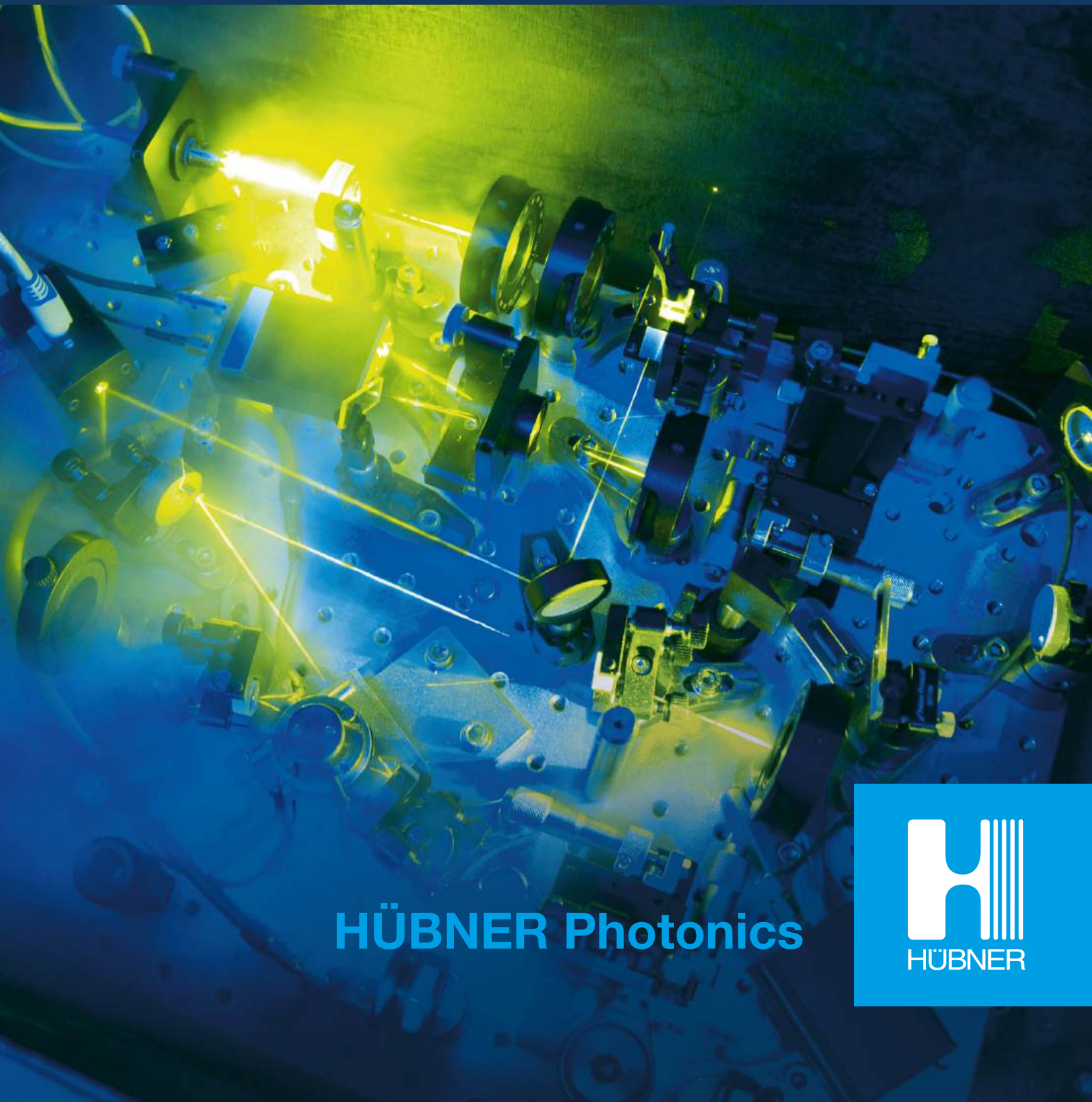


# Laser and Terahertz Technology

**HÜBNER Photonics** | Coherence matters.



**HÜBNER Photonics**



**Mobility. Materials. Photonics.** | united by passion.

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HÜBNER Group  
**Mobility. Materials. Photonics.**  
united by passion.



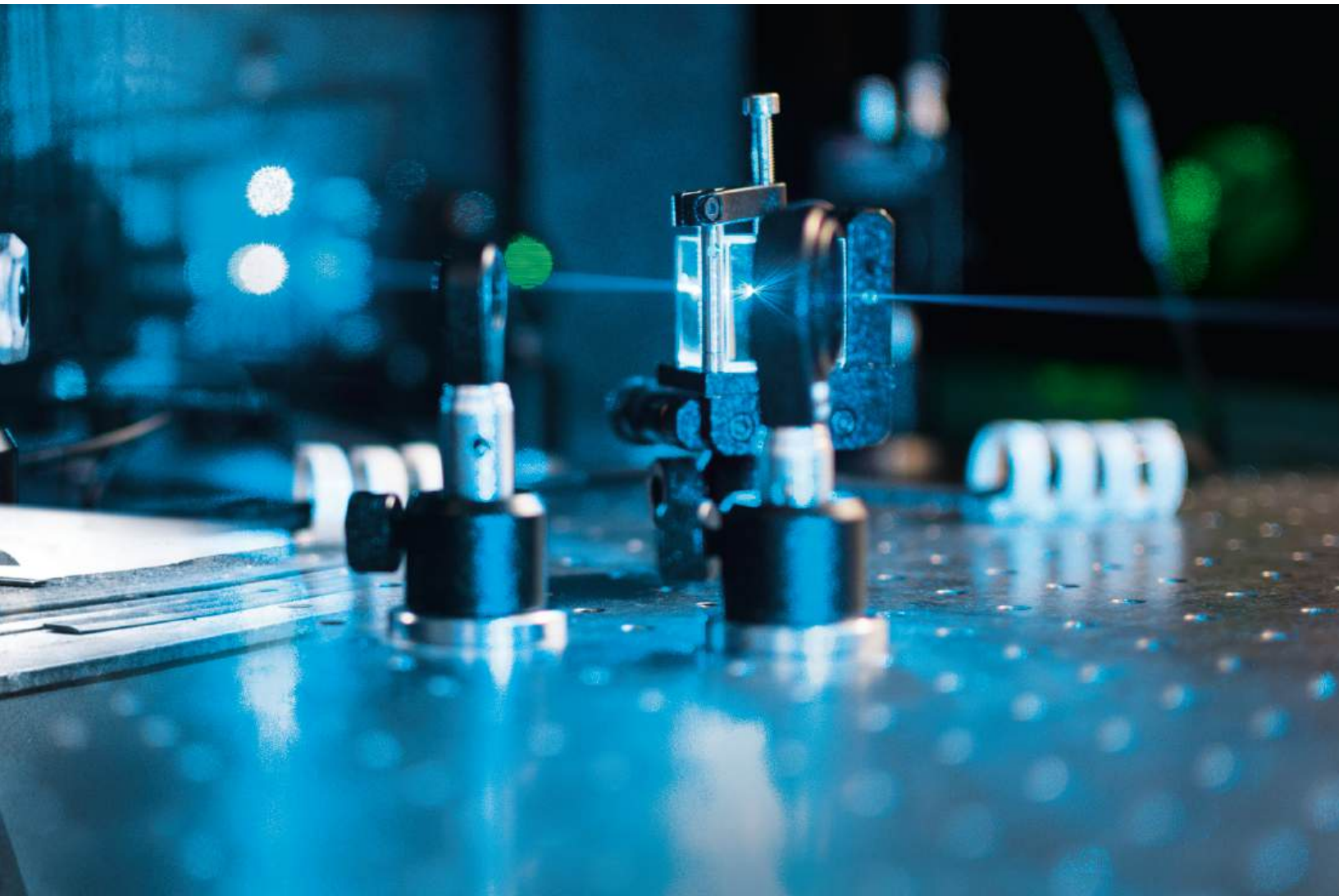


Since the beginning in 1946 when Kurt Hübner founded the company, HÜBNER has been shaped by a spirit of enterprise, inventiveness and innovation. Today it continues to be the same passion for new solutions that drives the company and its employees. Again and again over the years, new concepts for new products and new markets have been developed and implemented.

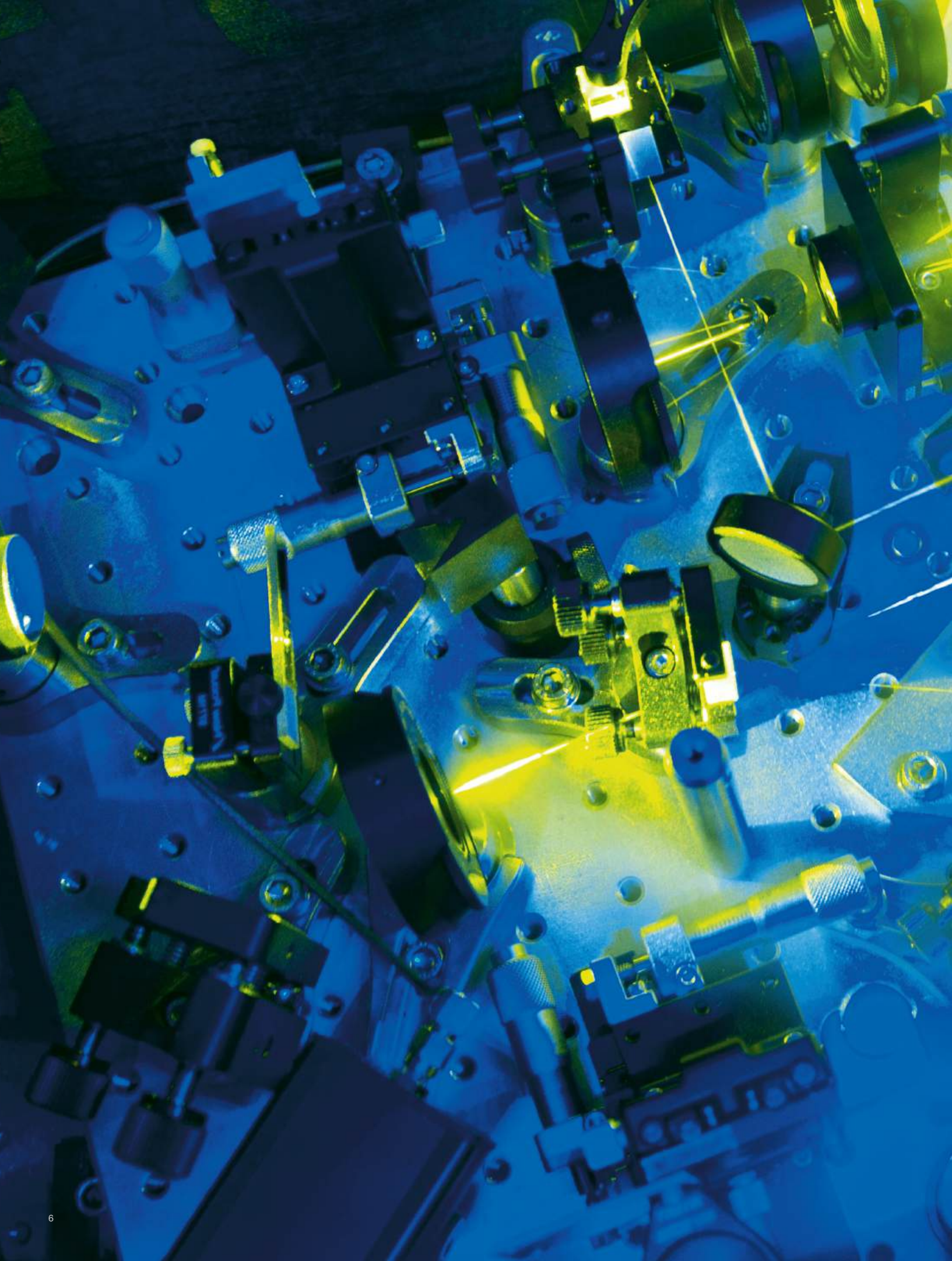
It is on this basis that HÜBNER has become the company that it is today: A comprehensive system supplier for transportation technology and the worldwide leader for gangway systems (Mobility), a well-recognized specialist for sophisticated elastomer solutions and products, insulation and composite materials (Material Solutions), as well as an up-and-coming company in the field of laser and terahertz technologies (Photonics).

Today the HÜBNER Group consists of more than 30 different companies and has more than 3,500 employees around the world. And HÜBNER products continue to stand out with their high-quality workmanship, their superior convenience and their distinctive durability. This high level of quality is to be found in all of the Group's business sectors and throughout the entire product range.

This all comes together in our company slogan:  
**Mobility. Materials. Photonics.** | united by passion.











# HÜBNER Photonics | Coherence matters.

“Two wave sources are perfectly coherent if they have a constant phase difference and the same frequency.” In a way, this condition sums up everything HÜBNER Photonics stands for.

We not only make game-changing lasers and light sources, but also rethink all kinds of other wave technologies including terahertz imaging and spectroscopy. The proven corporate values of the HÜBNER Group are brought together with innovative ideas and top-notch technologies.

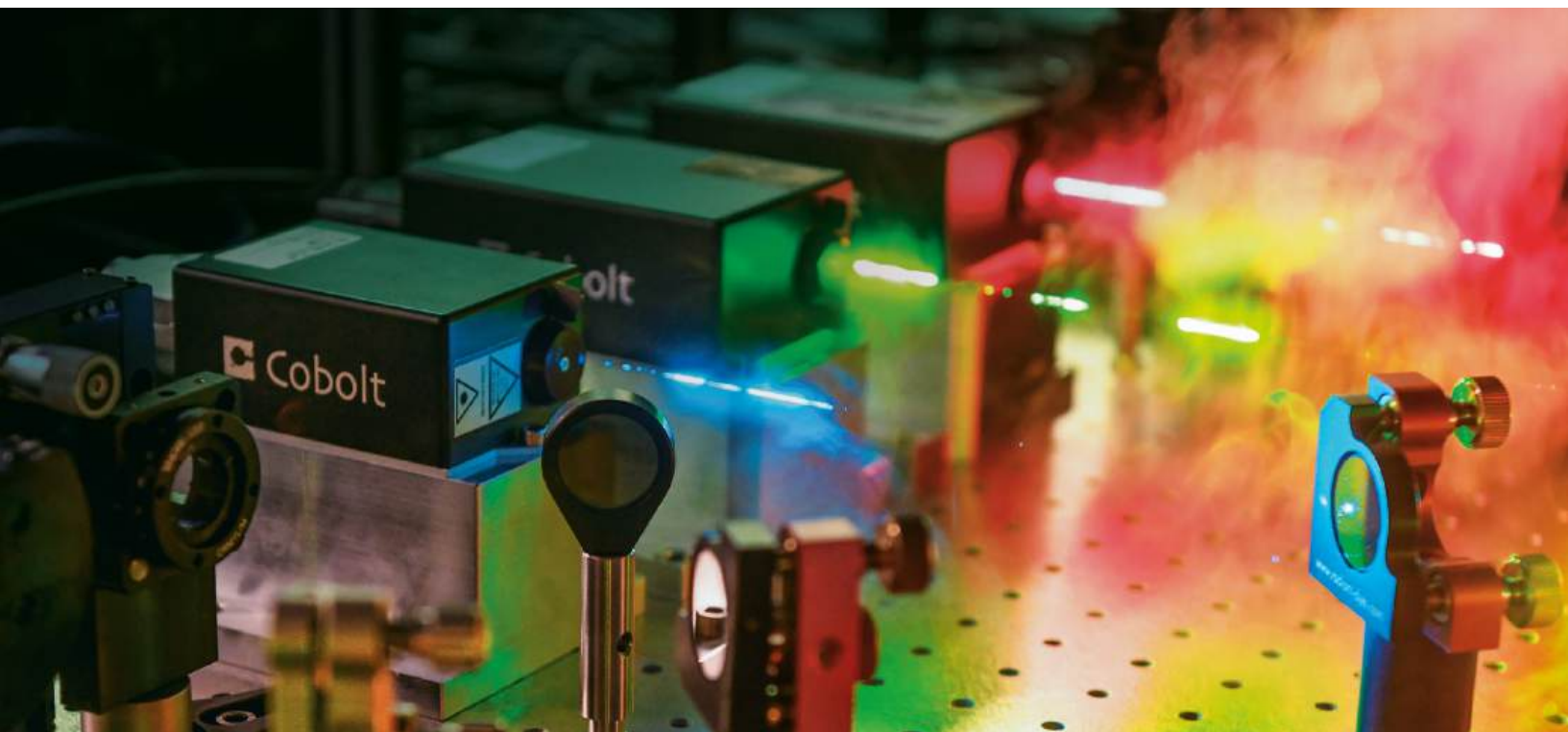
Coherence for us is far more than the perfect interaction of waves. It is the basis of our daily work and the fundament on which we build our business and our relations within our company and with our partners.

Coherence matters for our products – since we are committed to supplying reliable, innovative high performance photonics solutions.

Coherence matters in our attitude – our teams are built up by world-leading expertise in photonics, moving as one.

Coherence matters in our customer relations – we operate in phase with our customers’ needs and therefore stand out by maximizing customer value.

Coherence matters is in our genes and our spirit – all day, every day.



# TERAHERTZ TECHNOLOGY

## Terahertz technology

### **An innovative tool for the detection, analysis and imaging of materials**

Outstanding ease of use, extremely compact and entirely safe for persons and materials – these are the characteristics of the terahertz systems developed by HÜBNER Photonics on the basis of cutting edge research. Using terahertz waves, the new devices make it possible to visualize concealed contents in various enclosures. For example, in letters and packages, suspicious substances and objects can be detected immediately and analyzed and visualized with hyperspectral imaging within seconds. The HÜBNER Photonics imagers and spectrometers are therefore especially well suited for use in mail-rooms and other settings where security is essential. The devices also offer unique capabilities for non-destructive quality control in connection with industrial production.



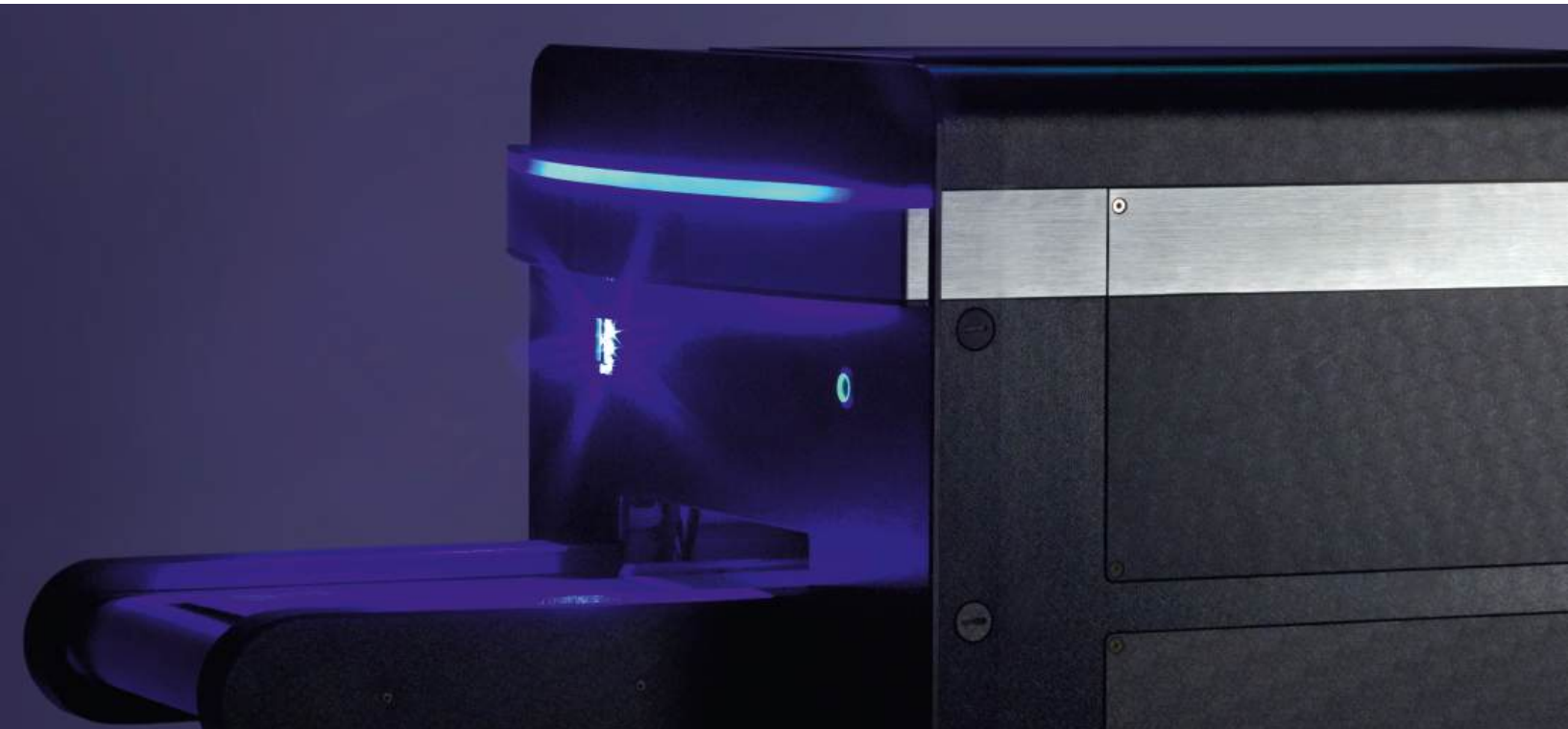


# LASER TECHNOLOGY

## Laser technology

### High-performance lasers for science and industry

HÜBNER Photonics offers a wide assortment of high performance laser products which meet the ever increasing opportunities for lasers in science and industry. This portfolio includes compact single frequency CW lasers, single frequency tunable CW lasers, multi-line lasers, diode lasers, frequency locked lasers, Q-switched lasers, femtosecond lasers and laser combiners covering the full UV-Visible-MidIR spectrum. Main application markets are to be found in spectroscopy, holography, quantum optics and many others. The combination of competencies across the HÜBNER Photonics division facilitates volume manufacturing of exceptional laser designs with unparalleled reliability. This means that life science and analytical instrument manufacturers now have a supplier they can really rely on and research scientists have a reputable source for lasers to meet their needs.



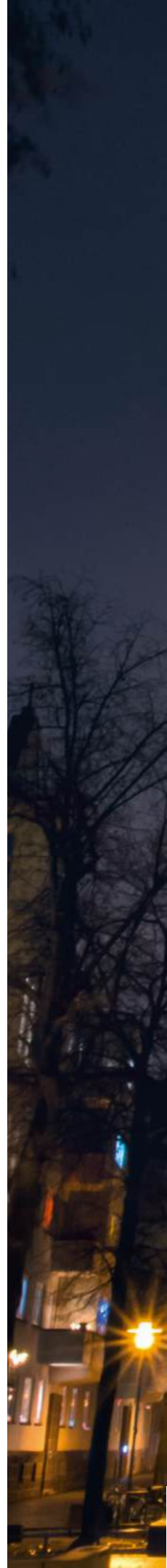
## History **A bright way into the future**

Again and again, HÜBNER has been a driving force for technological progress. The family-owned company places a high priority on the innovative value and quality of its products and concepts – from the initial idea to the market-ready product.

In the field of laser and terahertz technologies, HÜBNER made a commitment to basic research early on and began to cooperate with leading scientific institutes. The company secured further know-how through its integration of the Swedish laser manufacturer Cobolt in 2015.

Even before the company's activities had been combined into the new business segment HÜBNER Photonics, two in-house developments received the renowned photonics Prism Award – the tunable laser C-WAVE as well as the terahertz spectrometer T-COGNITION.

In addition to its involvement in fundamental science, HÜBNER Photonics is also committed to ensuring the utility of its developments for customers in the industry. Many products and solutions are developed in close cooperation with industrial customers and with an eye on their specific needs. And these products also undergo continual enhancement and improvement based on the demands of commercial use. In addition, all customers benefit from the wide cross-industry know-how of the HÜBNER Group.







**2025** Ampheia™ product line introduced

**2021** Acquisition of VALO Innovations GmbH

**2019** Expansion of clean-room facilities in Kassel and Stockholm

**2017** Introduction of Cobolt Skyra™ and C-FLEX

**2016** Formation of new division HÜBNER Photonics, encompassing laser and terahertz technology

**2015** Acquisition of Cobolt AB

**2014** Prism Award for C-WAVE and T-COGNITION™

**2012** Diversification into laser technology in collaboration with Fraunhofer Institute

**2008** Introduction of HTCure™ process by Cobolt

**2006** Diversification from HÜBNER into terahertz technology in collaboration with Fraunhofer Institute

**2000** Founding of Cobolt AB

**1952** Production of rubber tubing connections as gangways for railway passenger cars of the Deutsch Bahn and production of the folding bellows for articulated buses

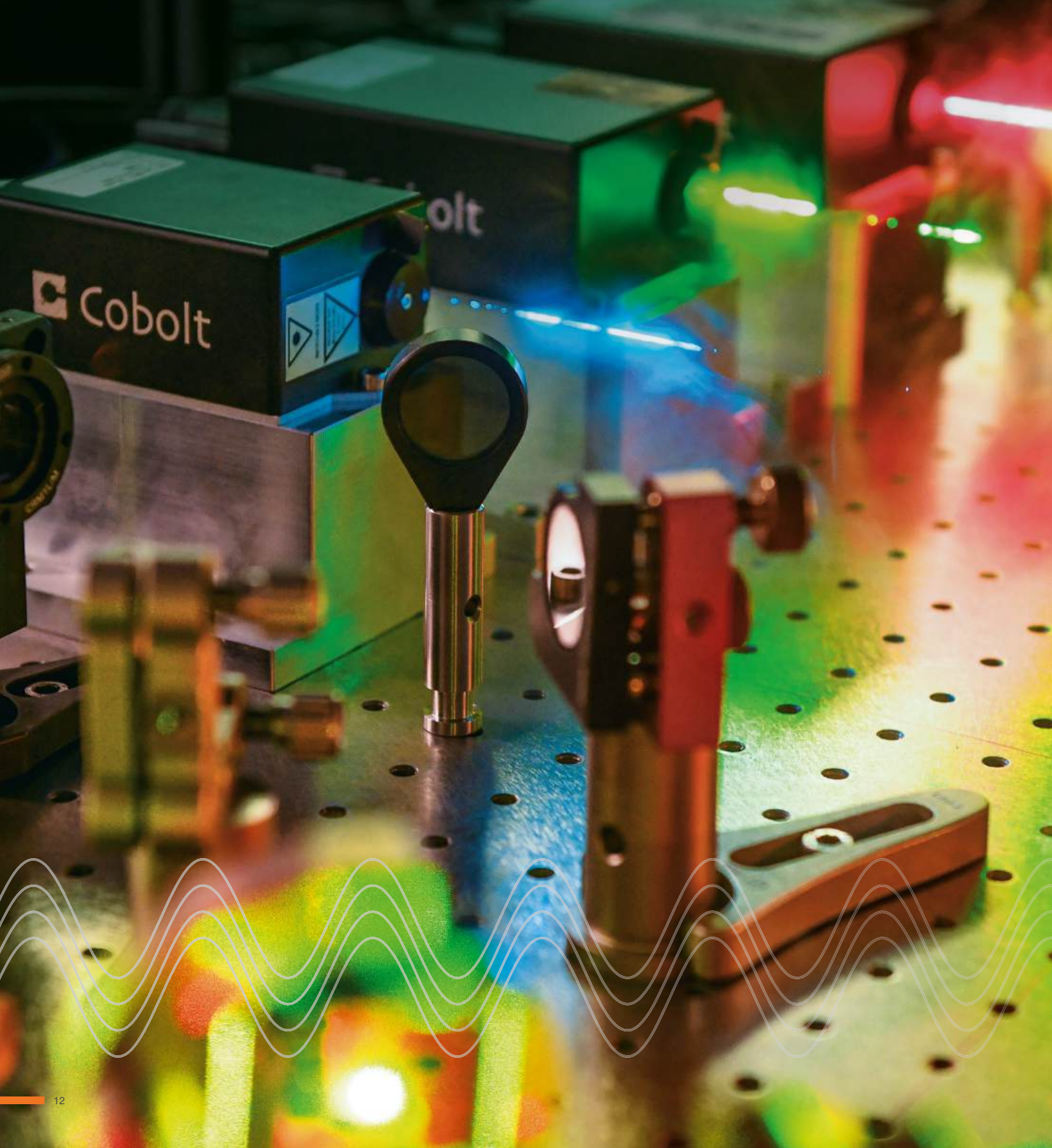
**1946** Founding of the company by Kurt Hübner in Kassel, Germany. Start of rubber production activities

Lasers have long played a special role in Kassel, where the HÜBNER headquarters is located. For more than 40 years, green laser lines have marked the night sky of the city. Kassel's "Laserscape", created for the Documenta exhibition in 1977, is the world's first permanent laser light artwork.



# Laser technology

## LASER TECHNOLOGY





# High-performance lasers

## A wide array of laser sources

Laser technology has come to have an indispensable role in scientific and medical research, in industrial production and even in many everyday applications from cosmetics to autonomous vehicles. At HÜBNER Photonics, our laser technology is offered in 5 product lines:



### Ampheia™ – Ultra-Low Noise Fiber Amplifier & Laser Systems

Fiber laser systems with unparalleled performance. Ultra-low noise and exceptional relative intensity noise set Ampheia apart from the competition. A complete laser system that is affordable, with outstanding laser performance.



### C-FLEX – Laser combiner

With the trend towards simplicity and user friendliness, the C-FLEX laser combiners offer the flexibility of combining any lasers from the extensive range of high-performance lasers from Cobolt in a single convenient box.



### Cobolt – Single and multi-line lasers

Through the well-known Swedish laser manufacturer Cobolt, a proven supplier of high-performance lasers of more than 25 years, HÜBNER Photonics offers one of the industry's broadest ranges of compact single-frequency CW lasers, diode lasers, compact tunable lasers and pulsed lasers across the full UV-Visible-MidIR spectrum.



### C-WAVE – Widely tunable lasers

Complementing Cobolt's broad portfolio of compact lasers, the tunable lasers developed by HÜBNER Photonics cover an unusually wide spectrum and have gained a strong reputation throughout the industry. C-WAVE is one of the most unique kinds of lasers on the market providing broadly tunable emission across the visible (and NIR) spectrum at the click of a button.



### VALO – Femtosecond fiber lasers

A natural compliment to the high-performance laser portfolio is the VALO ultrashort fiber lasers. Thanks to an innovative laser design with sophisticated control of dispersion and non-linear effects, the VALO lasers offer market leading ultra-short pulses from a compact, robust and turn-key system.

# AMPHEIA™

Unparalleled performance





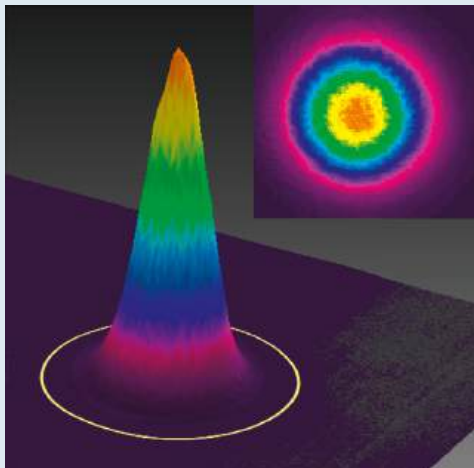
### Ampheia™ – Ultra-Low Noise Fiber Amplifier & Laser Systems

The Ampheia™ Series is a family of high-power fiber amplifier and laser systems, delivering ultra-low relative intensity noise (RIN) and high power single-frequency CW emission. The system offers up to 50 W of power at 1064 nm and 5W at 532 nm in a perfect beam, < 100 kHz linewidth and uniquely high spectral purity.

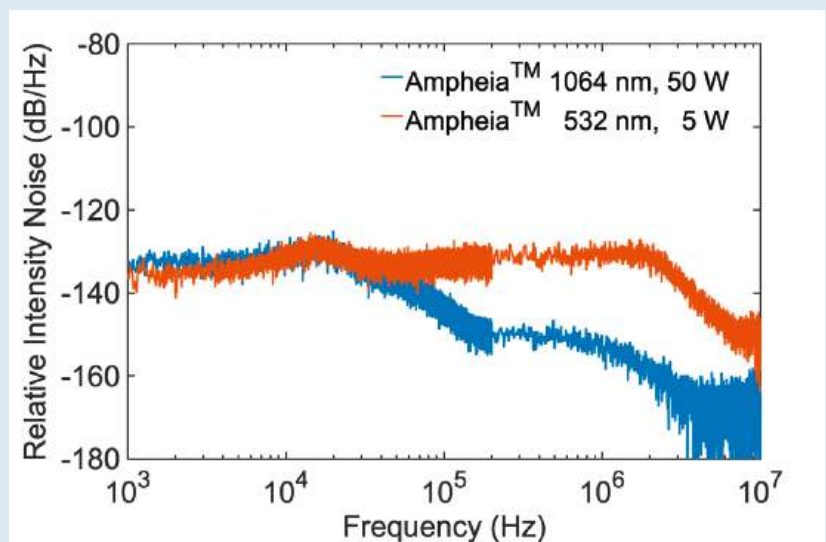
These high performance fiber laser systems are fiber amplifier systems delivered with an integrated seed laser in a standard 19" 3U rack housing and a detachable beam delivery head. A complete laser system that is affordable, easy to system integrate and with outstanding laser performance. Based on established and robust laser manufacturing processes, the Ampheia™ fiber laser systems guarantee a high level of reliability, while meeting the stringent performance requirements of quantum research, laser pumping, particle analysis, and semiconductor inspection applications.

### Applications

- Quantum Research
- Atom Trapping
- Particle Analysis
- Optical Metrology
- Semiconductor Inspection
- Holography
- Low-Noise Laser Pump Source



Typical Beam Profile



Typical Relative Intensity Noise (RIN)

375 nm	●
395 nm	●
405 nm	●
415 nm	●
425 nm	●
445 nm	●
457 nm	●
473 nm	●
488 nm	●
491 nm	●
505 nm	●
515 nm	●
520 nm	●
532 nm	●
553 nm	●
561 nm	●
594 nm	●
633 nm	●
638 nm	●
640 nm	●
647 nm	●
660 nm	●
685 nm	●
690 nm	●
705 nm	●
730 nm	●
760 nm	●
785 nm	●
808 nm	●
830 nm	●
852 nm	●
915 nm	●
940 nm	●
975 nm	●
1064 nm	●

## C-FLEX

### Laser combiners

### Choose your colors

The C-FLEX laser combiner harnesses the quality and reliability of the Cobolt high performance lasers. The C-FLEX laser combiners are available in three platform sizes (C4, C6, and C8) and can be equipped with up to 4, 6, or 8 Cobolt lasers. C-FLEX can be fully customized, or is available as application-specific configurations. The design allows for full flexibility in the choice of laser technology, ranging from plug and play diode lasers to high power, single frequency diode pumped lasers.

#### The way setups are meant to be

C-FLEX features a common power supply and common interlock (key switch plus remote interlock) for all lasers. It is field upgradeable and customizable. The compact and robust design of the C-FLEX provides excellent long-term stability and outstanding flexibility for your application.

#### Highest flexibility

- 375 nm to 1064 nm, up to 1000 mW
- Easy to install and field upgradeable
- High speed modulation, optional AOM (acousto-optical modulators) for fast modulation of DPSS lasers and power regulation
- Fiber coupling with options for multiple outputs
- Optional electromechanical aperture shutters
- User friendly software interface

**Can't see the wavelength of your choice?**  
**Contact our sales team.**



## Applications

- Fluorescence microscopy
- Flow cytometry
- Raman spectroscopy
- Optogenetics
- Photochemistry
- Holography
- Argon-Ion replacement
- Custom Solutions







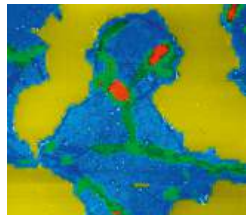
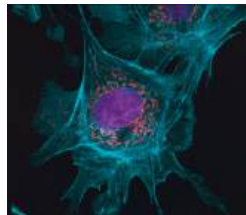
# Cobolt – Single and multi-line lasers

Innovative laser solutions with high output power, stable single mode operation and large wavelength flexibility in the UV-Visible-MidIR spectral range.

Cobolt lasers have become a preferred choice by leading instrument manufacturers and scientists in some of the most challenging applications in the fields of biomedical research, on-line quality and process control, clinical diagnosis, material research, particle analysis and semiconductor metrology. Our commitment is to increase the availability of laser-based equipment that can contribute to improving the quality of life and a better environment.

A combination of sophisticated laser designs and the HTCure™ Technology for advanced laser manufacturing allows Cobolt to provide lasers in compact formats with the performance and reliability required by the most demanding applications and for use in industrial environments.

## Applications











- Fluorescence microscopy
- Super-resolution microscopy
- DNA sequencing and analysis
- Raman spectroscopy
- Flow cytometry
- Interferometry
- Semiconductor metrology
- Gas detection
- Materials processing
- Optogenetics
- Optical tweezers
- Holography
- LIBS
- LIDAR
- Dynamic light scattering

# Cobolt

## CW and pulsed lasers

Compact single-frequency CW lasers, diode lasers and Q-switched lasers across the full UV-visible-MidIR spectrum. Using proprietary HTCure™ laser manufacturing technology, Cobolt lasers are associated with outstanding reliability and lifetime.



	 Cobolt 04-01 / 05-01 Series	 Cobolt 06-01 Series	 Cobolt 08-01 Series	 Cobolt Qu-T™ Series	 Cobolt Odin™ Series	 Cobolt Rogue™	 Cobolt Skyra™	 Cobolt Tor™ Series	max. power level
CW lasers	●	●	●	●		●	●		3000 mW
Pulsed lasers				●				●	1000 mW
Single frequency	●		●	●					3000 mW
Modulated lasers		●					●		300 mW
Narrow linewidth	●		●						500 mW
Tunable lasers				●	●				80 mW
Multi-line lasers							●		100 mW
Fiber coupled/pigtailed	●	●	●	●			●		> 500 mW



## CW lasers

### Cobolt 04-01 Series and 05-01 Series



#### Powerful single frequency CW diode pumped lasers

- 320 – 1064 nm up to 3 W
- < 0.25 % rms noise, in a perfect TEM00 beam
- < 1 MHz linewidth, superior spectral purity and wavelength stability

### Cobolt 06-01 Series



#### Plug & play modulatable CW lasers

- 375 – 1064 nm up to 400 mW
- Modulated laser diode (MLD) and diode pumped lasers (DPL) with fully integrated electronics
- Fast and deep modulation, fiber pigtailed option

### Cobolt 08-01 Series



#### Compact narrow-linewidth lasers

- 405 – 1064 nm up to 500 mW
- SLM diode pumped lasers (DPL) and narrow linewidth diode (NLD)
- Integrated optical isolators/filters

### Cobolt Skyra™



#### Multi-line laser

- Up to 4 laser lines, 405 – 660 nm
- Permanently aligned in a single beam
- Fully integrated electronics
- Fiber coupled option

### Cobolt Rogue™ Series



#### High power, CW diode pumped lasers

- 640 nm, up to 1 W
- < 150 GHz spectral bandwidth

## Pulsed lasers

### Cobolt Tor™ Series



#### High performance Q-switched lasers

- 355 nm, 532 nm, 1064 nm
- < 5 ns, > 7 kHz free running
- Single shot to 1 kHz triggerable
- up to 0.5 mJ/pulse

## Tunable lasers

### Cobolt Odin™ Series

#### Compact, tunable Mid-IR OPOs

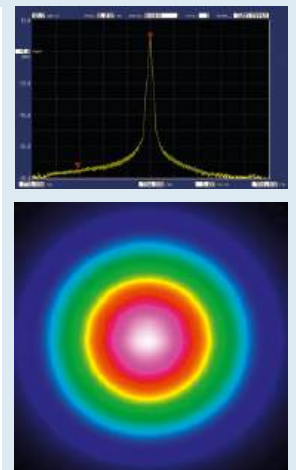
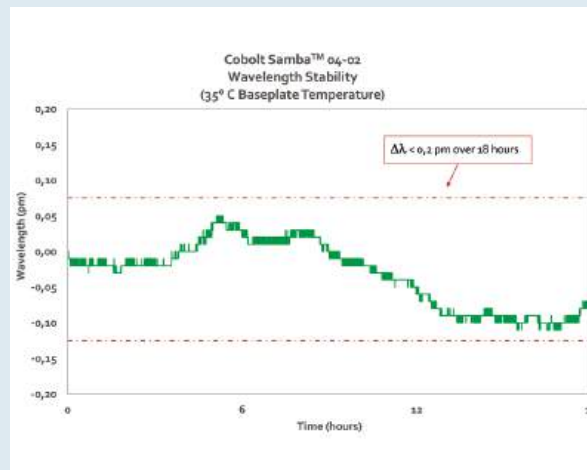
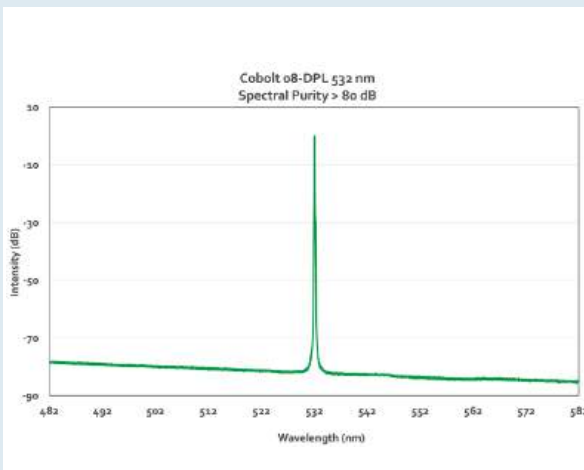
- Wavelength selectable 3,1 μm – 4,6 μm
- Tunable up to 50 nm, narrow linewidth option
- Up to 80 mW at 10 kHz

### Cobolt Qu-T™ Series



#### Compact tunable lasers

- 707 nm, 780 nm, 813 nm, > 500 mW
- < 50 kHz linewidth, SMSR > 60 dB spectral purity
- > 4 nm gap-free coarse tuning
- > 10 GHz mode-hop free fast fine tuning



# Outstanding from start to finish



## Pioneer with a patent

The Swedish company Cobolt arose from a research project in the year 2000. Today as part of HÜBNER Photonics, it is one of the world's leading developers and producers of high-performance lasers. The product portfolio encompasses innovative laser solutions with high output power and stable single-mode operation. In the UV-Visible-MidIR spectrum range, the products offer exceptional flexibility in wavelength adjustment.

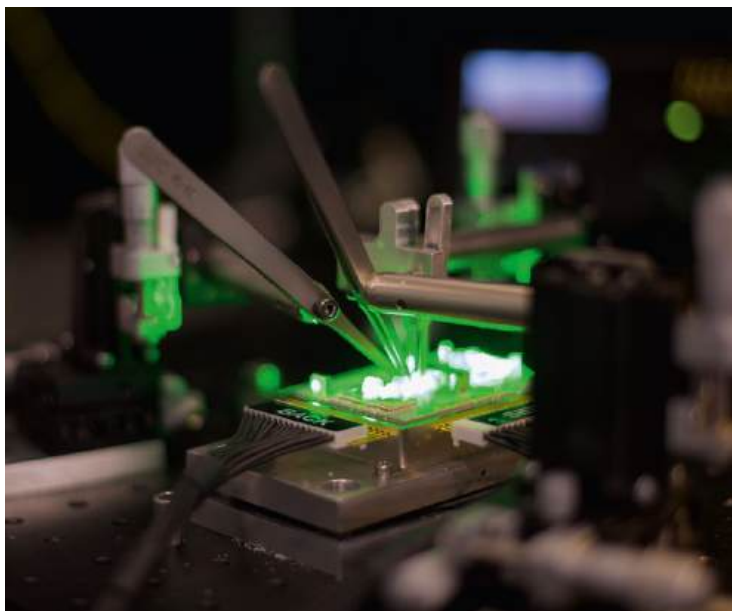
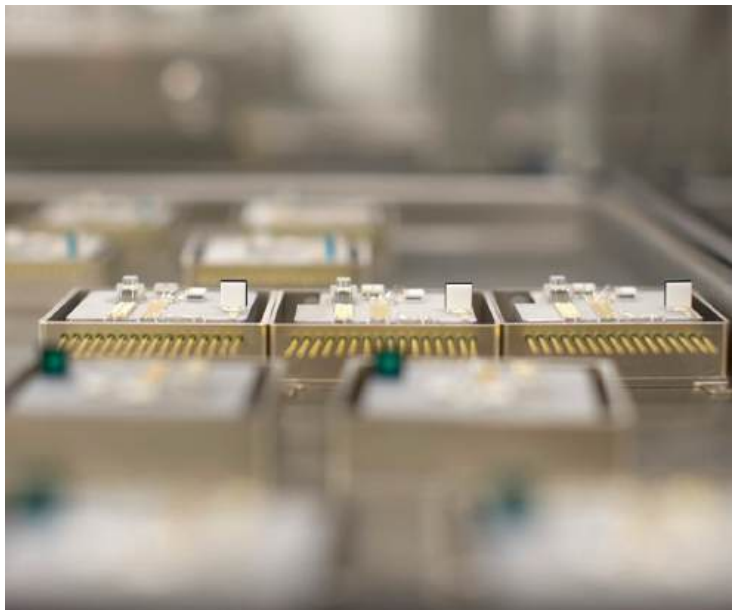
Thanks to the sophisticated cavity designs and patented HTCure™ production technology, Cobolt can produce compact lasers for a wide range of applications as well as for industrial use. Providing dependable, reliable, long-lasting laser technology for better quality of life and improved environmental protection – that's the aim of our company.

## The HTCure™ process

HTCure™ is a high-temperature curing process developed by Cobolt as part of the laser production process. It allows for a very high degree of reliability in the curing process, exceptional optical performance and unparalleled stability.

In the HTCure™ process, all of the components of the assembly are selected for their thermomechanical stability and the lasers are packaged in a hermetically sealed sub-housing. As a result, during the production the complete laser unit may be heated to over 100 degrees Celsius for several hours and in various steps without losing its alignment or suffering any damage.

This thermal curing step ensures an extremely rigid and at the same time robust solution so displacements do not occur later on.





## **C-WAVE** The **tunable laser** light source



C-WAVE is the tunable laser light source for continuous-wave (CW) emission in the visible and near-infrared wavelength range. Its technology is based on either optical parametric oscillation (OPO) or titanium-sapphire (Ti:sapphire) and it is fully computer controlled. Thus, it allows you to tune from blue to red and into the near-infrared without any change of dyes or optical components. This makes C-WAVE a flexible and user-friendly laser for your applications.

#### Change the way you work

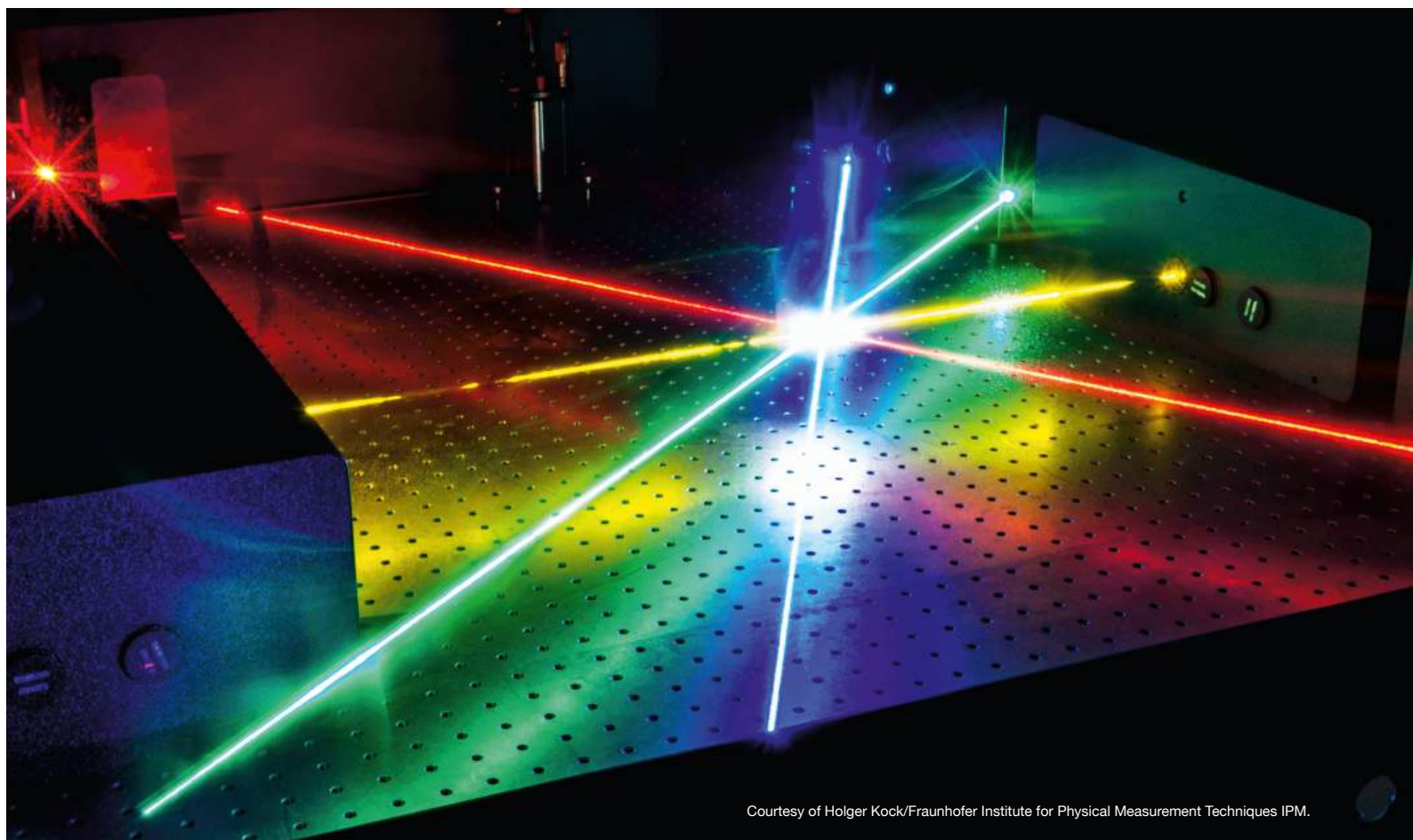
Visible, widely tunable, continuous-wave – for a long time this meant handling of toxic dyes, changing laser media or resonator mirrors and often a restricted narrow tuning range. C-WAVE is a solid state system that has no consumable components such as dyes. The wavelength can be simply set at the computer.

C-WAVE can be tuned automatically via the software and guarantees superior beam quality as well as output stability across the whole tuning range – offering both high flexibility and precision at the same time. It provides single frequency operation, narrow spectral line-width and options for frequency stabilization combined with an unprecedented spectral coverage.

Focus on your research, not on laser handling: C-WAVE helps you free your mind for your main tasks.

## Applications

- Quantum optics
- Holography
- Nanophotonics
- Atomic physics
- Metrology
- High resolution spectroscopy
- Biophotonics
- Photochemistry
- Interferometry
- Raman spectroscopy



Courtesy of Holger Kock/Fraunhofer Institute for Physical Measurement Techniques IPM.

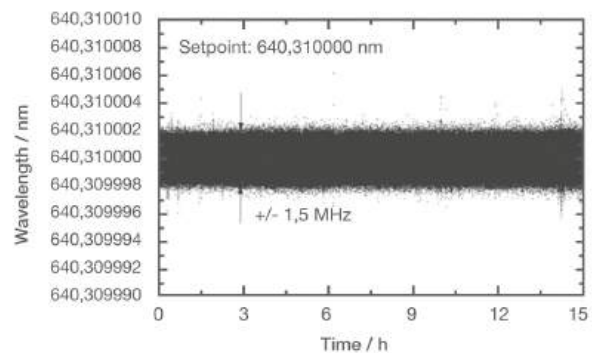
# C-WAVE

Flexibility – with precision



## AbsoluteLambda™

External wavelength measurement device (wavemeter) and software package to provide enhanced absolute wavelength accuracy as well as precise frequency stabilization for C-WAVE.



Exemplary measurement of stabilized wavelength using AbsoluteLambda.



### Operation principle

The C-WAVE uses nonlinear processes in solid state materials to achieve its outstanding spectral coverage. In a first process, a fixed frequency laser is upconverted to the NIR or IR range with OPO or Ti:sapphire lasing processes.

Subsequent second harmonic generation (SHG) using a frequency doubling crystal leads to conversion of the tunable infrared light into the visible wavelength range.

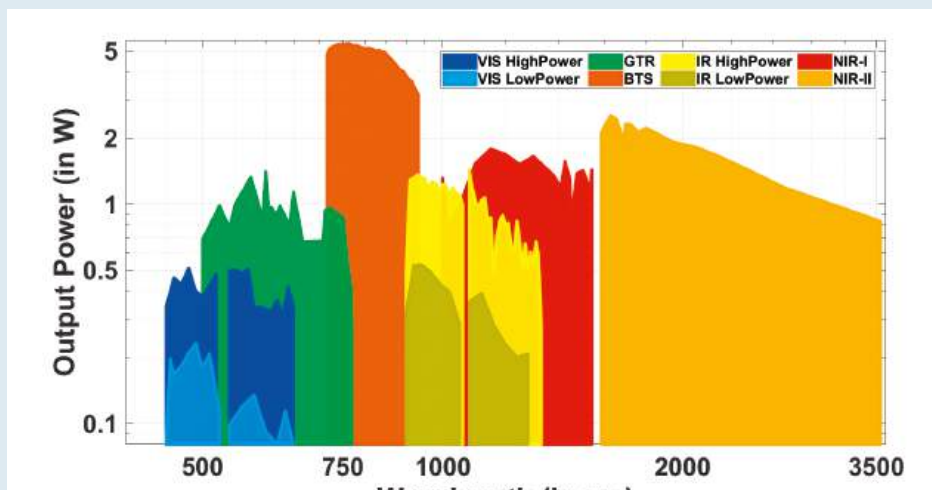
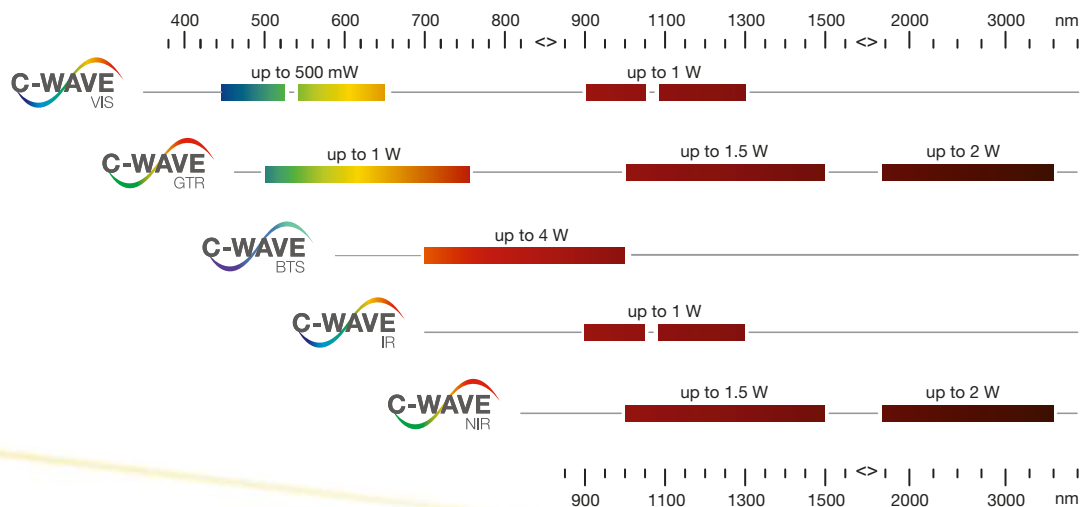
The modular design of C-WAVE enables you to choose the color ranges that you require!

### Wide tunability – choose your colors

The concept of C-WAVE allows the user to build laser-light sources for tunable continuous-wave emission from the near UV to the infrared.

### Output power – tailored to your needs

Depending on the required output power level, C-WAVE is either pumped by an external single-frequency laser or comes with an integrated laser, making operation and application even easier for you.



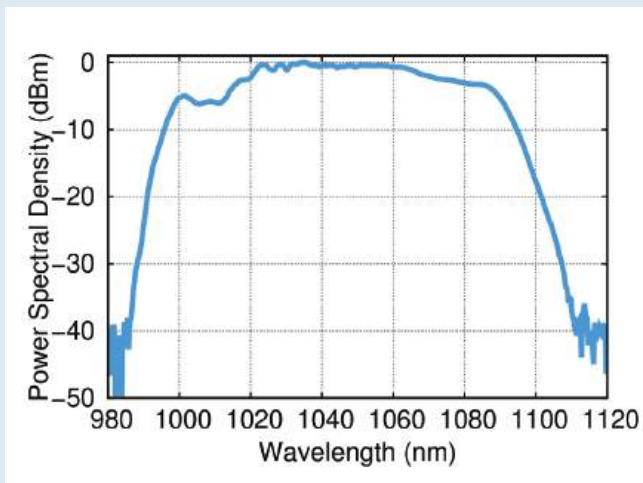
Typical output power of different C-WAVE models

# VALO

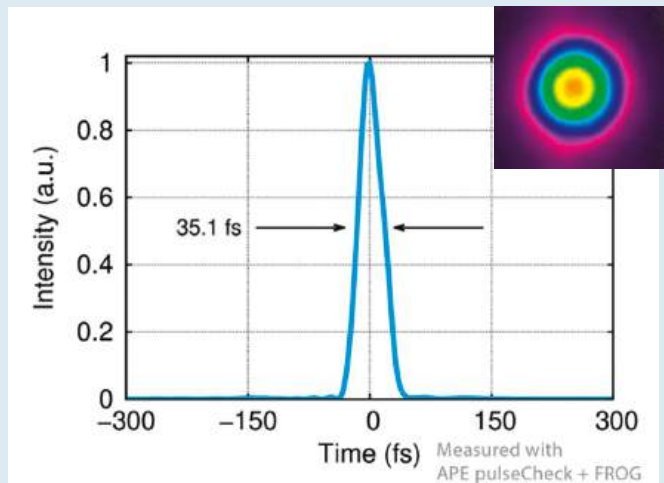
## Ultrashort femtosecond fiber lasers



Typical optical spectrum



Typical temporal profile



### Fiber lasers

In general fiber lasers offer a lot of advantages compared to solid state lasers. Due to the waveguide effect of optical fibers the laser systems have very good thermal and vibrational stability and can produce nearly diffraction limited beam profiles. Fiber lasers offer a low cost of ownership and they are essentially maintenance free.

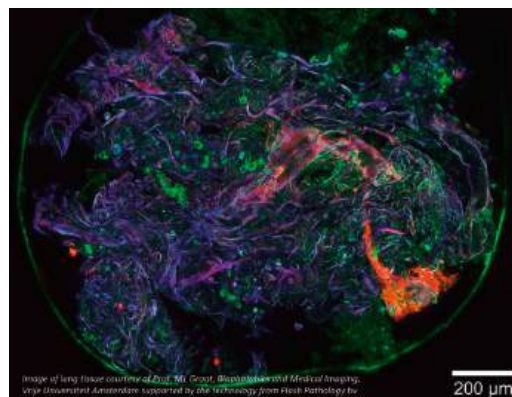
### Utilizing the nonlinear effects

The VALO Femtosecond Series lasers offer pulse durations of below 50 fs combined with remarkable pulse quality and different energy levels. Due to their unique design, with a perfect interaction of linear and nonlinear effects, an optical bandwidth much larger than standard lasers can be achieved.

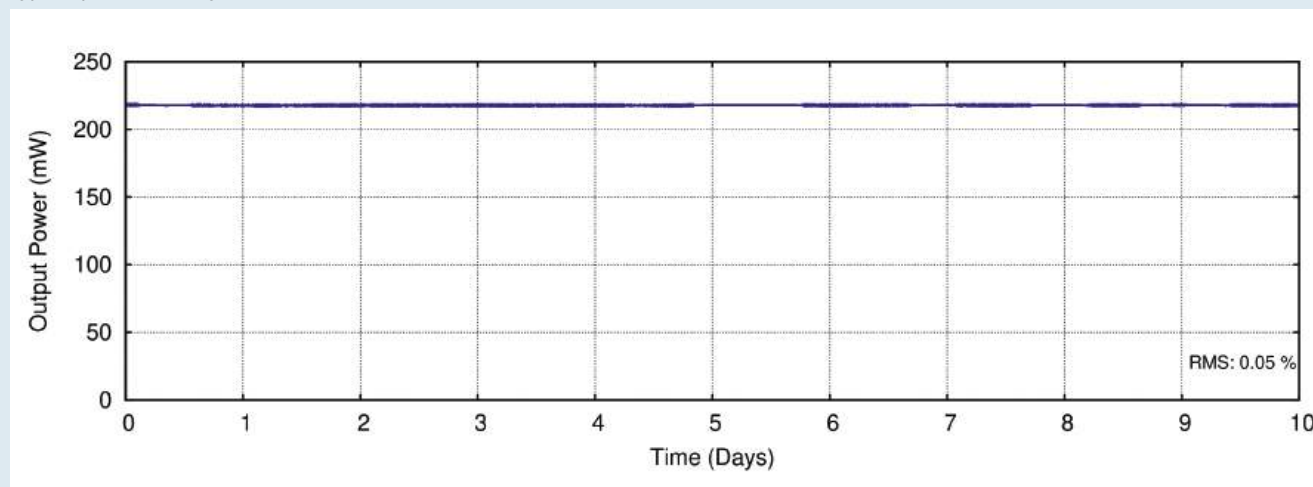
The lasers are passively cooled with no fan or water cooling. Their short pulses and resulting high pulse peak powers are especially interesting in applications like multiphoton microscopy since they allow for higher photon conversion efficiency while reducing photodamage and increasing cell viability. The lasers are built into a compact and robust package, making them suitable for integration into industrial screening tools and benchtop analytical instruments.

## Applications

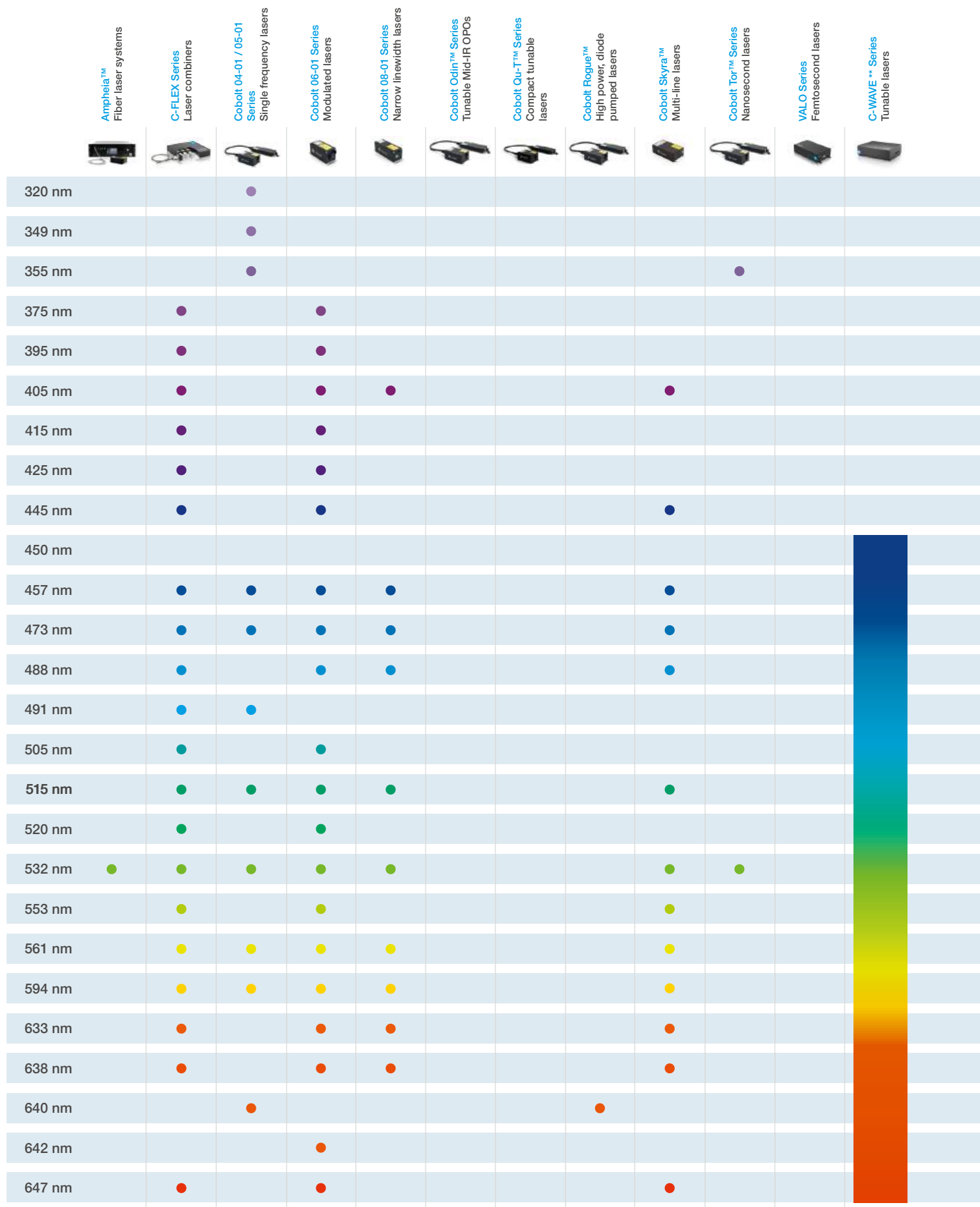
- Multiphoton microscopy
- Optogenetics
- Two-photon polymerization
- Terahertz generation



Typical power stability



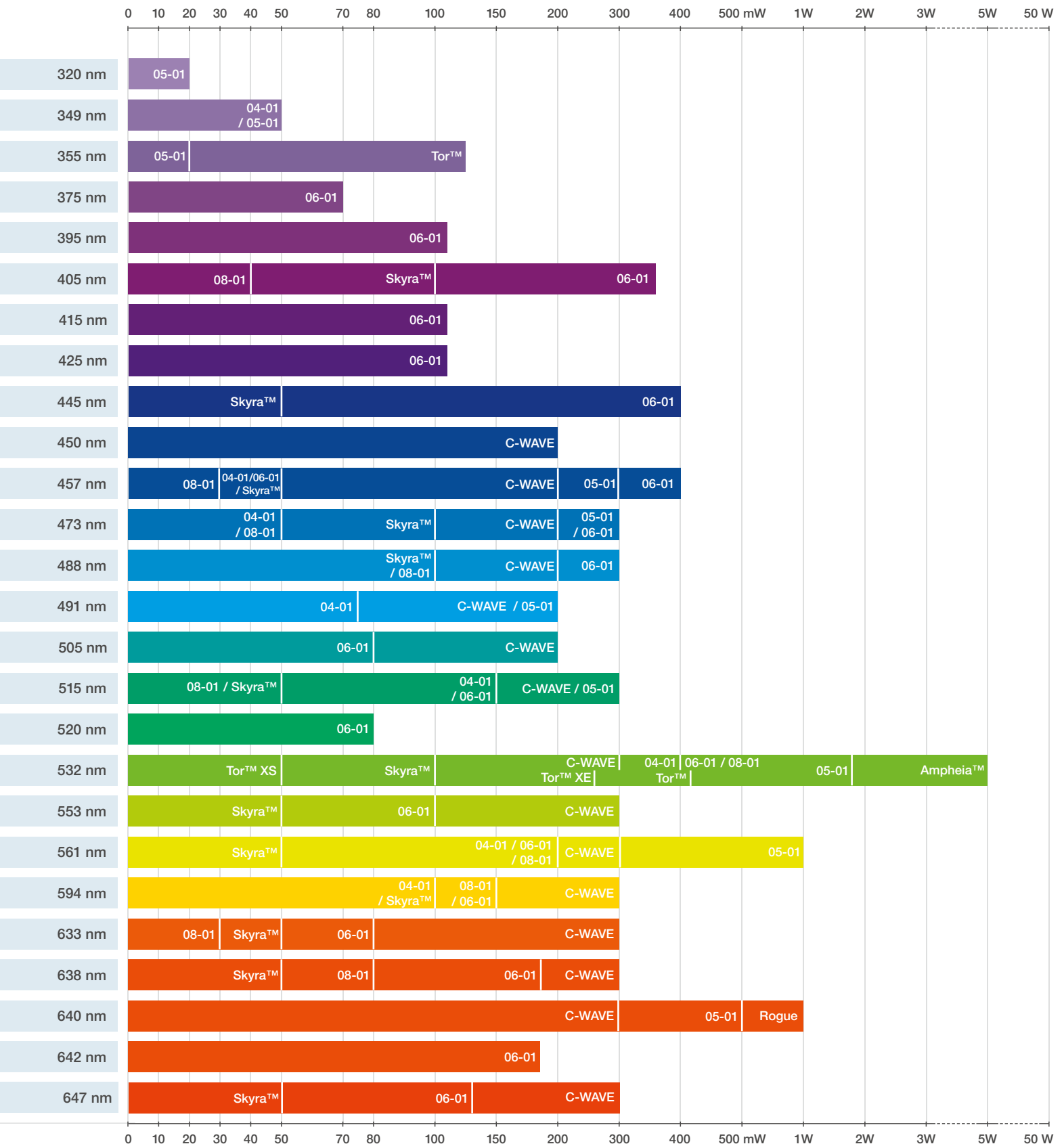









\* Center wavelength selectable between 2-5um, tunable 50nm.

\*\* C-WAVE typical powers can reach up to Watt-level in the visible and infrared wavelength range. Compare with typical tuning curve for more details.

# Our laser products – A wide array of wavelengths



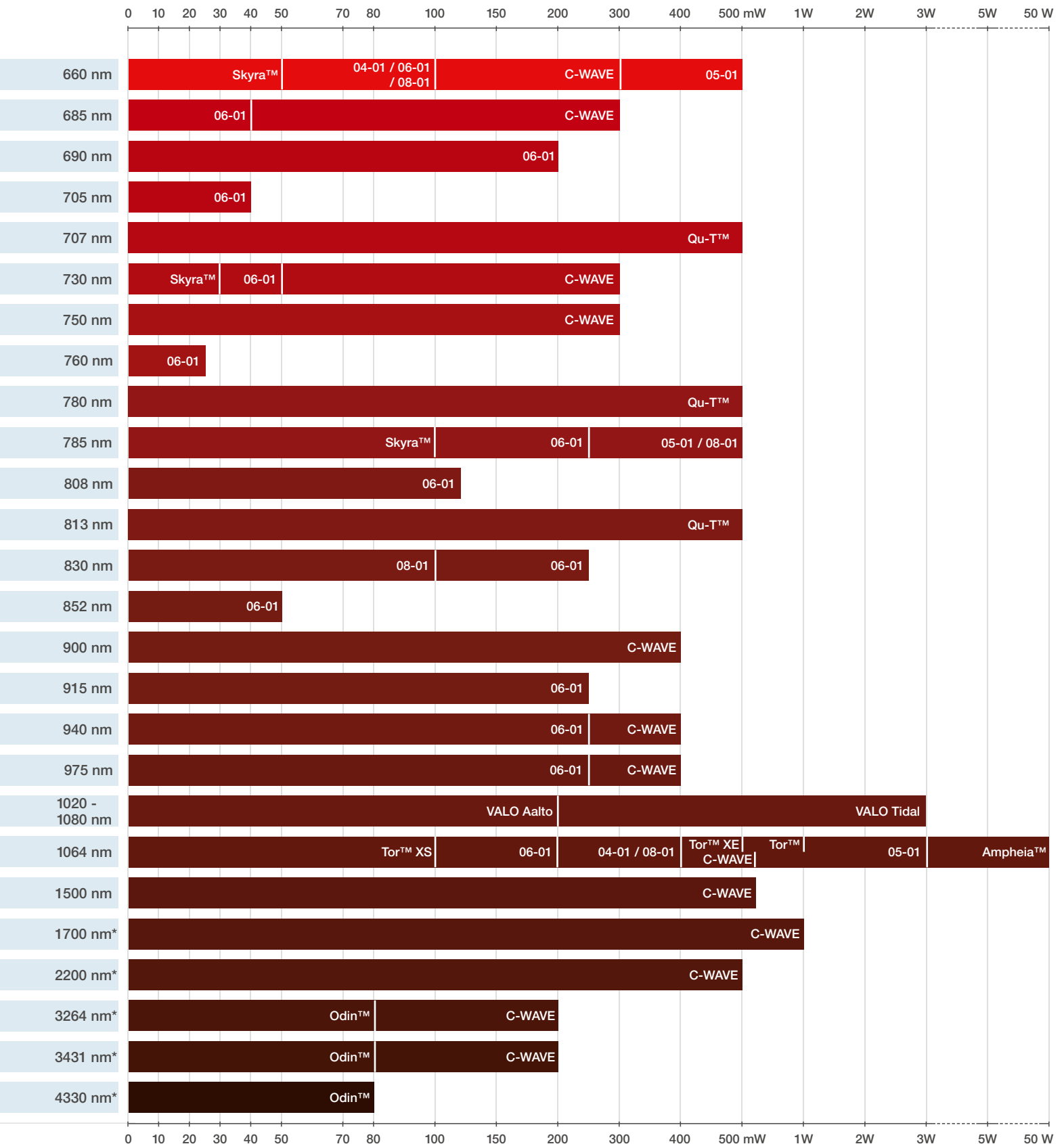
	<div>Amphelia™ Fiber laser systems</div> 	<div>C-FLEX Series Laser combiners</div> 	<div>Cobolt 04-01 / 05-01 Series Single frequency lasers</div> 	<div>Cobolt 06-01 Series Modulated lasers</div> 	<div>Cobolt 08-01 Series Narrow linewidth lasers</div> 	<div>Cobolt Odin™ Series Tunable Mid-IR OPOs</div> 	<div>Cobolt Qu-T™ Series Compact tunable lasers</div> 	<div>Cobolt Rogue™ High power, diode pumped lasers</div> 	<div>Cobolt Skyrä™ Multi-line lasers</div> 	<div>Cobolt Tor™ Series Nanosecond lasers</div> 	<div>VALO Series Femtosecond lasers</div> 	<div>C-WAVE ** Series Tunable lasers</div> 
660 nm		<div></div>	<div></div>	<div></div>	<div></div>				<div></div>			<div></div>
685 nm		<div></div>		<div></div>	<div></div>							
690 nm		<div></div>		<div></div>								
705 nm				<div></div>								
707 nm							<div></div>					
730 nm		<div></div>		<div></div>					<div></div>			
750 nm												
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852 nm		<div></div>		<div></div>								
900 nm												
915 nm		<div></div>		<div></div>								
940 nm		<div></div>		<div></div>								
975 nm		<div></div>		<div></div>								
1020 - 1080 nm										<div></div>		
1064 nm	<div></div>	<div></div>	<div></div>		<div></div>					<div></div>		
1500 nm												
1700 nm*											<div></div>	
2200 nm*												
3264 nm*						<div></div>						
3431 nm*											<div></div>	
4330 nm*						<div></div>						

\* Center wavelength selectable between 2-5µm, tunable 50nm.

\*\* C-WAVE typical powers can reach up to Watt-level in the visible and infrared wavelength range. Compare with typical tuning curve for more details.



# Our laser products – A wide array of wavelengths



# APPLICATIONS

## Applications



# Laser Solutions for many Applications

We expand the capabilities of your application – both in research as well as industry. As a highly experienced system supplier of technical industrial products, HÜBNER Photonics is developing innovative technology to meet the demands of the global market.

	Ampheia™ Fiber laser systems	C-FLEX Series Laser combiners	Cobolt 04-01 / 05-01 Series Single frequency lasers	Cobolt 06-01 Series Modulated lasers	Cobolt 08-01 Series Narrow linewidth lasers	Cobolt Qu-T™ Series Compact tunable lasers	Cobolt Rogue™ High power, diode pumped lasers	Cobolt Skyla™ Multi-line lasers	Cobolt Tor™ Series Nanosecond lasers	C-WAVE ** Series Tunable lasers	VALO Series Femtosecond lasers
Raman spectroscopy		●	●		●					●	
Life Science:											
- Fluorescence microscopy		●	●	●			●	●			
- Multiphoton microscopy											●
- Photoacoustics									●		
- Flow cytometry		●	●	●			●	●			
- DNA sequencing		●	●	●							
Semiconductor inspection	●		●	●	●					●	
Quantum research	●			●		●				●	
Interferometry		●	●		●					●	
LIBS									●		



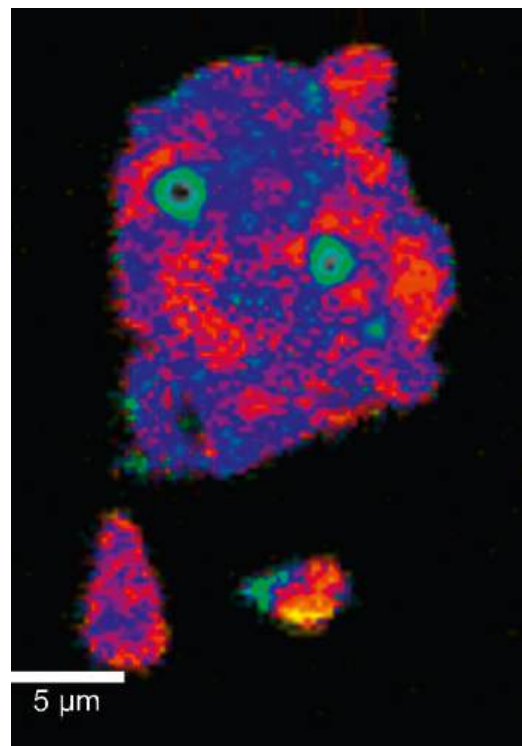
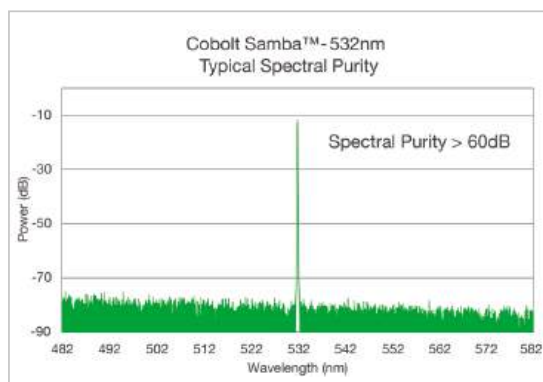
## Applications

# Lasers for Raman Spectroscopy

The “inelastic scattering of light” was first observed and identified by C.V. Raman in 1928. In 1930, he received the Nobel Prize in Physics for this work. But only in more recent times has it become possible to make use of the so-called Raman effect by which the frequency of light changes when it is deflected by molecules. In the past two decades, Raman spectroscopy has developed as a widely applicable method of examination – for fields ranging from material analysis to life sciences applications to point-of-care diagnostics. This has been made possible through the development of compact laser sources, highly sensitive cameras and compact high-resolution spectrometers.

With the lasers from Cobolt, HÜBNER Photonics has one of the widest ranges of products on the market for Raman spectroscopy applications. The Cobolt 08-01 Series of lasers, for example, has been specially developed for Raman applications with integrated Raman filters and optional isolators. Individual lasers can be combined with the C-FLEX laser combiner for added user friendliness. For applications requiring a tunable, single-frequency laser in the visible range, the C-WAVE laser is especially well suited.

- Cobolt – Single frequency and narrow linewidth lasers
- C-WAVE – Tunable laser, single frequency
- C-FLEX – Laser combiners

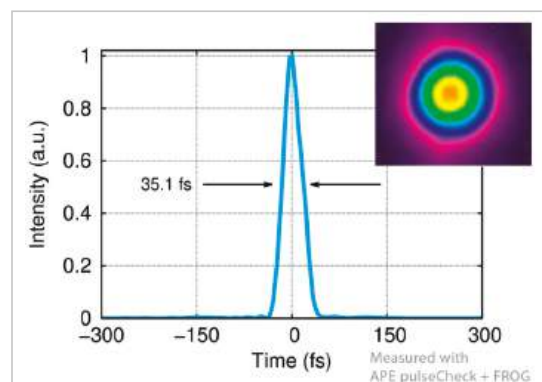


## Applications Lasers for Life Science

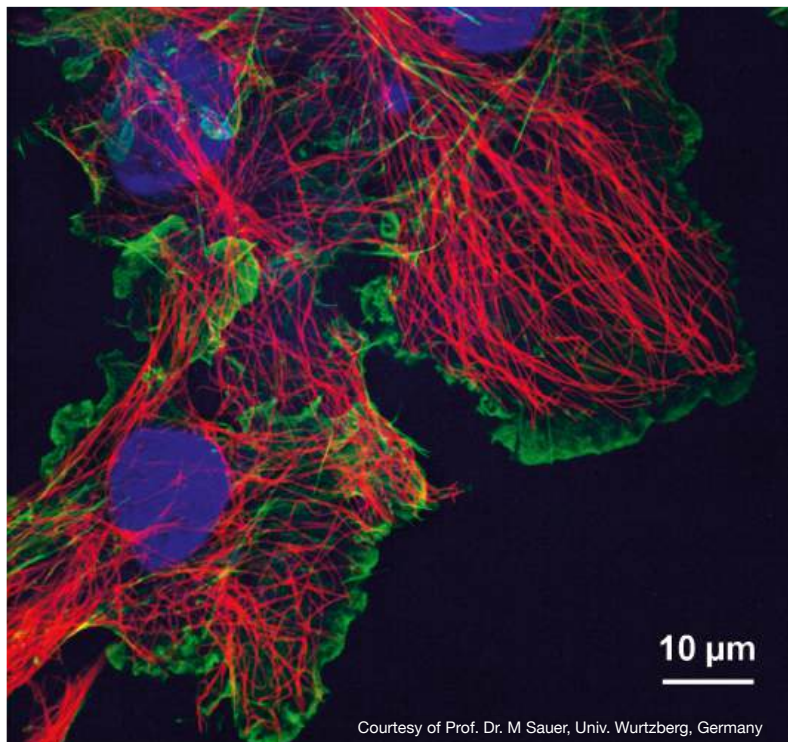
Significant applications in life science requiring lasers include fluorescence microscopy, multiphoton microscopy, photoacoustics, flow cytometry and DNA sequencing. In all of these applications the fluorescence of specific fluorophores or biomarkers is detected, counted or imaged, leading to a deeper understanding of biochemistry.

With the lasers produced by Cobolt, HÜBNER Photonics can provide a broad portfolio of high-performance lasers for fluorescence microscopy applications. Not only do these lasers feature a standard integrated clean-up filter, at >70 dB they have one of the best modulation-extinction ratios in the industry. For greater convenience and ease of use, the individual lasers can be combined using the C-FLEX laser combiner. For multiphoton microscopy, the VALO Femtosecond Series sub 50 fs pulses result in greater efficiency with lower total average power at the sample and therefore allowing longer imaging times – a true advantage.

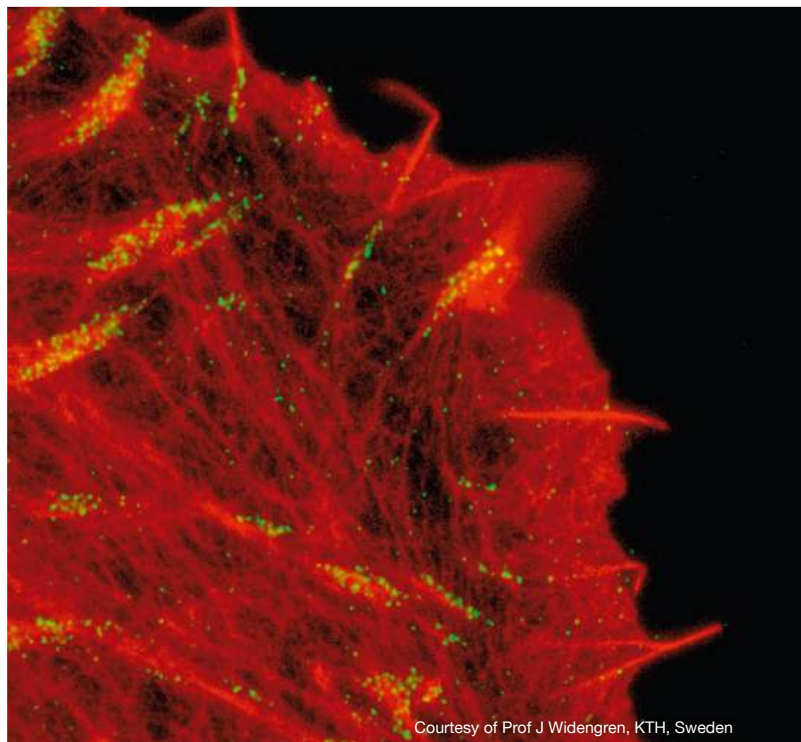
- VALO – < 50 femtosecond pulses
- Cobolt 06-01 – Modulated lasers
- Cobolt Skyra™ – Multi-line laser
- C-FLEX – Laser combiners
- Cobolt Tor™ Series – Nanosecond lasers



Typical pulse profile and beam profile of VALO femtosecond series



Courtesy of Prof. Dr. M Sauer, Univ. Wurtzburg, Germany



Courtesy of Prof J Widengren, KTH, Sweden



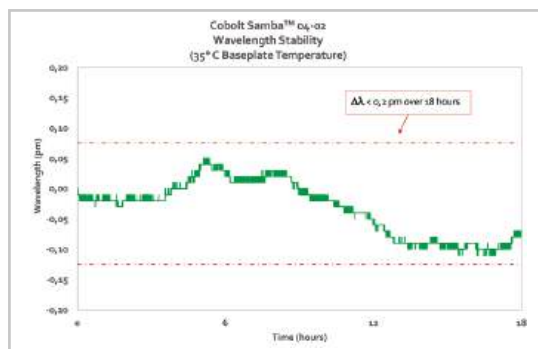
## Applications

# Lasers for Semiconductor Inspection

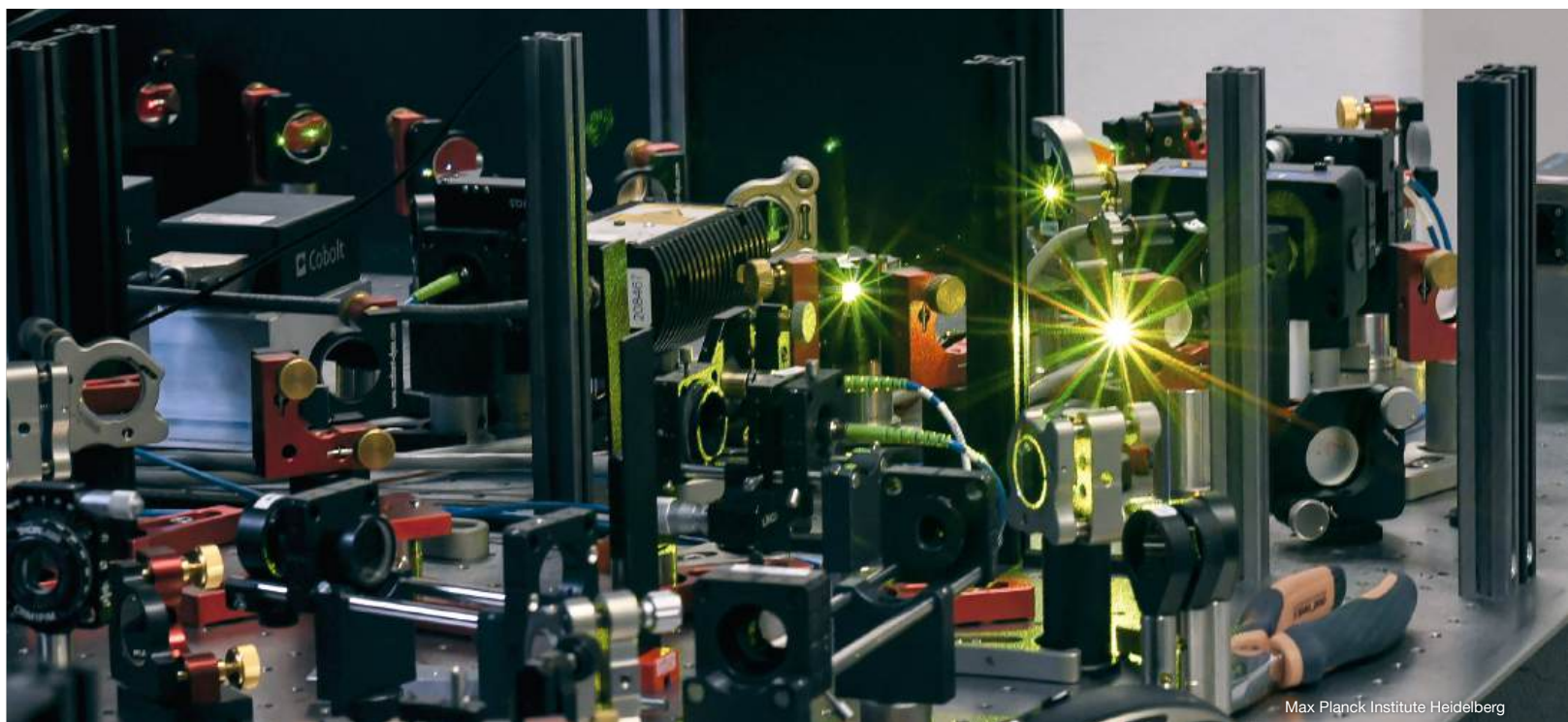
Semiconductor inspection includes many different techniques, some of which use lasers, for the metrology and inspection of semiconductor wafers during the manufacturing process.

A few of the inspection techniques used during this inspection process include interferometry, ellipsometry, particle analysis, photoluminescence, fluorescence and Raman spectroscopy. The high performance lasers from HÜBNER Photonics are commonly used for many of these inspection techniques due to their extremely good performance specifications and excellent robustness, meeting the requirements of this demanding application.

- C-WAVE – Tunable laser, single frequency
- Cobolt – Single frequency and narrow linewidth lasers
- Ampheia™ – fiber amplifiers and systems







Max Planck Institute Heidelberg

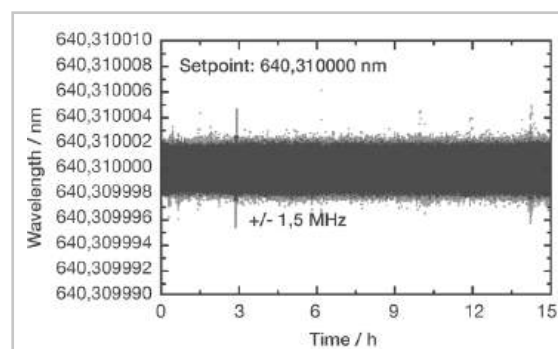
## Applications

# Lasers for Quantum Research

The field of quantum research deals with the interactions of light and matter. In this still young discipline, photons or “light quanta” – the smallest particles of light – are investigated. The aim of this type of research is to gain an understanding of the overall behavior of electromagnetic waves.

The laser sources produced by HÜBNER Photonics play an important role in quantum research. This is especially the case with the tunable C-WAVE laser and Cobolt lasers with their high spectral purity and excellent wavelength stability. They provide exactly the flexibility and the precision that are essential for basic research applications.

- C-WAVE – Tunable laser, single frequency
- Cobolt – Modulated diode and single frequency lasers
- Ampheia™ – fiber amplifiers and systems
- Cobolt Qu-T™ – compact tunable lasers



Exemplary measurement of stabilized wavelength using AbsoluteLambda™.

## Applications

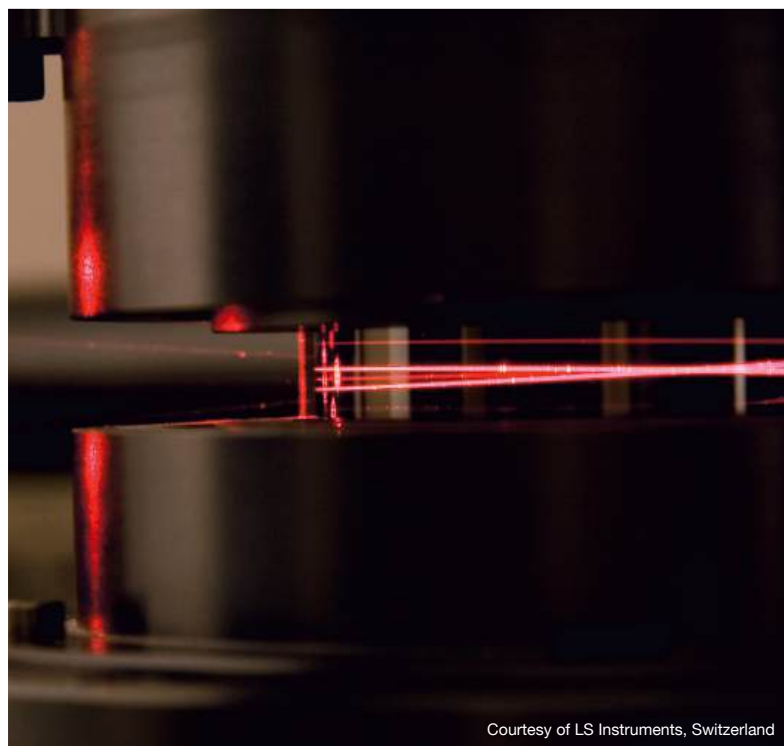
# Lasers for Interferometric Applications

The term interferometry derives from the word interference. Interference is a phenomenon that occurs when two waves of any kind come together at the same time and place. Interferometry makes use of interference phenomena for measurement purposes, for example investigation of the flatness of an optical surface.

Even though there are many different types of interferometric based applications, all of them basically operate on the same principle. Two beams are separated and then combined so that they interfere with each other. In order to get interference a highly coherent laser source is required. The more coherent the laser beam, or the longer the coherence length, the finer the detail that can be resolved.

HÜBNER Photonics has one of the widest ranges of single frequency lasers in the industry for interferometric techniques, including holography, Doppler velocimetry and dynamic light scattering.

- Cobolt – Single frequency lasers
- C-FLEX – Laser combiner
- C-WAVE – Tunable laser, single frequency



Courtesy of LS Instruments, Switzerland



## Applications

# Lasers for LIBS

Laser-Induced Breakdown Spectroscopy

Laser-induced breakdown spectroscopy (LIBS) is an atomic-emission spectroscopy technique that enables rapid chemical analysis of a wide range of materials ranging from metals, semiconductors, glasses, biological tissues, plastics, soils, thin-paint coating, and electronic materials. LIBS based imaging is extending the capability of this technique even further by providing information on the distribution of critical elements within a sample (as seen below).

The Cobolt Tor™ Series lasers represent a new class of compact high performance diode-pumped Q-switched lasers that could really boost the trend of extending the use of LIBS systems from laboratory work to industrial applications. A key advantage of the Cobolt Tor™ Series lasers is their unique combination of compact size and performance. The lasers are also manufactured into hermetically sealed packages ensuring robust performance and long lifetime in varying ambient conditions making the lasers highly suitable for integration into demanding industrial applications.

### ■ Cobolt Tor™ – Nanosecond lasers

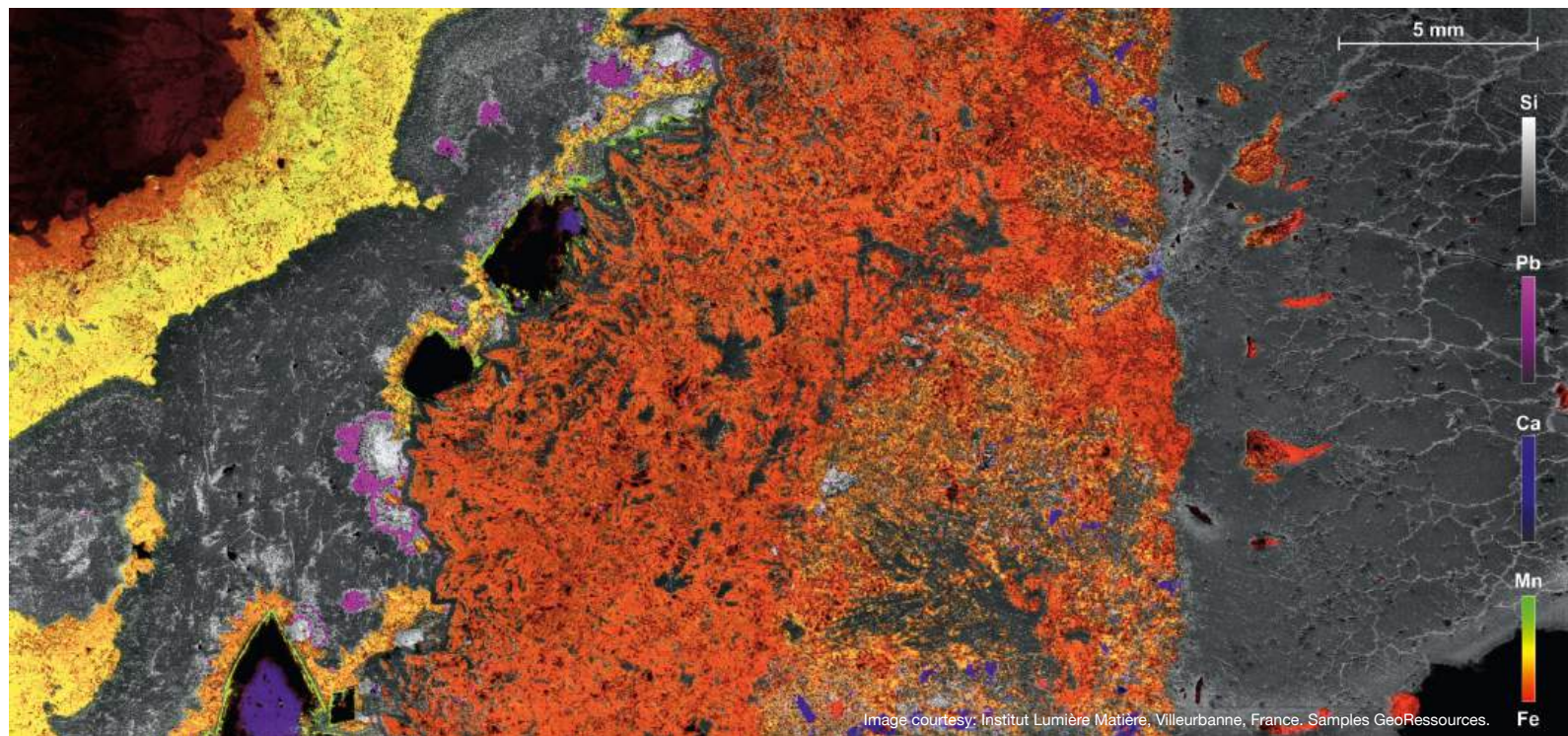


Image courtesy: Institut Lumière Matière, Villeurbanne, France. Samples GeoRessources.

# TERAHERTZ TECHNOLOGY

## Terahertz technology

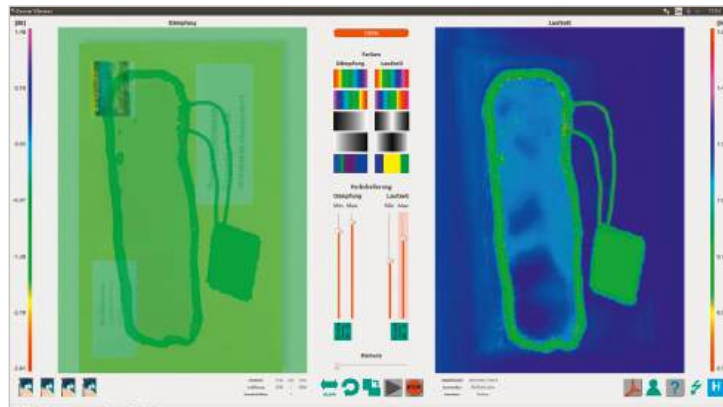
### Visualizing the invisible

Terahertz (THz) waves penetrate paper, clothing, plastics and many other materials without causing any damage – contact-free and in seconds. This makes THz technology a unique tool for the detection, analysis and hyperspectral imaging of materials. On the basis of the latest research, HÜBNER Photonics is developing highly compact systems for various applications, ranging from mail inspection to industrial quality control. With their plug-and-play features and intuitive user interfaces, HÜBNER Photonics products also deliver outstanding ease of operation. Due to its non-invasive and non-ionizing properties, THz waves are completely harmless for human tissue. Thus, no expensive safety precautions are required for operation.

With the THz imager T-SENSE, small packages and letters can be scanned and hidden contents can be visualized. This makes it possible to detect dangerous materials such as drugs or explosives before opening the mail.

The Prism Award winning THz spectrometer T-COGNITION has been developed in cooperation with the Fraunhofer Institute for Physical Measurement Techniques (IPM) and is an advanced system for the automated identification of hidden drugs or explosives inside letters or small parcels within seconds on the basis of their characteristic spectroscopic fingerprints. The systems help to improve security in mailrooms, at customs stations or at official offices – without any health risk for the users.

The T-SPECTRALYZER product family comprises turn-key THz spectrometers for scientific research as well as industrial non-destructive testing (NDT) applications. The variety of available options provides highest flexibility to make the T-SPECTRALYZER fit to the customers' individual applications.



T-SENSE user interface with different filters side by side. All parameters are intuitively customizable.

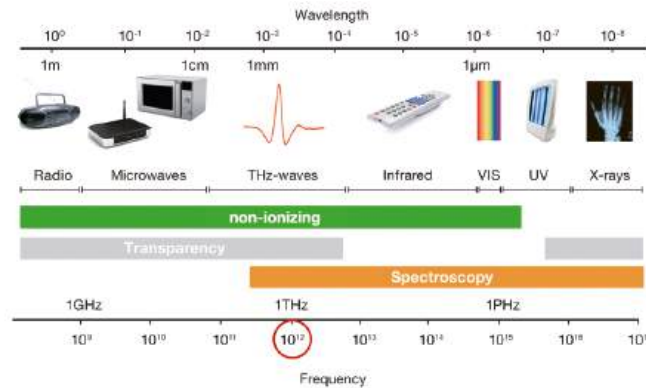






# THz waves – Combining characteristics

THz waves are a part of the electromagnetic spectrum in the frequency range of 0.1 THz to 10 THz. Many non-conductive materials such as plastics or PVC, ceramics, paper or clothing are nearly transparent in the THz frequency range, a characteristic feature known from GHz waves. At the same time, THz waves are absorbed at varying degrees by substances such as drugs, explosives and many other materials, providing spectroscopic information about the sample material, similar to a spectrum produced using optical wavelengths. These absorption characteristics can be used to produce a sort of spectroscopic fingerprint, making it possible to identify various substances, even when they are concealed in a letter or parcel, for example.



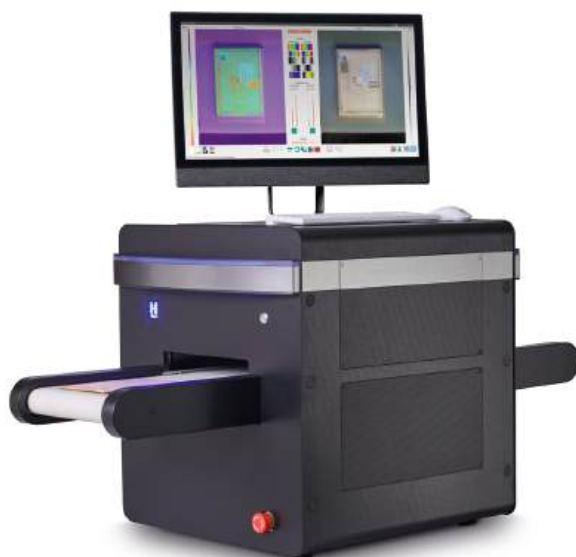
## Applications

### Public security

- Mail inspection by hyperspectral imaging for detection of hazardous goods
- Identification of drugs and explosives using Time-Domain-Spectroscopy (TDS)

### Non-destructive testing (NDT)

- Detection of defects and cavities in components (hyperspectral imaging)
- Identification of substances through plastic pipes or tubing and other types of packaging using Time-Domain-Spectroscopy (TDS)
- Determination of the thickness of layers of multi-layered systems for identification purposes
- Analysis of substances in powder and tablet form
- Analysis of gases
- Investigation of moisture distribution
- Distinction between crystal and amorphous structures



## T-SENSE

### The THz imager for safe and secure mail inspection

Mailrooms in companies and in public agencies are particularly vulnerable to attacks via postal deliveries. Often the personnel at these facilities are not protected against the dangers of such attacks. To reduce these risks, HÜBNER Photonics has developed an innovative table-top device for the inspection of letters and small packages. The THz imager T-SENSE visualizes objects and hazardous substances that may be concealed in postal items.

Unlike x-rays, there is no health risk with the THz imager T-SENSE. Typical safety precautions for conventional imaging devices are not needed. And thanks to its intuitive graphic user interface, the systems are very simple to operate. T-SENSE facilitates effective and safe postal inspection, helping to keep people safe and secure.



## T-COGNITION

### Identifying hazardous substances

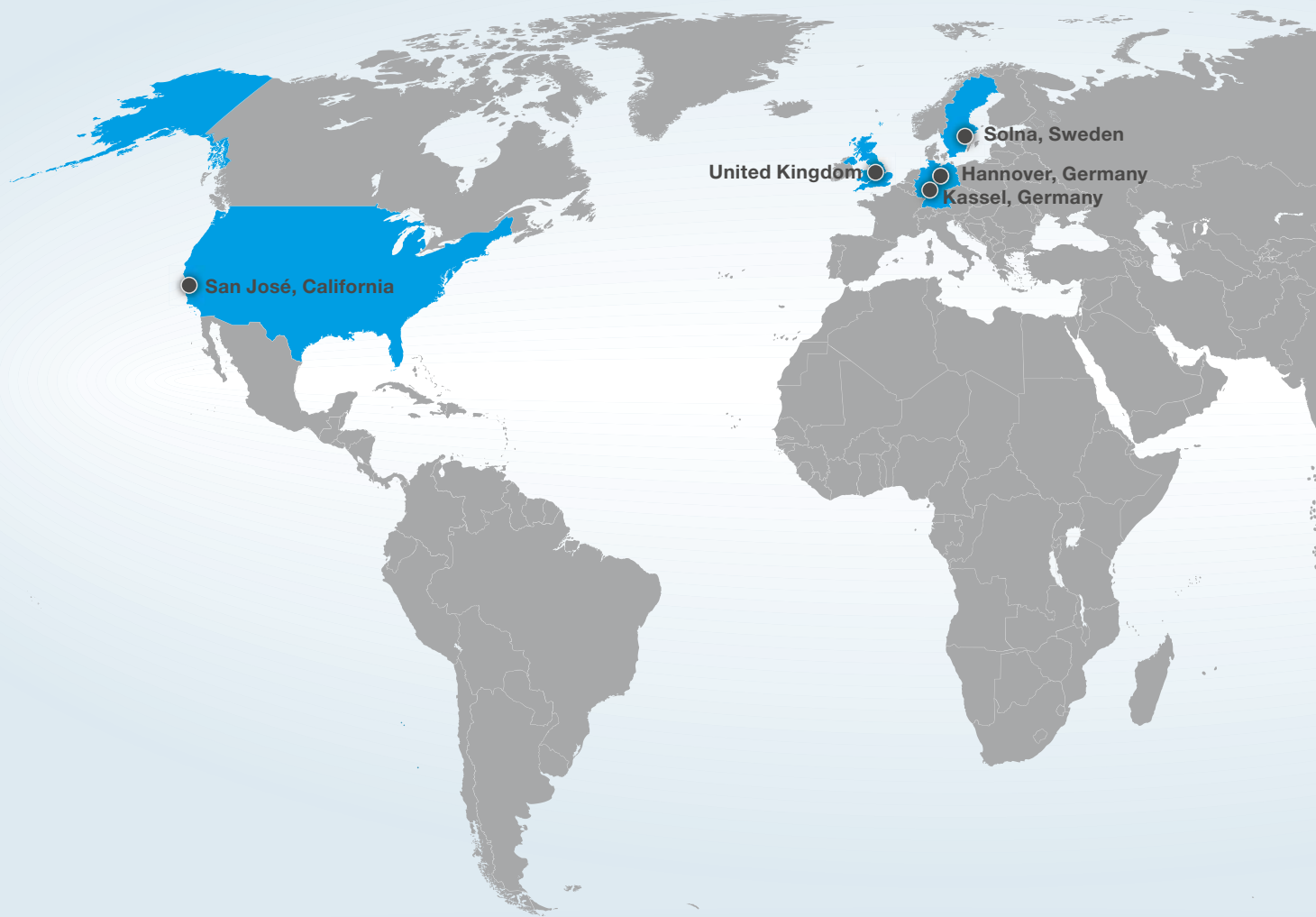
The THz spectrometer T-COGNITION is an extremely effective security technology. With reliability and precision, it identifies hidden drugs and explosives in letters and small packages without the necessity of handling or opening the item in question. Within seconds, T-COGNITION identifies the spectroscopic fingerprint of the hazardous substance or material by comparing the data with its own database. This system enhances work safety in prisons, at custom controls, at authorities, in companies and embassies, to name but a few.

## T-SPECTRALYZER

### The all-round spectrometer

The T-SPECTRALYZER products have been developed for quick use applications and for routine measurements in daily analytical work. The product family comprises turn-key systems operating either in transmission or reflection geometry or both simultaneously as well as fiber-coupled solutions, which provide full flexibility to adapt the spectrometer to the customer's application. The systems only require a normal mains connection and are ready for use without any additional infrastructure. Thanks to the most modern technology, the THz spectrometers function without any additional cooling or external gas supply. This allows for quiet and very economical operation. Individual add-on modules and the intuitive user interface support the recording, processing and export of measurement results. Not least, the automatic user-configurable report functionality makes T-SPECTRALYZER the most user-friendly THz spectrometer.









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**HÜBNER Photonics**