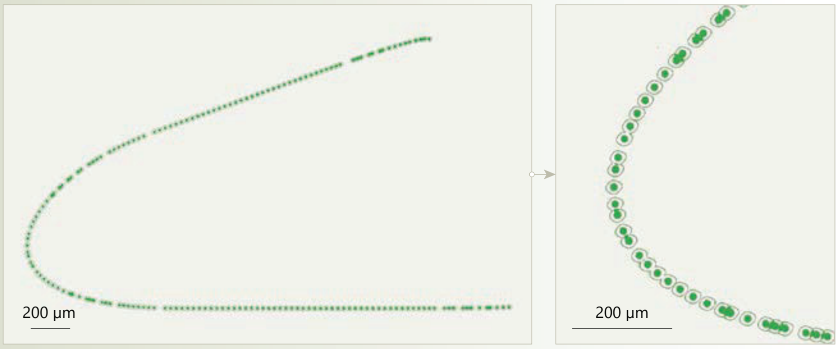
Time based laser triggering

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.



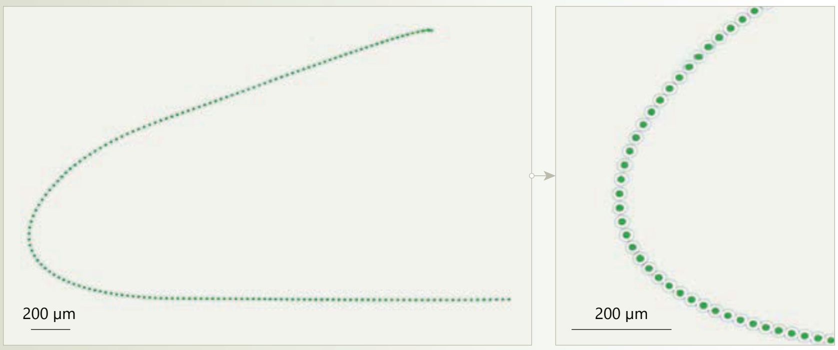
Position based laser triggering

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.

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