CARBIDE

Unibody-Design Femtosecond Lasers for Industry and Science

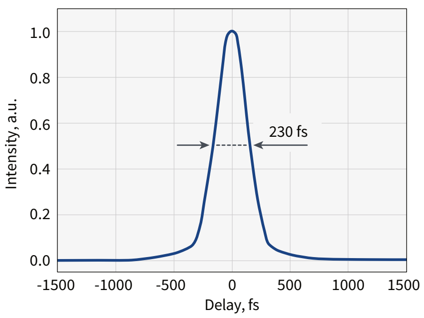
FEATURES

- Tunable pulse duration, 190 fs – 20 ps
- Maximum output of 120 W, 1 mJ or 80 W, 2 mJ
- Single-shot – 2 MHz repetition rate
- Pulse-on-demand and BiBurst for pulse control
- Up to 5th harmonic or tunable extensions
- Air-cooled model
- Compact industrial-grade design

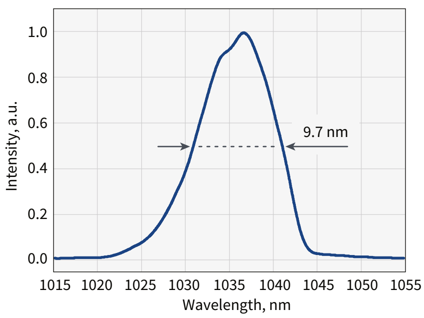
CARBIDE-CB3

CARBIDE is a series of femtosecond lasers combining high average power and excellent power stability. CARBIDE features market-leading output parameters without compromises to beam quality and stability. A compact and robust optomechanical CARBIDE design allows a variety of applications in top-class research centers, as well as display, automotive, LED, medical, and other industries. The reliability of CARBIDE has been proven by hundreds of systems operating 24/7 in the industrial environment.

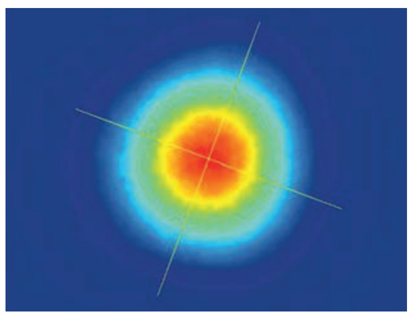
CARBIDE features high-power water-cooled (CB3) and air-cooled (CB5) models. The tunability of CARBIDE lasers enables our customers to discover the most efficient manufacturing processes. Tunable parameters include pulse duration (190 fs – 20 ps), repetition rate (single-shot – 2 MHz), pulse energy (up to 2 mJ), and average power (up to 120 W). A pulse-on-demand mode is available using the built-in pulse picker. The CARBIDE lasers can be equipped with industrial-grade modules, including but not limited to harmonic generators and optical parametric amplifiers.

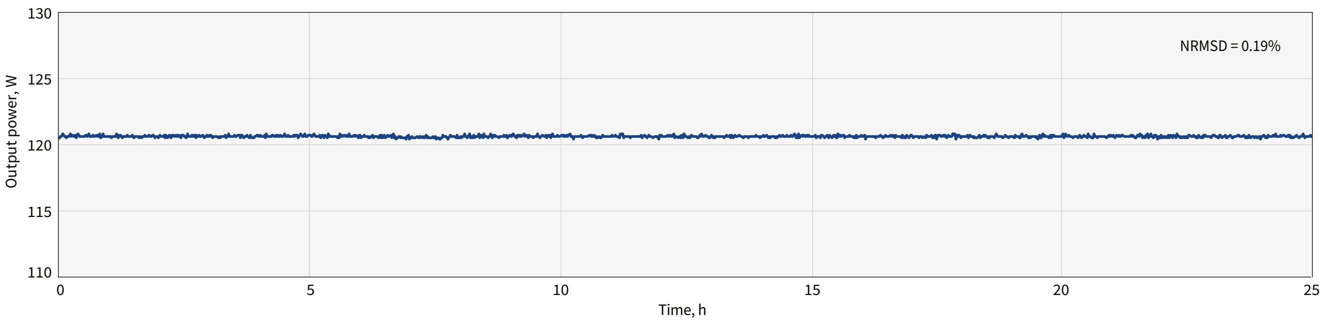


Typical pulse duration of CARBIDE-CB3



Typical spectrum of CARBIDE-CB3


Typical beam profile of CARBIDE-CB3



Long-term power stability of CARBIDE-CB3-120W

LIGHT CONVERSION

REV. 230904

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CARBIDE-CB3 SPECIFICATIONS

Model		CB3-20W	CB3-40W	CB3-80W		CB3-120W NEW
OUTPUT CHARACTERISTICS						
Cooling method		Water-cooled				
Center wavelength [1]		1030 ± 10 nm				
Maximum output power		20 W	40 W	80 W		120 W
Pulse duration [2]		< 250 fs			< 350 fs [3]	< 250 fs
Pulse duration tuning range		250 fs – 10 ps			350 fs – 10 ps	250 fs – 10 ps
Maximum pulse energy		0.4 mJ		0.8 mJ	2 mJ	1 mJ
Repetition rate		Single-shot – 1 MHz	Single-shot – 1 MHz (2 MHz on request)	Single-shot – 2 MHz		Single-shot – 1 MHz (2 MHz on request)
Pulse selection		Single-shot, pulse-on-demand, any fundamental repetition rate division				
Polarization		Linear, vertical; 1 : 1000				
Beam quality, M^2		< 1.2				
Beam diameter [4]		3.9 ± 0.4 mm		4.2 ± 0.4 mm	5.1 ± 0.7 mm	4.5 ± 0.5 mm
Beam pointing stability		< 20 µrad/°C				
Pulse picker		FEC [5]				
Pulse picker leakage		< 0.25%				
Pulse-to-pulse energy stability, 24 h [6]		< 0.5%				
Long-term power stability, 100 h [6]		< 0.5%				
MAIN OPTIONS						
Oscillator output		< 0.5 W, 120 – 250 fs, 1030 ± 10 nm, ≈ 65 MHz [7]				
Harmonic generator [8]		515 nm, 343 nm, 257 nm, or 206 nm; *see page 23*				
Optical parametric amplifier [9]		320 – 10000 nm; *see page 30*				–
BiBurst option		Tunable GHz and MHz burst with burst-in-burst capability; *see page 17*				
PHYSICAL DIMENSIONS						
Laser head (L × W × H)		632 × 305 × 174 mm				
Chiller (L × W × H)		585 × 484 × 221 mm		680 × 484 × 307 mm		
24 V DC power supply (L × W × H) [10]		280 × 144 × 49 mm		320 × 200 × 75 mm		
ENVIRONMENTAL AND UTILITY REQUIREMENTS						
Operating temperature		15 – 30 °C				
Relative humidity		< 80% (non-condensing)				
Electrical requirements	Laser	100 V AC, 7 A – 240 V AC, 3A; 50 – 60 Hz		100 V AC, 12 A – 240 V AC, 5 A; 50 – 60 Hz		
	Chiller	100 – 230 V AC; 50 – 60 Hz		200 – 230 V AC; 50 – 60 Hz		
Rated power	Laser	600 W		1000 W		2000 W
	Chiller	1400 W		2000 W		
Power consumption	Laser	500 W		900 W		1400 W
	Chiller	1000 W		1300 W		1700 W

1) *Precise center wavelength for specific models available upon request.*
2) *Assuming Gaussian pulse shape.*
3) *Pulse duration can be reduced to < 250 fs if pulse peak intensity of > 50 GW/cm² is tolerated by the customer setup.*
4) *FW 1/e², using maximum pulse energy.*
5) *Provides fast energy control; external analog control input available. Response time – next available RA pulse.*
6) *Under stable environmental conditions. Expressed as NRMSD (normalized root mean squared deviation).*
7) *Available simultaneously, requires scientific interface. Contact sales@lightcon.com for details or customized solutions.*
8) *Integrated. For external harmonic generator, refer to HIRO.*
9) *Integrated. For more options and OPAs for -4mJ and -UP models, refer to ORPHEUS series of OPAs.*
10) *Power supply can be different if optional 2 MHz version is selected.*

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

CARBIDE-CB5 SPECIFICATIONS

Model	CB5		CB5-SP
OUTPUT CHARACTERISTICS			
Cooling method	Air-cooled [1]		
Center wavelength [2]	1030 ± 10 nm		
Maximum output power	6 W	5 W	
Pulse duration [3]	< 290 fs		< 190 fs
Pulse duration tuning range	290 fs – 20 ps		190 fs – 20 ps
Maximum pulse energy	100 µJ	83 µJ	100 µJ
Repetition rate	Single-shot – 1 MHz		
Pulse selection	Single-shot, pulse-on-demand, any fundamental repetition rate division		
Polarization	Linear, vertical; 1 : 1000		
Beam quality, M^2	< 1.2		
Beam diameter [4]	2.1 ± 0.4 mm		
Beam pointing stability	< 20 µrad/°C		
Pulse picker	Included	Included [5]	Included
Pulse picker leakage	< 2 %	< 0.1 %	< 2 %
Pulse-to-pulse energy stability, 24 h [6]	< 0.5%		
Long-term power stability, 100 h [6]	< 0.5%		
MAIN OPTIONS			
Oscillator output	n/a		
Harmonic generator [7]	515 nm, 343 nm, 257 nm, or 206 nm; *see page 23*		
Optical parametric amplifier [8]	320 – 10000 nm; *see page 30*		
BiBurst option	n/a		
PHYSICAL DIMENSIONS			
Laser head (L × W × H)	631 × 324 × 162 mm		
Chiller	Not required		
24 V DC power supply (L × W × H)	220 × 95 × 46 mm		
ENVIRONMENTAL AND UTILITY REQUIREMENTS			
Operating temperature	17 – 27 °C		
Relative humidity	< 80% (non-condensing)		
Electrical requirements	100 V AC, 3 A – 240 V AC, 1.3 A; 50 – 60 Hz		
Rated power	300 W		
Power consumption	150 W		

1) *Water-cooled version available on request.*
2) *Precise center wavelength for specific models available upon request.*
3) *Assuming Gaussian pulse shape.*
4) *FW 1/e², using maximum pulse energy.*
5) *Enhanced contrast AOM. Provides fast amplitude control of output pulse train.*
6) *Under stable environmental conditions. Expressed as NRMSD (normalized root mean squared deviation).*
7) *Integrated. For external harmonic generator, refer to HIRO.*
8) *Integrated. For stand-alone OPAs, refer to ORPHEUS series of OPAs.*

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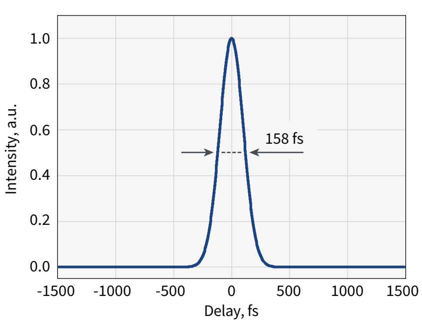
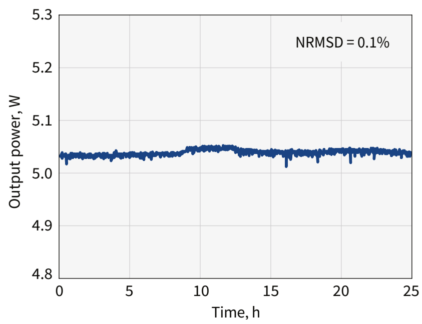
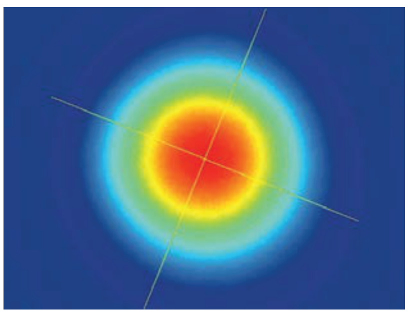


Typical pulse duration of CARBIDE-CB5



Long-term power stability of CARBIDE-CB5


Typical beam profile of CARBIDE-CB5

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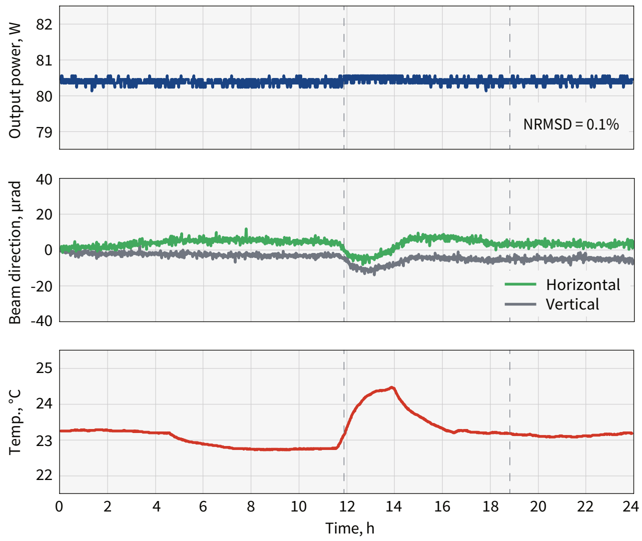
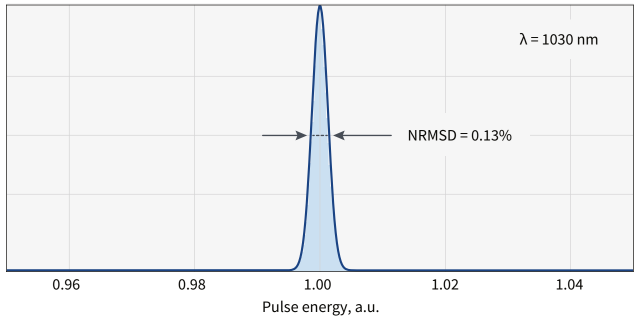
STABILITY MEASUREMENTS

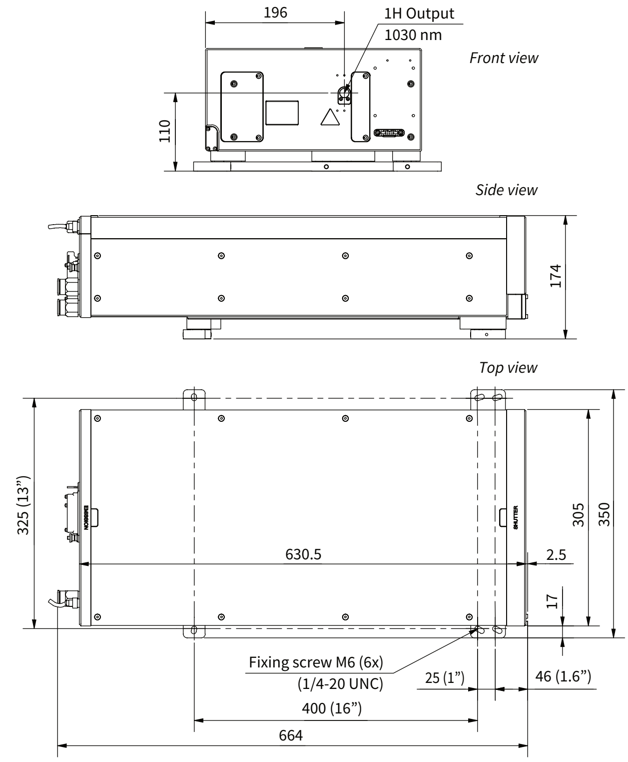


CARBIDE-CB3 output power and beam direction with power lock enabled, under varying environmental conditions

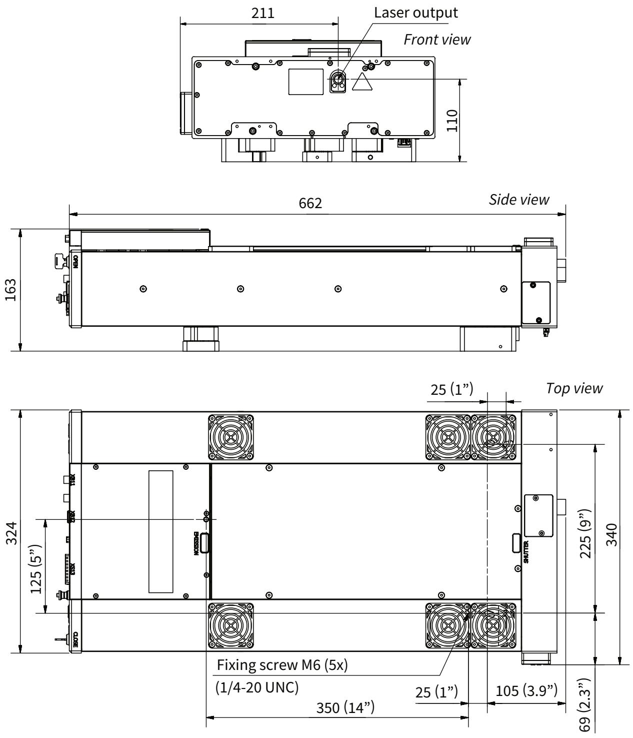


Typical pulse-to-pulse energy stability

DRAWINGS



Drawing of CARBIDE-CB3



Drawing of air-cooled CARBIDE-CB5 with attenuator

CARBIDE | CB3-UV

NEW

High-Power UV Femtosecond Lasers

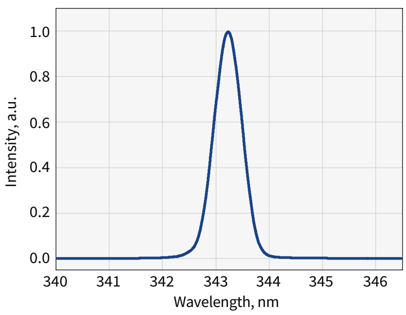
FEATURES

- Maximum output of 50 W
- 500 fs pulse duration
- Up to MHz repetition rate
- High beam quality and stability
- Compact industrial-grade design

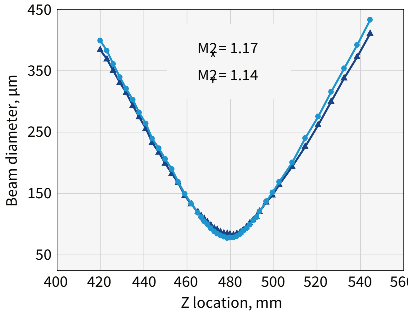
CARBIDE-CB3-UV

CARBIDE-CB3-UV is a series of femtosecond lasers for high-power ultraviolet (UV) applications. As indicated by its name, the CARBIDE-CB3-UV laser is based on a market-proven industrial-grade CARBIDE laser platform. It emits 500 fs pulses at a 343 nm wavelength and fits into the footprint of 84 × 35 cm^2, making it the most compact 50 W UV femtosecond laser currently available in the market.

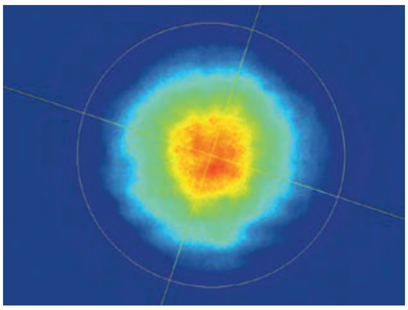
The CARBIDE-CB3-UV ensures long-term performance without the need for user intervention. The high power comes with the advantage of splitting the beam into multiple parts, thereby parallelizing the micromachining processes and subsequently increasing throughput. The CARBIDE platform ensures simple integration into industrial 24/7 workstations.



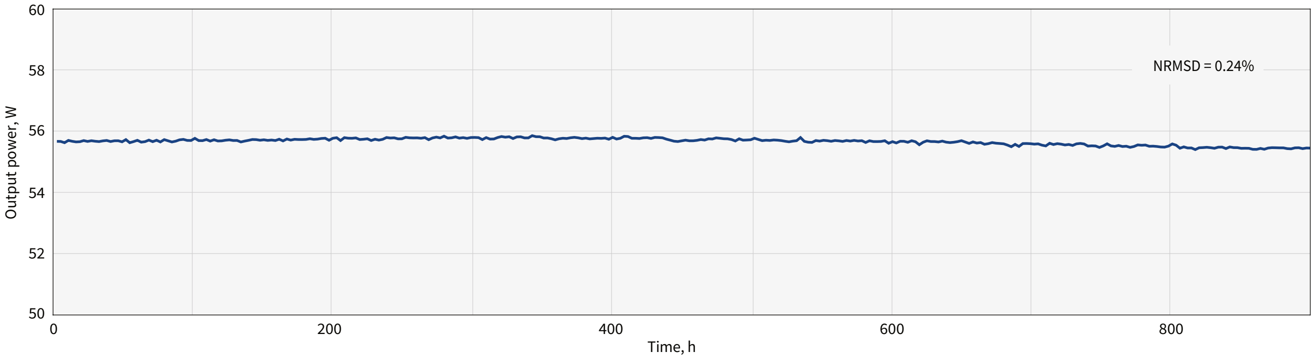
Typical spectrum of CARBIDE-CB3-UV



Typical M^2 measurement data of CARBIDE-CB3-UV



Beam profile of CARBIDE-CB3-UV-50W



Long-term power stability of CARBIDE-CB3-UV-50W

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SPECIFICATIONS

Model		CB3-UV-30W	CB3-UV-50W (NEW)
OUTPUT CHARACTERISTICS			
Cooling method		Water-cooled	
Center wavelength		343 ± 3 nm	
Maximum output power		> 30 W	> 50 W
Pulse duration [1]		≈ 500 fs	
Output pulse energy		35 – 150 µJ	
Repetition rate		200 – 800 kHz	300 – 1200 kHz
Polarization		Linear, vertical; 1 : 200	
Beam quality, M^2		< 1.3	
Beam diameter [2]		2.5 – 5 mm	
Long-term power stability, 12 h [3]		< 0.5%	
Lifetime		10000 h	
MAIN OPTIONS			
Optional amplifier outputs		1030 nm, 515 nm	
PHYSICAL DIMENSIONS			
Laser head (L × W × H)		832 × 350 × 174 mm	
Chiller (L × W × H)		680 × 484 × 307 mm	
24 V DC power supply (L × W × H)		320 × 200 × 75 mm	
ENVIRONMENTAL AND UTILITY REQUIREMENTS			
Operating temperature		15 – 30 °C	
Relative humidity		< 80% (non-condensing)	
Electrical requirements	Laser	100 V AC, 12 A – 240 V AC, 5 A	
	Chiller	200 – 230 V AC; 50 – 60 Hz	
Rated power	Laser	1000 W	
	Chiller	2000 W	
Power consumption	Laser	900 W	
	Chiller	1300 W	

1) *Assuming Gaussian pulse shape.*
2) *FW $1/e^2$, using maximum pulse energy.*
3) *Under stable environmental conditions. Expressed as NRMSD (normalized root mean squared deviation).*

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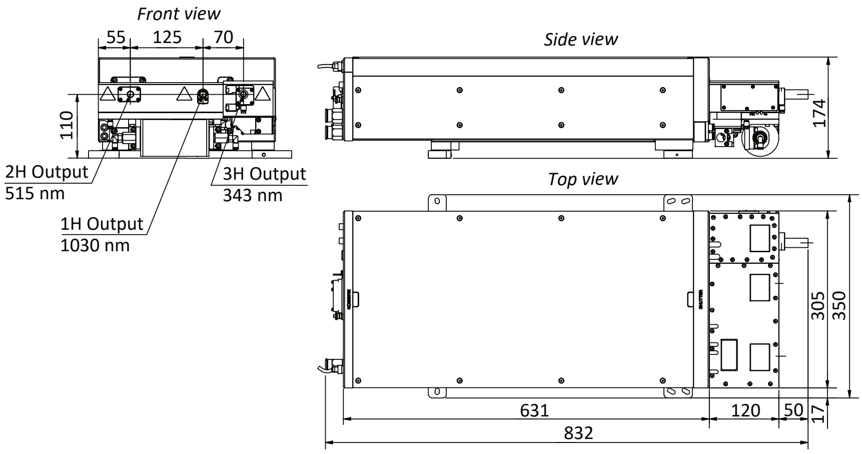
DRAWINGS



Drawing of CARBIDE-CB3-UV

SCI-M | CARBIDE

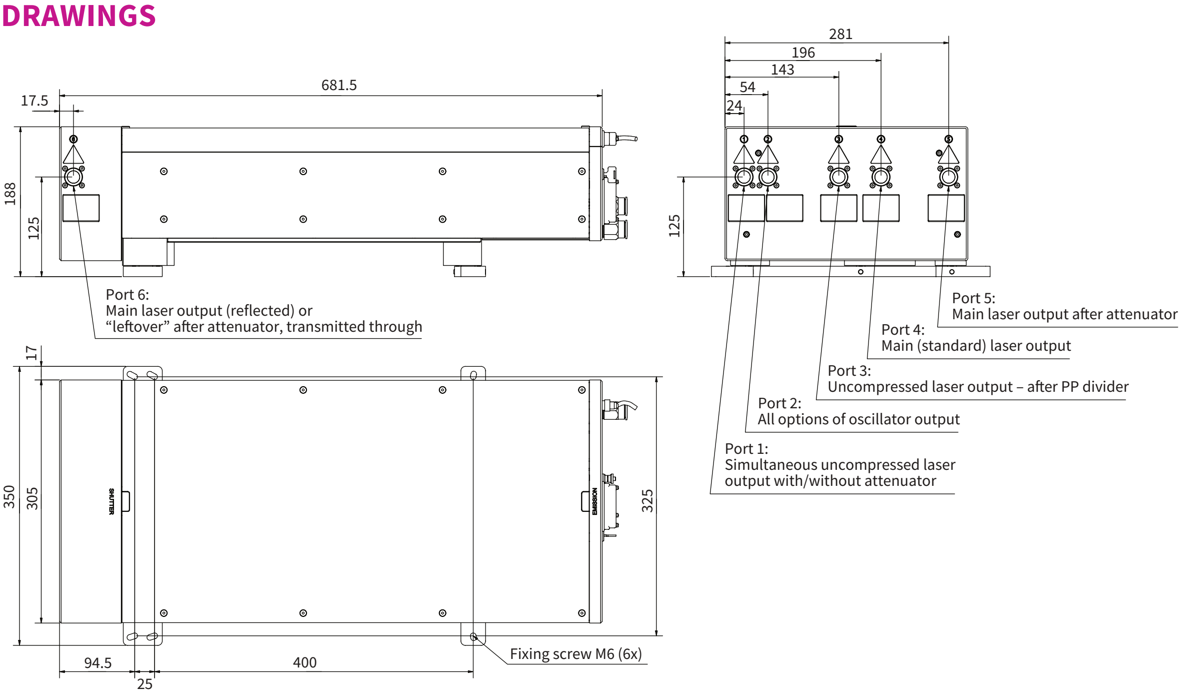
Scientific Interface Module for CARBIDE

FEATURES

- Simultaneous or separate oscillator output
- Uncompressed laser output
- Seeding by an external oscillator
- Beam-splitting options

The CARBIDE scientific interface module extends the versatility of the industrial-grade laser and makes it particularly attractive to scientific applications. This module incorporates multiple options such as a simultaneous or separate oscillator output, a second compressed or uncompressed laser output, and seeding by an external oscillator. For example, using it, the CARBIDE laser can be seeded by an oscillator from another CARBIDE laser, thus ensuring a precise optical synchronization between the two lasers. All the aforementioned outputs can be equipped with automated power attenuators. All options are compatible in between.

DRAWINGS



Drawing of CARBIDE-CB3-40-200 with scientific interface module

HG | CARBIDE

Automated Harmonic Generators

FEATURES

- 515 nm, 343 nm, or 257 nm output
- Automated harmonic selection
- Mounted directly on the laser head
- Industrial-grade design
- 50 W UV model

CARBIDE-CB3 with 2H-3H

CARBIDE lasers equipped with automated harmonic generators (HGs) provide a selection of fundamental (1030 nm), second (515 nm), third (343 nm), or fourth (257 nm) harmonic outputs using software control.

HGs are perfect for industrial applications that require a single-wavelength output. Modules, mounted directly at the output of the laser, are fully integrated into the system.

SPECIFICATIONS

Model		2H	2H-3H	2H-4H	30W UV [1]	50W UV [1]
Output wavelength [2] (automated selection)		1030 nm 515 nm	1030 nm 515 nm 343 nm	1030 nm 515 nm 257 nm	1030 nm 515 nm 343 nm	1030 nm 343 nm
Pump pulse energy		20 – 2000 µJ	50 – 2000 µJ	20 – 2000 µJ	80 – 400 µJ	120 – 400 µJ
Pump pulse duration		< 300 fs			≈ 500 fs	
Conversion efficiency / Output power		> 50% (2H)	> 50% (2H) > 25% (3H)	> 50% (2H) > 10% (4H) [3]	40 W (2H) 30 W (3H)	50 W (3H)
Beam quality (M²) typical values	≤ 400 µJ pump	< 1.15 (2H)	< 1.15 (2H) < 1.2 (3H)	< 1.15 (2H) n/a (4H)	< 1.2 (2H) < 1.3 (3H)	< 1.3 (3H)
	> 400 µJ pump	< 1.2 (2H)	< 1.2 (2H) < 1.3 (3H)	< 1.2 (2H) n/a (4H)	n/a	

1) Refer to CARBIDE-CB3-UV for more details.
2) Depends on pump laser model. Up to 5th harmonic available; contact sales@lightcon.com for details.
3) Maximum output power of 1 W.

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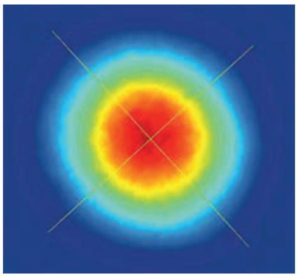
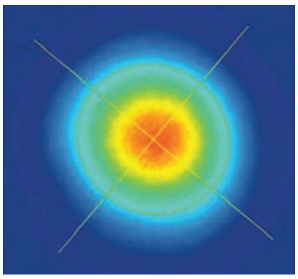
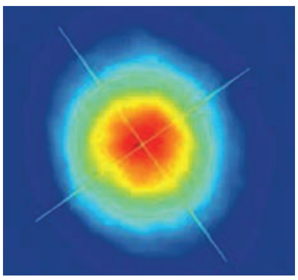
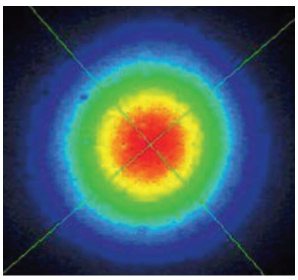
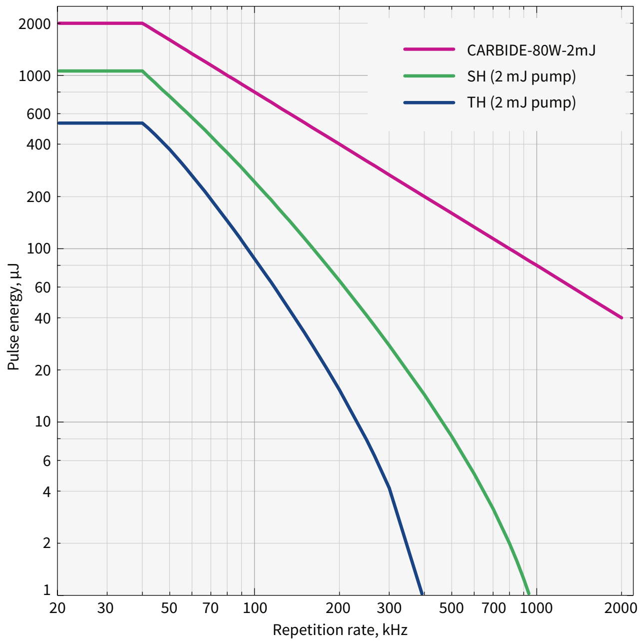

Typical 1H beam profile of CARBIDE-CB5 (100 kHz, 6 W)


Typical 2H beam profile of CARBIDE-CB5 (100 kHz, 3.4 W)


Typical 3H beam profile of CARBIDE-CB5 (100 kHz, 2.2 W)


Typical 4H beam profile of CARBIDE-CB5 (100 kHz, 100 mW)



Pulse energy vs repetition rate of CARBIDE-CB3-80W with HG

BiBurst option

Tunable GHz and MHz Burst with Burst-in-Burst Capability

PHAROS and CARBIDE-CB3 lasers have an option for tunable GHz and MHz burst with burst-in-burst capability – called BiBurst.

In standard mode, a single pulse is emitted at some fixed frequency. In burst mode, the output consists of pulse packets instead of single pulses. Each packet consists of a certain number of equally separated pulses. MHz-Burst contains N pulses with a nanosecond period, GHz-Burst contains P pulses with a picosecond period. If both bursts are used, the equally separated pulse packets contain sub-packets of pulses (burst-in-burst, BiBurst).

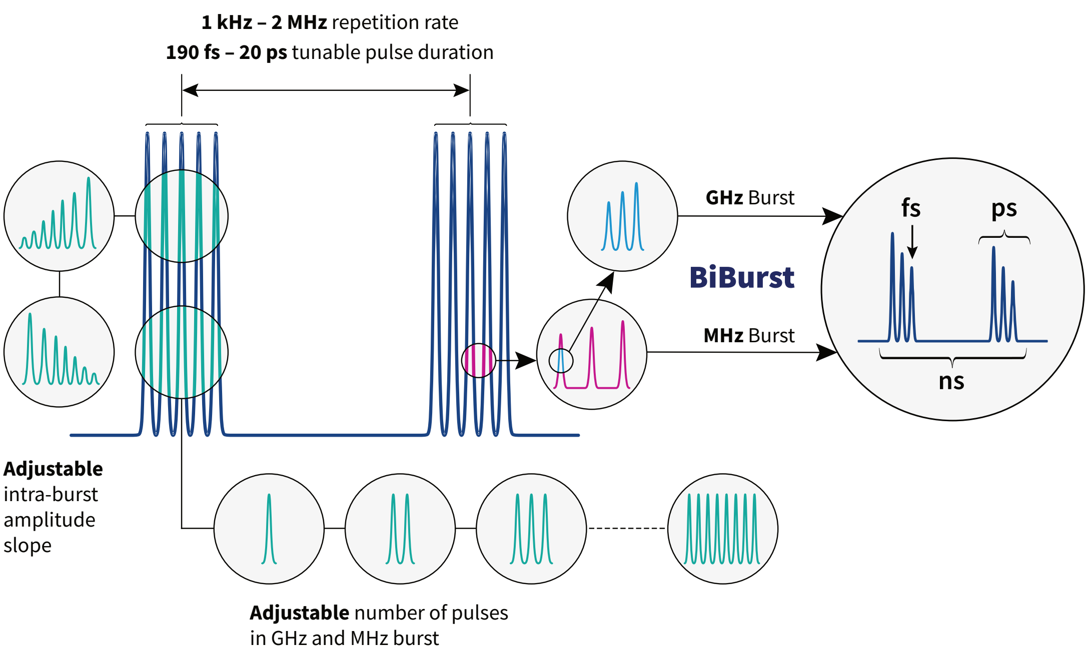
PHAROS and CARBIDE lasers with the BiBurst option bring new capabilities to high-tech manufacturing industries such as consumer electronics, integrated photonic chip manufacturing, future display manufacturing, and quantum technologies. The applications include:

- brittle material drilling and cutting
- deep engraving
- selective ablation
- volume modification of transparent materials
- hidden marking
- surface polishing
- surface functionalization

SPECIFICATIONS

Model		CARBIDE-CB3	PHAROS
GHz Burst	Intra burst pulse period [1]	440 ± 40 ps	200 ± 40 ps
	Number of pulses, P [2]	1 – 10	1 – 25
MHz Burst	Intra burst pulse period	≈ 15 ns	
	Number of pulses, N	1 – 10	1 – 9 (7 with FEC [3])

[1] *Custom spacing is available on request.*
[2] *Maximum number of pulses in a burst depends on the laser repetition rate and the energy. Custom number of pulses is available on request.*
[3] *Fast energy control option. Enables formation of any pulse envelope at laser pulse repetition rate.*



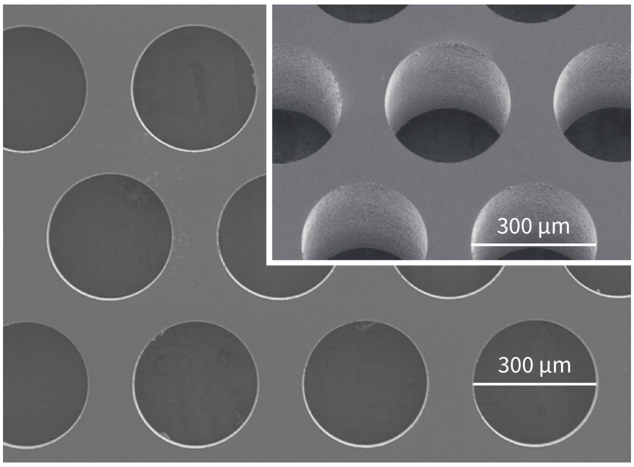
Micro- and Nanofabrication

Birefringent volume modification in glass

Form induced birefringence-retardance variation results in different colors in parallel polarized light.

Source: Workshop of Photonics.

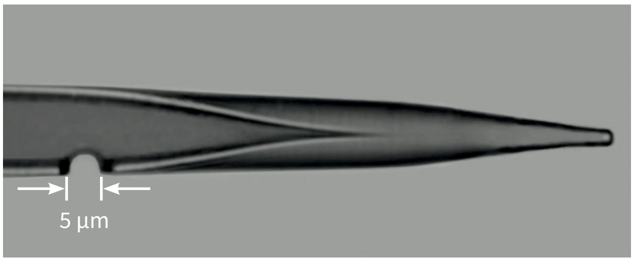
High precision glass drilling



Various glass drilling.

Source: Workshop of Photonics.

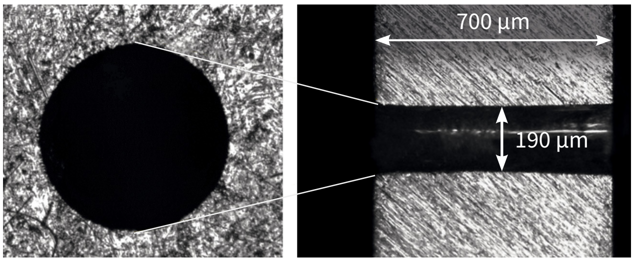
Glass needle microdrilling



Glass needle microdrilling.

Source: Workshop of Photonics.

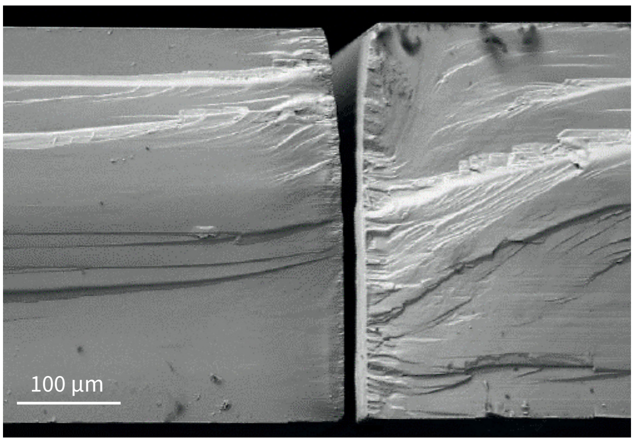
Steel drilling



Taperless hole microdrilling in stainless steel alloys.

Source: Workshop of Photonics.

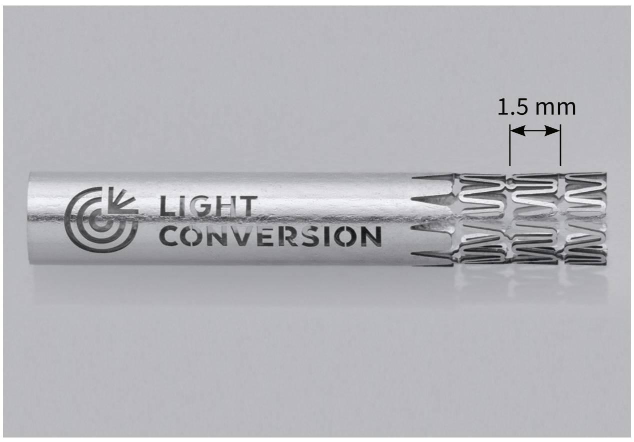
Brittle & highly thermal-sensitive material cutting



Multi-pass cadmium tungstate cutting.
No cracks. All thermal trace effects eliminated.

Source: Micronanics Laser Solutions Centre.

Stainless steel stent cutting



Cutting from stainless steel.

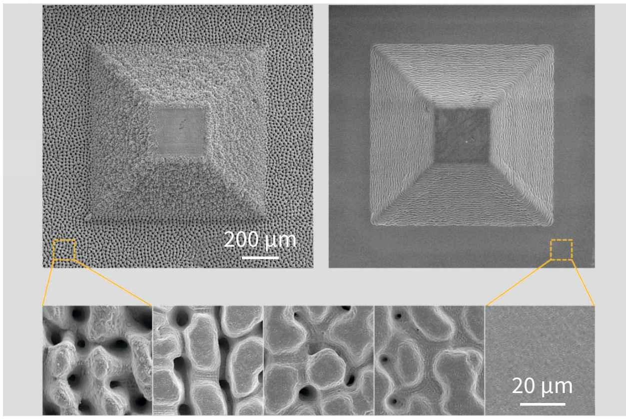
Example of stent cut from stainless steel.

Milling of complex 3D surfaces

3D milled sample in copper. Zoom in SEM image.

Source: "Highly-efficient laser ablation of copper by bursts of ultrashort tuneable (fs-ps) pulses", A.Žemaitis, P.Gečys, M.Barkauskas, G.Račiukaitis, M.Gedvilas. Scientific Reports (2019).

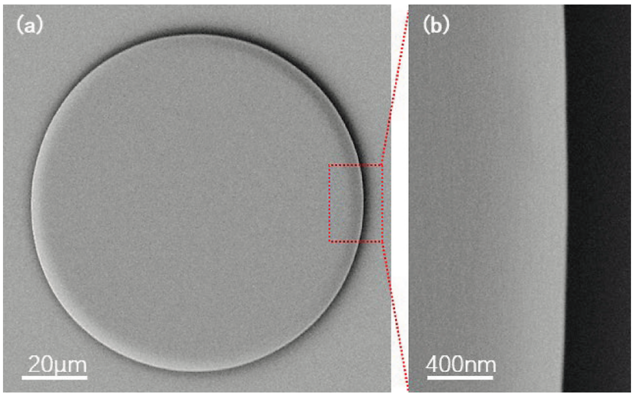
Stainless steel polishing



SEM imags of structures ablated in stainless steel, before and after polishing using GHz burst (from left to right).

Source: "High quality surface treatment using GHz burst mode with tunable ultrashort pulses", D.Metzner , P.Lickschat and S.Weißmantel. Applied Surface Science (2020).

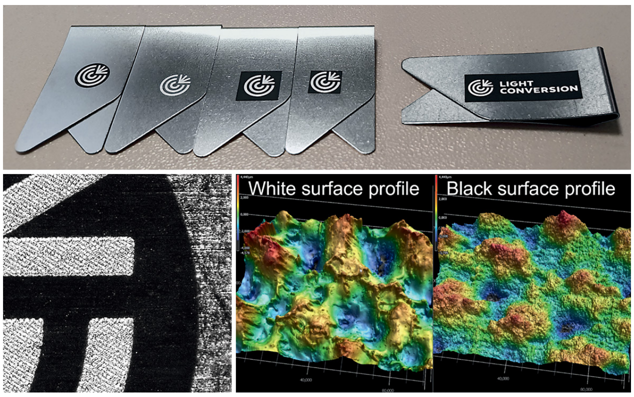
Selective ablation



Lithium niobate microdisks fabricated using selective ablation.

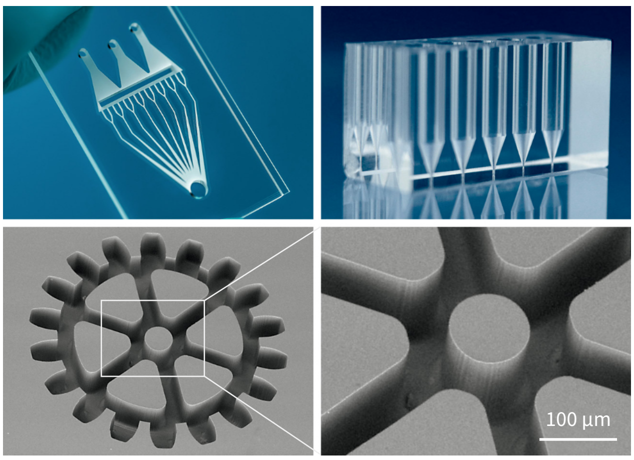
Source: "Fabrication of crystalline microresonators of high quality factors with a controllable wedge angle on lithium niobate on insulator", J.Zhang, Z.Fang, J.Lin, J.Zhou, M.Wang, R.Wu, R.Gao, Y.Cheng. Nanomaterials (2019).

High-contrast marking



High-contrast black-and-white marking on stainless steel clips using the BiBurst option.

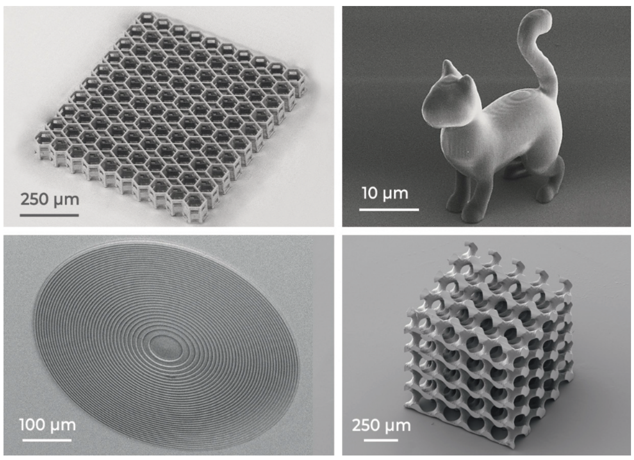
3D glass etching



Various structures fabricated in fused silica glass.

Source: Workshop of Photonics & Femtika.

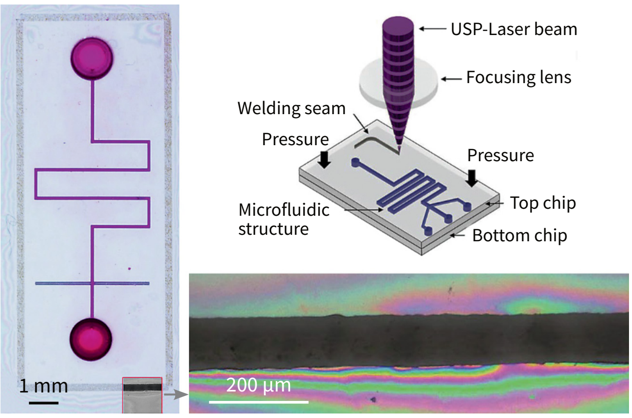
3D multiphoton polymerization



Various 3D structures fabricated in SZ2080 polymer using multi-photon polymerization.

Source: Workshop of Photonics & Femtika.

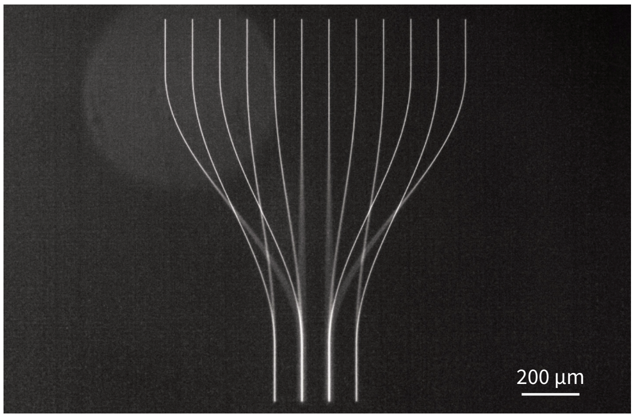
Lab-on-chip channel ablation and welding



Welding of transparent polymers for sealing of microfluidic devices. Top view on a sealed microfluidic device (left), welding seam (bottom right).

Source: “A new approach to seal polymer microfluidic devices using ultrashort laser pulses”, G. Roth, C. Esen and R. Hellmann. JLMN-Journal of Laser Micro/Nanoengineering (2019).

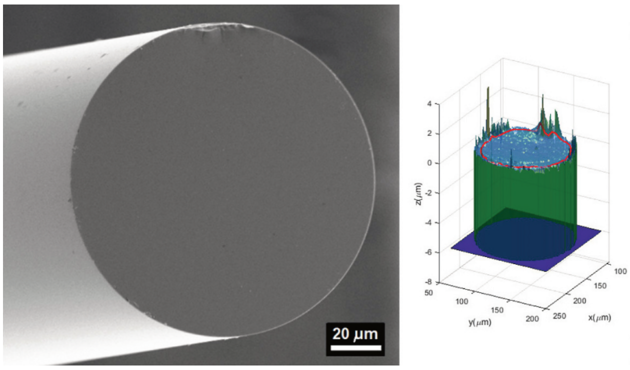
3D waveguides



3D waveguides fabricated in fused silica glass.

Source: Workshop of Photonics.

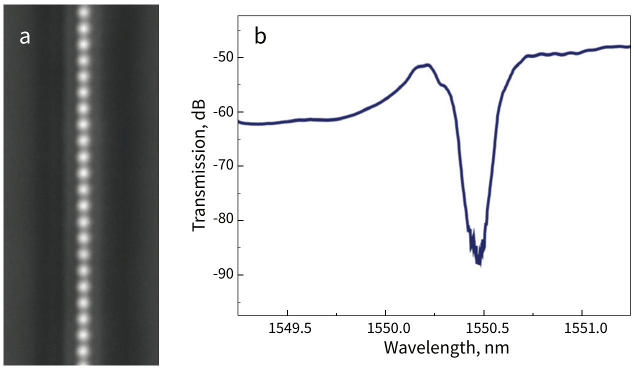
Fiber cleaving



Fiber end face after laser-based scribing (left) and its surface profile (right).

Source: RMIT University, Melbourne.

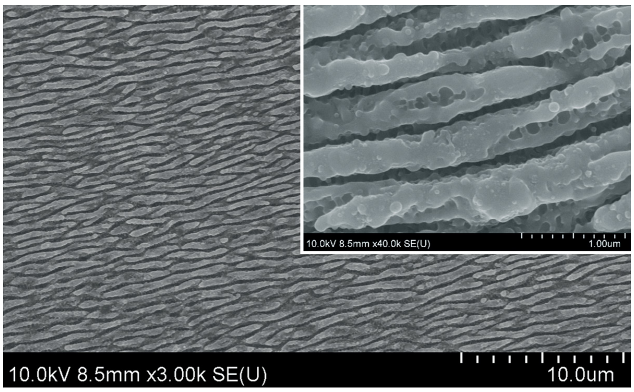
Bragg grating waveguide (BGW) writing



First-order Bragg gratings inscribed in waveguide (a). Resonant spectral transmission of inscribed BGW (b).

Source: “Ultrashort Bessel beam photoinscription of Bragg grating waveguides and their application as temperature sensors”, G.Zhang, G. heng, M.Bhuyan, C.D’Amico, Y.Wang, R.Stoian. Photon. Res. (2019).

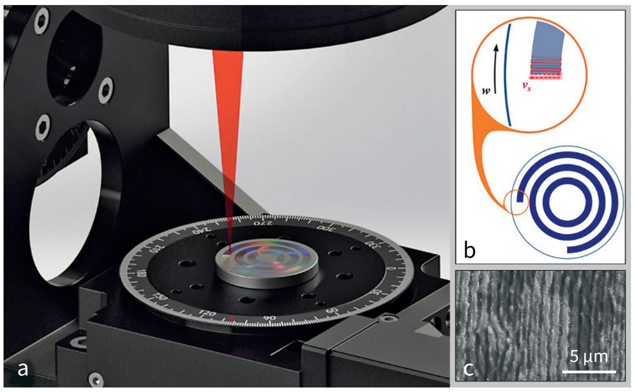
SERS sensor fabrication



SEM image of the Ti-6Al-4V (TC4) surface after irradiation with progressive laser scan.

Source: “Large-scale fabrication of nanostructure on bio-metallic substrate for surface enhanced Raman and fluorescence scattering”, L.Lu, J.Zhang, L.Jiao, Y.Guan. Nanomaterials (2019).

Friction and wear reduction



Schematic of the laser treatment (a), laser patterning strategy (b), SEM image of induced LIPSS (c).

Source: “Tribological properties of high-speed uniform femtosecond laser patterning on stainless steel”, I.Gnilitskyi, A.Rota, E.Gualtieri, S.Valeri, L.Orazi. Lubricants (2019).