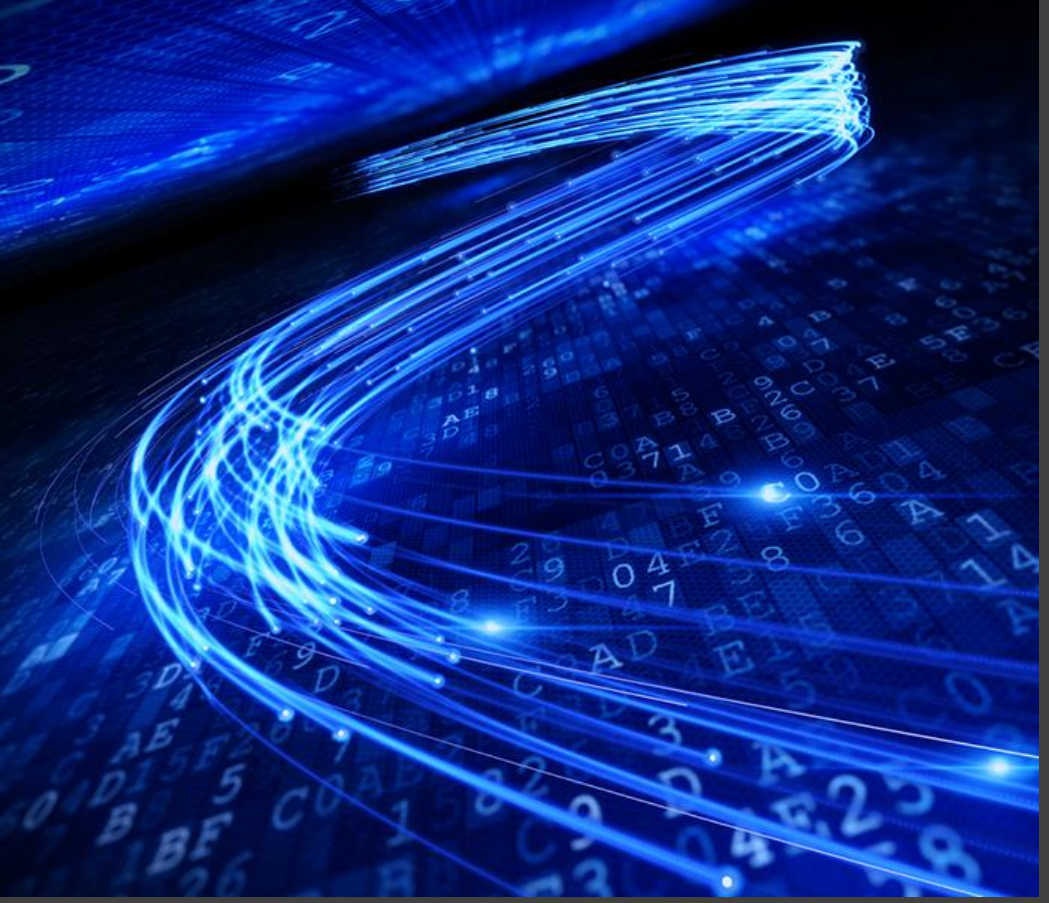
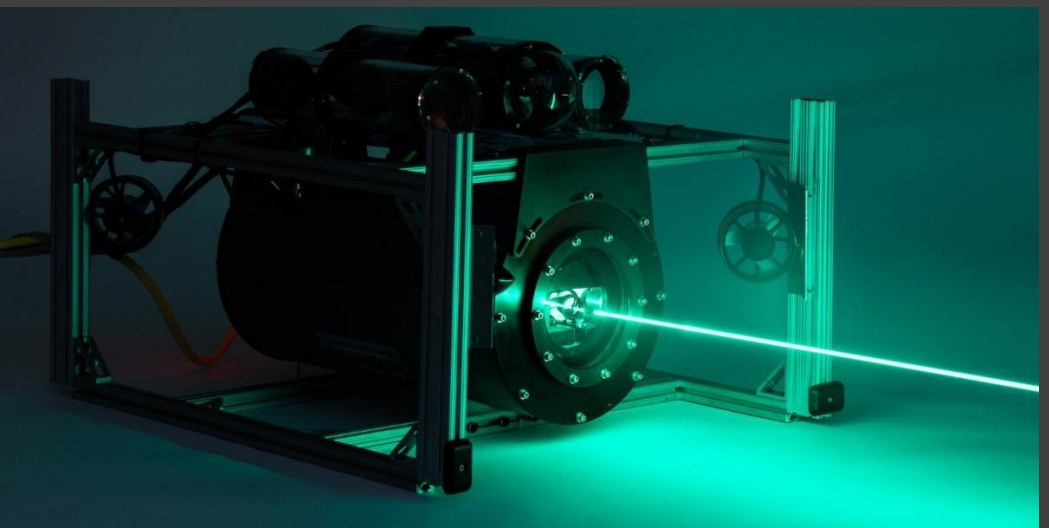




*FEATURED M&A REPORT*

# Lasers Report

RCL Tech M&A Trends

*February 2021*

RCL
RENEVO CAPITAL LIMITED

# Contents

# Scope of the Report

The photonics industry is maturing and growing, even in the face of the global COVID-19 pandemic. There have been multiple megamergers between the top players, along with significant investments and constant innovation across the globe. The Laser portion of the photonics market is more than playing its part, with multiple laser companies reporting increased revenue and profitability over the COVID period.

Always slightly mysterious, lasers have fascinated scientists and the general population alike. No longer just mesmerising, lasers perform critical functions in modern life and are as indispensable to the world economies as semiconductor electronics.

This report attempts to make sense of the incredible diversity of the commercial world of lasers and caste it in the light of investment and M&A activity. The first in a series of reports we focus here on High-Power, Pulsed and Diode Pumped Lasers.

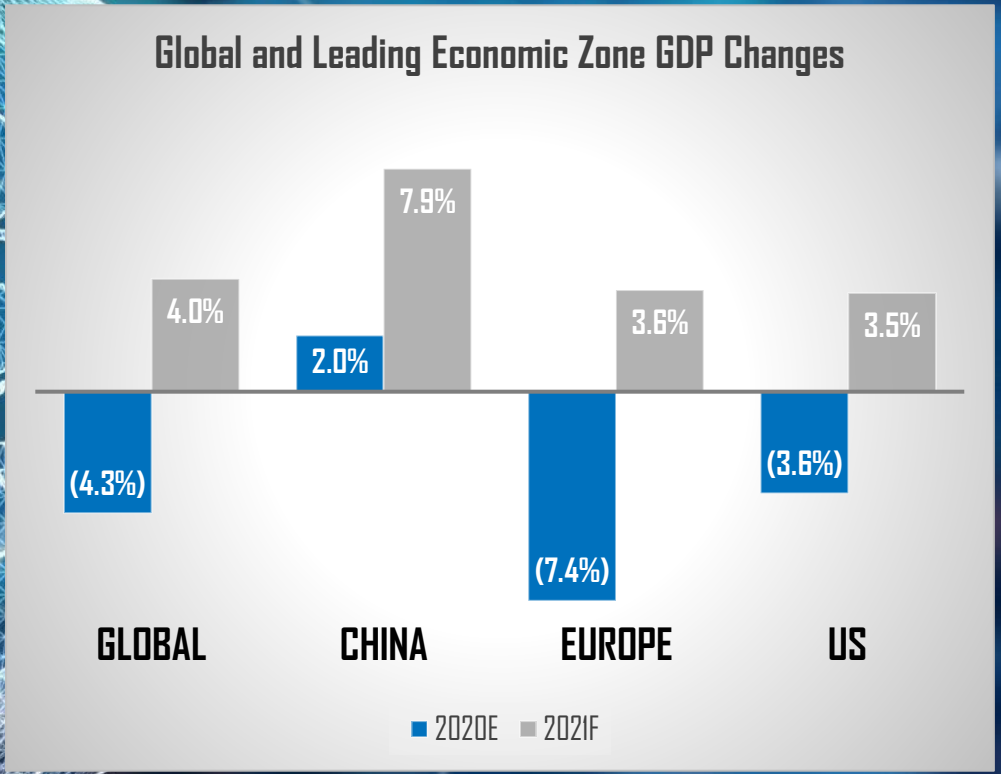
# GLOBAL ECONOMY

Following a global economic collapse in 2020 due to the pandemic, global economic output is expected to expand 4% in 2021 but will remain more than 5% below pre-pandemic projections.

The global recovery, dampened by the resurgence of COVID-19 cases, is expected to strengthen as mass vaccination continues.

Policy makers must balance the risks from large and growing debt loads with those from slowing the economy through premature fiscal tightening.

The World Bank believes that confronting the adverse legacies of the pandemic requires fostering resilience by safeguarding health and education, and prioritising investments in digital technologies and green infrastructure.



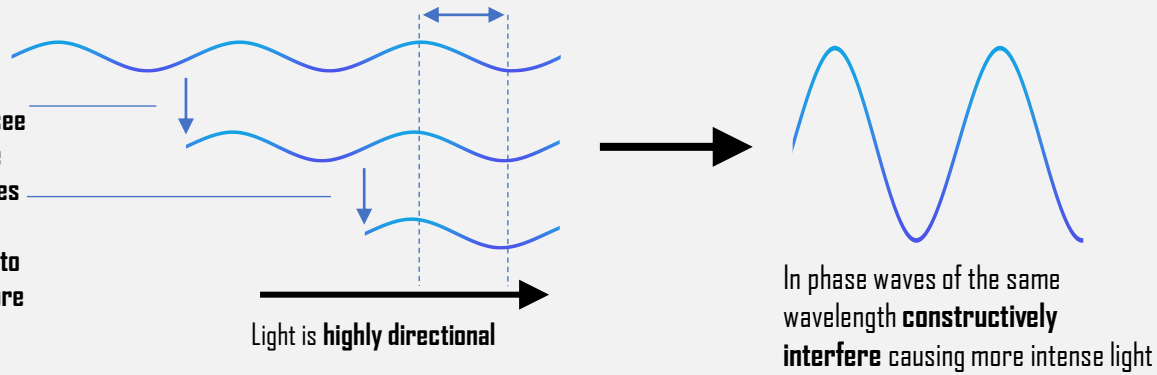

*Source: World Bank*

# Background to Lasers

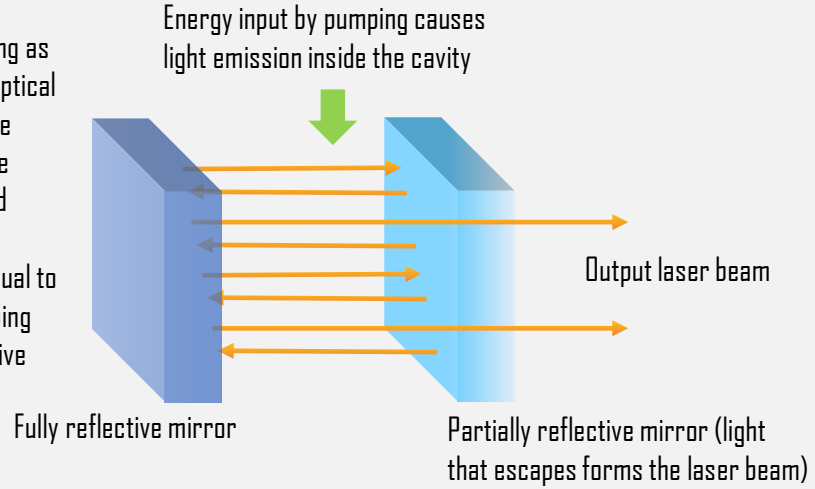
# What are Lasers?

LASER stands for Light Amplification by Stimulated Emission of Radiation. A laser is a device which produces highly directional light. It emits light through a process called stimulated emission of radiation which increases the intensity of light.

## Key Features of Lasers




Lasing will continue as long as a threshold electrical / optical energy is supplied into the cavity. This is because the amount of light generated inside the cavity from stimulated emission is equal to the amount of light escaping from the partially reflective mirror.




First demonstrated in 1960, lasers have evolved rapidly from, what was originally, a mere lab curiosity to become an integral part of life, be it in consumer devices, medical devices and industrial machines. Such is the economy surrounding lasers that there is a vibrant international M&A market for companies spanning all aspects of the commercial laser ecosystem.

# Laser Types

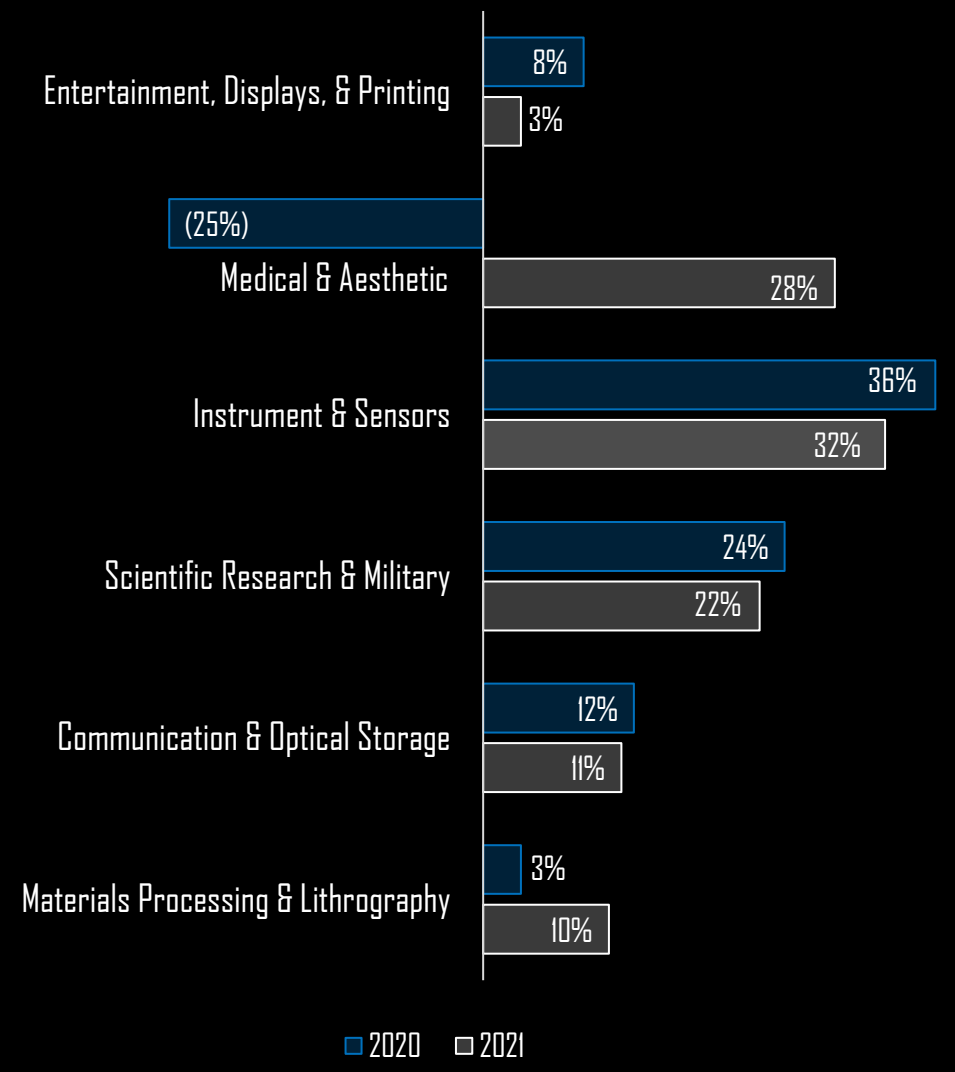
| Key Lasing Process | Key Attribute | Manufacturing Process | Applications |
|---|---|---|---|
| Gas<br>Chemical<br>Dye<br>Metal Vapour<br>Solid State<br>Semiconductor<br>Quantum Cascade<br>Free Electron | Continuous Wave Modulated<br>Pulsed<br>Tunable<br>Comb<br>High Power<br>High Fidelity | Breadboard<br>Bulk Optics<br>Micro Optics<br>Heterogeneous Wafer-scale | Communications<br>(free space, fibre)<br>Test & Measurement<br>Material Modification<br>Military<br>Sensing<br>Medical<br>Imaging<br>Quantum Processes |

**Lasers are now available in a bewildering array, encompassing many different types of laser light generations, all chosen to enhance key attributes required for end-market applications, of which there are many thousands.**

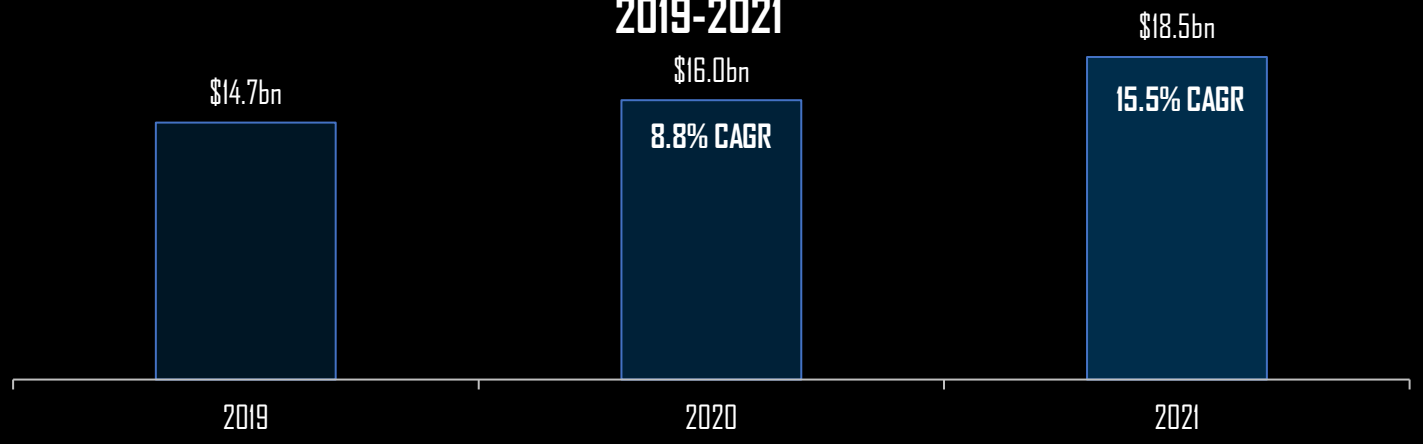
**In the modern world you are never far from laser light of some type…**

# Laser Market

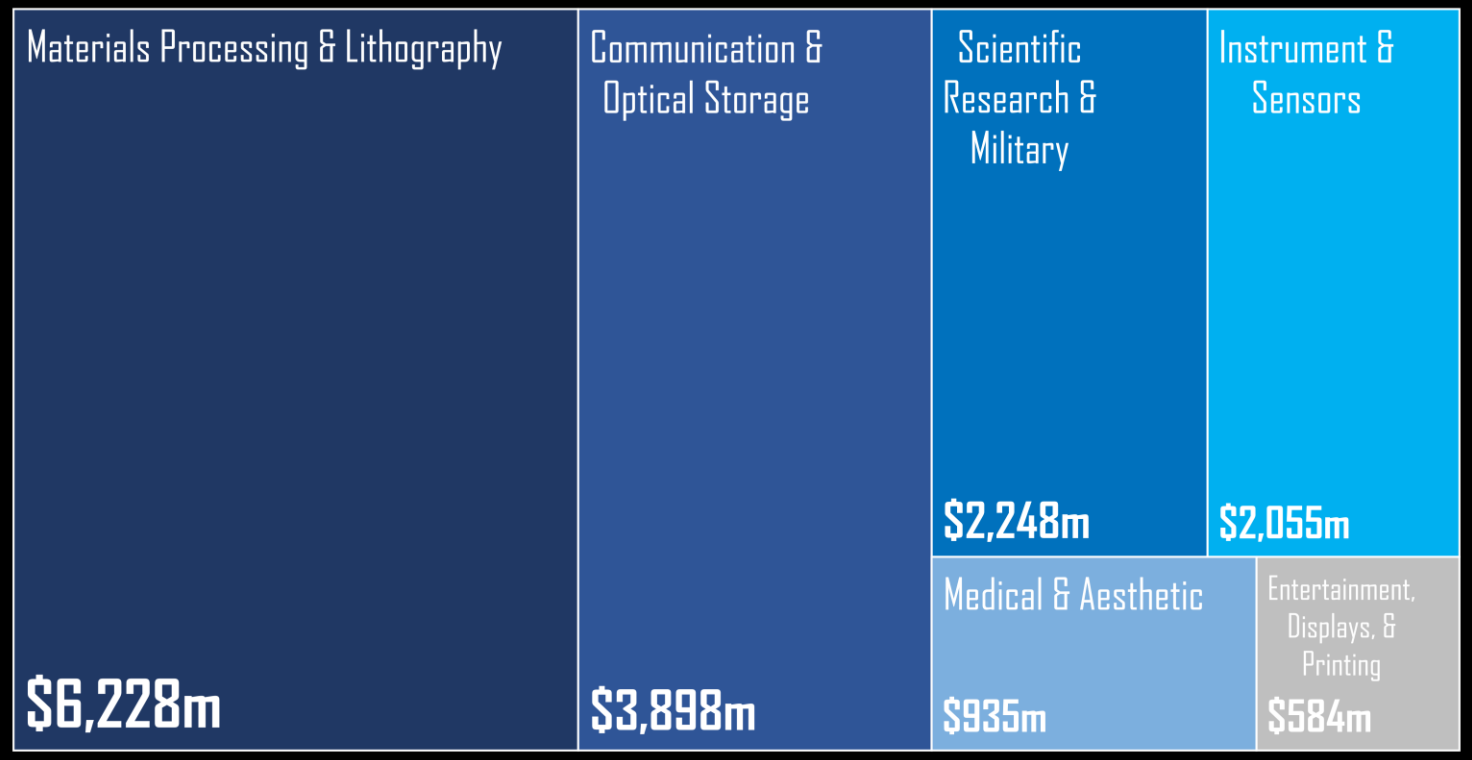
## Revenue by Laser Application 2020-2021




## Laser Market Overview 2019-2021




## 2020 Laser Revenues




*Source: Laser Focus World Magazine*

# COVID-19 IMPACT

- Closed factories & lockdowns
- Supply chain problems & shipping delays
- Limited business travel / conferences
- China revenue down 80% in Q1
- There have been winners in the laser industry…

COVID-19 can affect the global economy in three main ways:
(1) directly affecting production and demand;
(2) creating supply chain and market disruption;
(3) financial impact on firms and financial markets

## Instruments and Sensors

- Almost 60% of the total laser revenue
- Lidar <10% of the total
- Flow cytometry ~ 12%
- Global smartphone sales decline 2.5%

## Medical & Aesthetic

- Elective procedures were not a priority in 2020
- Dental was way down
- Cosmetic down 35%
- Surgical up 4%
- Ophthalmic down 20%

## Scientific Research & Military

- The military adopting laser-directed energy weapons
- R&D stayed the same due to COVID
- However, R&D spending increased in China

## Communication & Optical Storage

- Homeworking has produced impact on communications
- Communication laser revenues have already started to increase

## Materials Processing & Lithography

- Most of the lasers are used for EUV (no effect from COVID)
- Materials Processing had some slowdowns
- Chinese economy has much improved, Europe & US will improve after mass vaccination

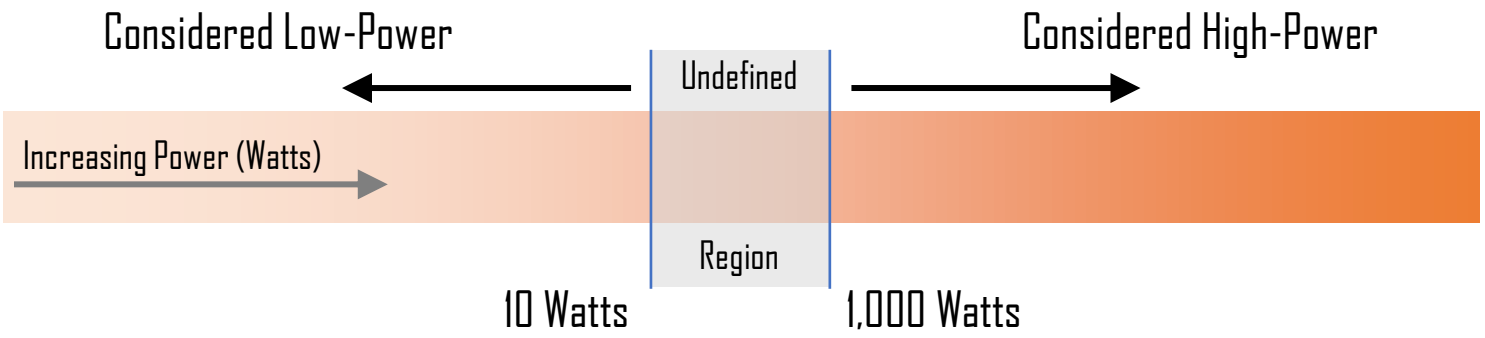
## Entertainment, Displays, Printing

- Entertainment Lasers mainly from China & Japan
- Home offices need printers
- At home entertainment more important than ever

*Source: Laser Focus World Magazine*

# High-Power Lasers

# High-Power Lasers




Although the diagram above represents the commonly accepted way of thinking of high-power lasers, one can also think of it as the higher power lasers for a given sub-class of laser technology; e.g., some "high-powered" laser pointers emit a few hundred milliwatts, whereas ordinary laser pointers are limited to a few milliwatts.

## Applications

### Material Processing

Welding, Cutting, Drilling, Soldering, Marking, Surface Modification

### Large-scale Laser Displays

RGB sources

### Remote Sensing

LIDAR

### Medical Applications

Surgery

### Military Applications

Anti-missile Weapons

### Fundamental Science

Particle Acceleration

### Laser-induced Nuclear Fusion

# Challenges of High-Power Lasers

## 1 Pump Requirements

- One or more powerful pump sources needed
- Lamp pumping was originally the only viable approach for most solid-state lasers,
- Now pumping with high-power laser diodes has become more and more widespread.
- Diode-pumped lasers now offer the highest output powers in continuous-wave operation
- For very high pulse energies (e.g., tens of joules), lamp pumping is still more practical

## 2 Efficient Gain Medium

- A substantial fraction of the pump power is converted into heat
- In the worst case, this causes thermally induced stress leading to laser crystal fracture
- Can also lead to thermal lensing (changing of refractive index and mechanical stress causing shift in optical properties
- Achieving high beam quality becomes substantially more difficult
- Efficient heat removal and thermal management are therefore important issues

## 3 Nonlinear Effects

- Stimulated Raman scattering, Brillouin scattering and four-wave mixing

## 4 Laser Induced Damage

- Particularly in Q-switched lasers, very high optical intensities can occur
- This can lead to laser-induced damage of optics (such as laser mirrors) e.g. via laser-induced breakdown.
- Even tiny dust particles can provoke damage phenomena
- It can therefore be essential to keep the laser setup clean and isolated and using precision optics with a high optical damage threshold.

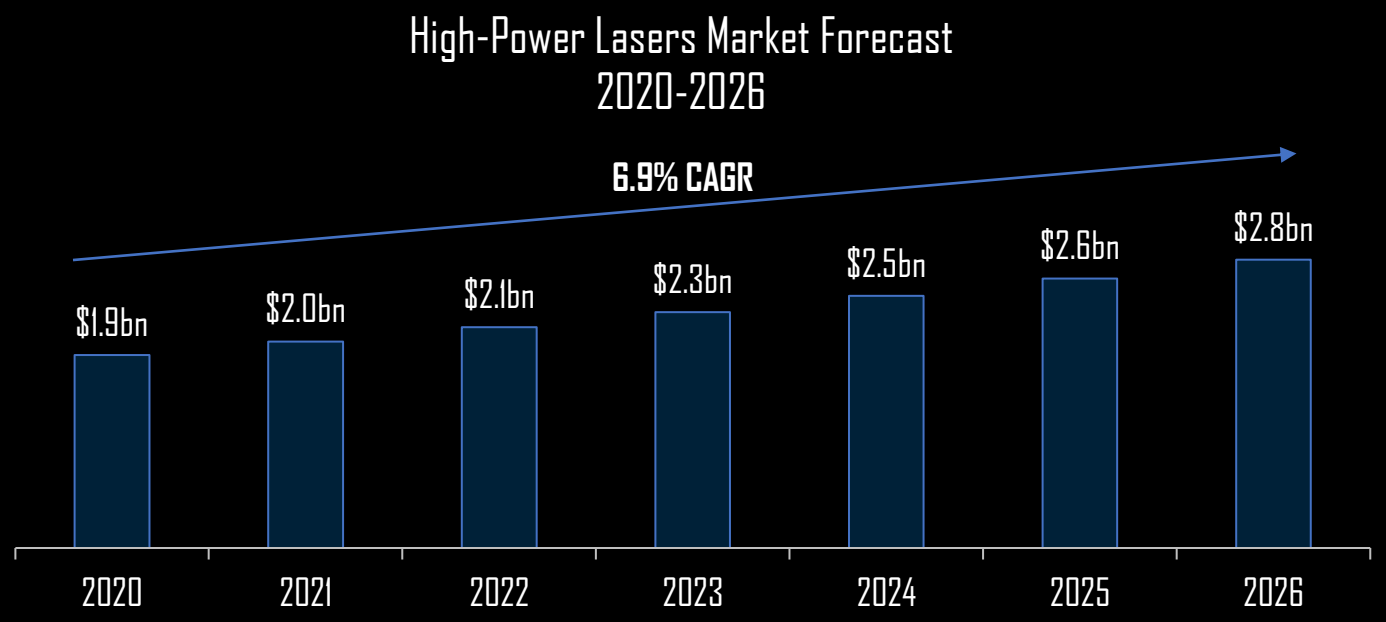
## 5 Misalignment

- Laser resonators with large effective mode areas tend to be sensitive to misalignment and vibrations of optical components
- Challenging to achieve robust maintenance-free operation and a good beam pointing stability

High power lasers are now considered reliable and are widely used in generic industrial environments (albeit with the appropriate safety protocols) further development and innovation is focused on not just new applications but on lifetime cost reduction and ever-increasing operating lifetimes. There is always innovation to attain even higher power and extending wavelength range.

# High-Power Lasers Market

- Global high-power laser market is likely to be positively influenced by the rising demand from the industrial sector
- Laser processing equipment is widely used in industrial applications
- High-power laser market is likely to face pricing pressures
- Altering manufacturing and design procedures of laser diodes are resulting in a fundamental shift in reliability and cost of high-power laser systems
- There has been a noteworthy progress in demand for lasers owing to extremely abridged laser size, rising wall plug competence, low power intake, and low cost




*Source: WFMJ*

# Selected High-Power Laser Companies

Recently, Han's Laser broke through a series of ultra-thick laser cutting technology barriers, successfully mastering the 20KW ultra-high power laser cutting process technology and developed a 20KW fiber laser cutting machine. This laser cutting system can increase the thickness of stainless-steel cutting to 100mm and improve cutting efficiency and equipment reliability by more than 20%.

High power kilowatt-class fiber laser sources are available from one to hundreds of kilowatts average power. Housed in rugged cabinets, these systems are designed to operate in industrial manufacturing environments. A variety of beam delivery and process head options provide the ultimate flexibility in optimising one laser for many different applications. IPG high power industrial fiber lasers are recognised as reliable and productive tools in demanding industries such as automotive, aerospace and oil & gas.

**Lumentum** is a market-leading designer and manufacturer of innovative optical and photonic products enabling optical networking and laser applications worldwide. All CORELIGHT high-power fiber laser products incorporate **Lumentum**-patented ST Series high-brightness diode pump modules resulting in a compact design with industry-leading brightness and electrical-to-optical efficiency.

**Lumibird** manufactures a wide range of high-power lasers. Their three key technologies: pulsed solid-state lasers (nanosecond range), CW and pulsed fiber lasers and fiber amplifiers and laser diodes. Various application areas are addressed, in industry (manufacturing, lidar sensors), science (laboratories and universities), medical (ophthalmology) and defense.

**Luxinar** has been at the forefront of laser technology for over 20 years and is a leading manufacturer of sealed carbon dioxide ($CO^2$) laser sources up to 1,000W and, more recently, femtosecond laser sources. To date, they have an installed base of over 18,000 lasers worldwide.

The **Koheras HARMONIK** fiber laser system provides over 7 W output at 780 nm with a unique combination of low noise, narrow linewidth, and beam quality. It is alignment-free and maintenance-free. The **HARMONIK** system is a high-power frequency-doubled laser system consisting of popular low-noise **Koheras BOOSTIK HP** fiber laser platform in combination with new frequency converter module.

# Selected High-Power Laser Companies

Compact and versatile, **nLIGHT** designed their lasers with trusted and durable components for high operating efficiency in a wide range of materials processing applications. Based on nearly two decades of high-power laser innovation, **nLIGHT** fiber lasers feature the latest in optical technology, allowing consistent part quality and increasing the capability of different metals and thicknesses that can be cut by the job shop.

**PENTA LASER** is a joint venture of **Italian El.En Group** and **Chutian Laser Group**, which designs and manufactures high-power laser cutting systems. With more than 30 years of experience in laser systems from El.En Group Italy, **PENTA LASER** has core technologies in both manufacturing advanced high-power laser sources and CNC machinery integration with high compatibility.

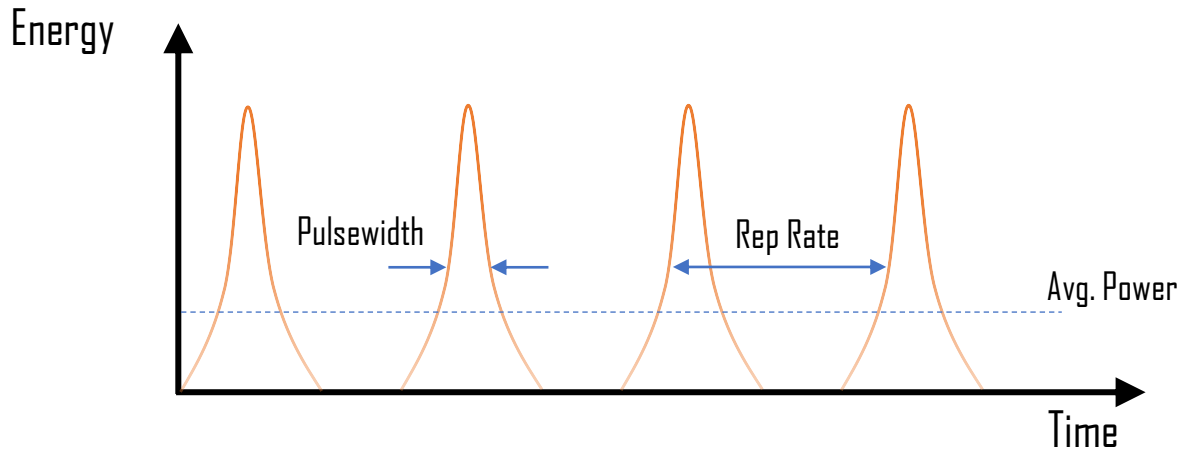
**Raycus Fiber Laser Technologies** (Raycus) is the pioneering and leading developer and manufacturer of high-power fiber laser and core components in China. Founded in 2007, Raycus has developed 10-100W Q-switched Pulsed fiber lasers, 5-10KW CW fiber lasers, short pulse MOPA structure fiber lasers, and direct diode lasers. Raycus keeps expanding its facility and product line and has built an annual production capacity of 10,000 units of pulsed fiber laser and 1,000 units of medium and high-power CW fiber laser.

**Thales** joined the Extreme Light Infrastructure for Nuclear Physics (ELI-NP) programme in 2013 to develop the High Power Laser System (HPLS). Under this first contract, **Thales** is providing the National Institute of Physics and Nuclear Engineering (IFIN-HH) in Romania with a laser system delivering 2x10 PetaWatt (20 million billion Watt) of power — more than any other laser system to date.

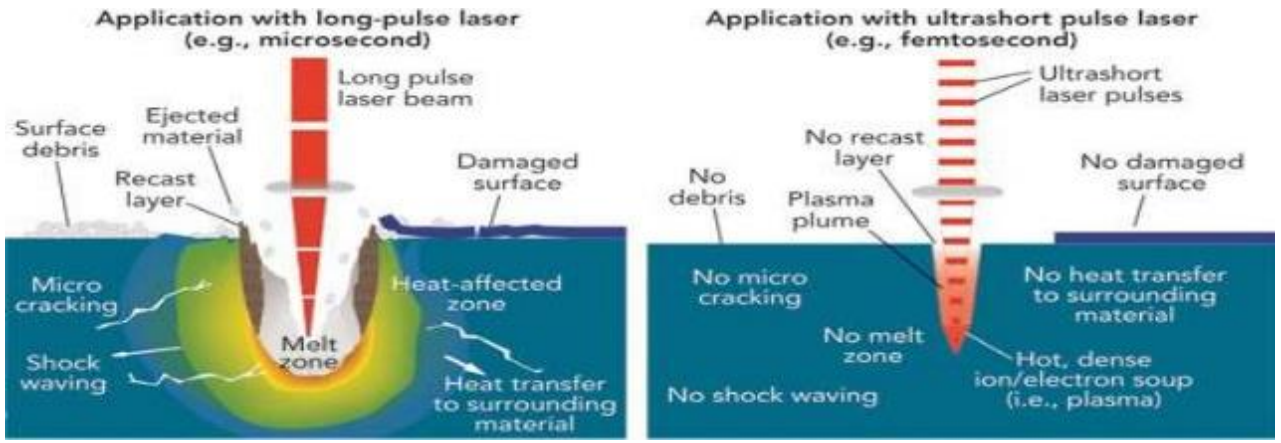
A compact footprint, long service life, single-mode beam quality up to 2 kW as well as a robust "all-in-fiber" resonator concept – all these features make **TRUMPF** fiber lasers first choice for a wide range of applications. The fiber laser-based **TruMark Series 5000** offers the optimum combination of high power, high frequencies, and adjustable pulse duration. The high-power marking laser is designed for demanding applications with high power requirements and short cycle times.

# Pulsed Lasers

# Pulsed Lasers




Technological developments in lasers have allowed for pulse durations of lasers to become increasingly small: nano-, pico- and now femto-second laser are all commonplace commercially.
Of these, pico- and femto-second lasers are commonly referred to as ultrashort pulse or ultrafast lasers.




*Source: Assembly Magazine*

# Applications

## Industrial

Welding, Cutting, Drilling, Soldering, Marking, Surface Modification

## Life and Health Sciences

Microdissection, Neuroscience, Optogenetics, Embryology

## R&D

Various Spectroscopy Techniques

## Medical Applications

Bio-imaging for Eye Surgery

# Important Parameters for Pulsed Lasers

Key performance figures for ultrafast lasers:

1. Pulse Duration
2. Pulse Repetition Rate
3. Average Power

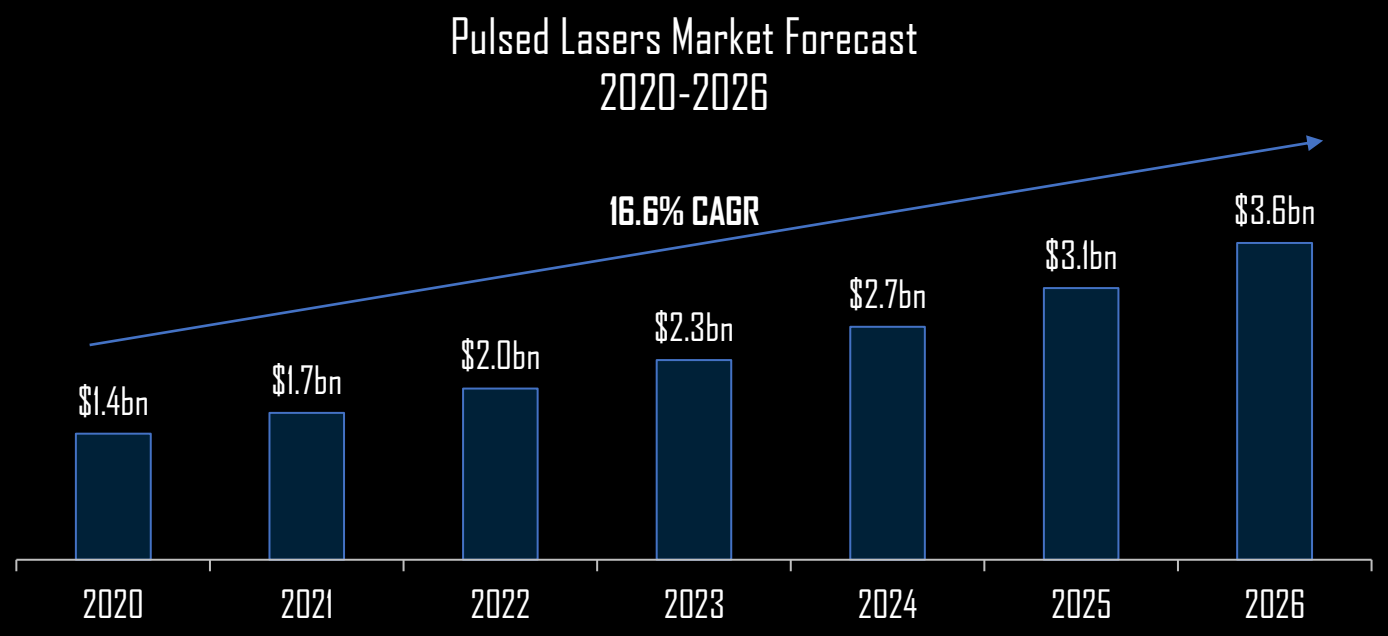
## Other important parameters:

- **Time–bandwidth product (TBP):** Shows whether the spectral width is larger than necessary for the given pulse duration. The pulse quality includes additional aspects such as details of the temporal and spectral pulse shape, such as the presence of temporal or spectral pedestals or side lobes
- **Polarisation:** Many femtosecond lasers offer a stable linear polarisation of the output, whereas others emit with an undefined polarisation state
- **Noise properties:** Can differ strongly between different types and models of femtosecond lasers. Includes noise of the pulse timing (timing jitter), the pulse energy (intensity noise), and different types of phase noise. Also important to check the stability of pulse parameters, including the sensitivity of external influences such as mechanical vibrations or optical feedback
- **Built-in stabilisation of pulse repetition to an external reference / tuning the output wavelength**
- **Built-in features for monitoring the output power, wavelength, or pulse duration**
- **Other aspects** Size of housing, electrical power consumption, cooling requirements, and interfaces for synchronization or computer control

# Pulsed Laser Market

Pulsed laser market growth is primarily driven by the increasing demand for material processing and semiconductor industries that in turn find their applications in several end-user industries like automotive, communication and technology, consumer electronics as well as healthcare.

Moreover, advances in the ultrafast laser market are projected to open new avenues of applications outside its core application of micromachining. For example, in 2019, an ultrafast pulsed laser was used to melt ceramic materials using less than 50 watts of laser power making it even more preferrable method than the current welding methods that necessitate heating various parts in the furnace.




*Source: Research and Markets*

# Selected Pulsed Laser Companies

**Amplitude** is a global manufacturer of femtosecond lasers for scientific, medical and industrial applications. **Amplitude** industrial compact femtosecond lasers are the result of more than 18 years of experience in the field. They are in line with all kinds of applications such as micro-machining, pixel repair, and many more, but can also be used by researchers in the fields of accelerators, material science and life science.

**Chromacity** fibre-based femtosecond laser source exploits the well-known advantages of Yb-doped fibres as gain media, while delivering high quality and high power ultrashort pulses. The **Chromacity** 1040 is ideal for coupling into microscope systems, empowering users to produce clear and high-resolution images, as a result of its excellent beam quality, ultrafast pulses and high average power levels.

**Class 5 Photonics** offer powerful and high-performance femtosecond lasers based on optical parametric chirped pulse amplification (OPCPA). Their products serving the ultrafast community with wavelengths ranging from high-flux extreme-ultraviolet (XUV) to high-field terahertz – enabling researchers in physics, chemistry, and biology to conduct research at the frontiers of their fields.

**EKSPLA** offers a wide range of femtosecond lasers for various applications. **FemtoLux3** series microjoule class industrial fiber laser, **Ultraflux** series femtosecond tunable wavelength laser based on the novel OPCPA technology, **FF200** series compact fiber laser.

**Halite** is a compact, single-box, all-fiber femtosecond laser, specifically designed to meet the most demanding applications in the field of neuroscience, biophotonics, microscopy and engineering. Pulses as short as <180 fs, average power up to 2 W at 1030 nm and the option of second harmonic generation at 515 nm.

The **FYLA SCH** lasers are for multiphoton and SHG microscopy. With a broadband spectrum (900–1180 nm), multiple fluorophores can be imaged simultaneously without the need of wavelength tuning. Delivering the shortest pulses on the sample plane (of the range of 15–20 fs), **FYLA´s SCH** offers >200 kW peak powers and the highest levels of brightness at reduced average power, improving photobleaching and photodamage to the sample.

# Selected Pulsed Laser Companies

**KMLabs** leads the way in the development, and commercialisation of table-top extreme UV and soft X-ray laser light for a variety of experiments. The QM **Quantum Microscope™** builds on the company's world leading technology in high harmonic generation to enable a range of techniques including coherent diffraction imaging, photoemission, pump–probe spectroscopy, and EUV metrology.

The femtosecond **PHAROS** and **CARBIDE** lasers combine millijoule pulse energies and high average powers for scientific and industrial applications. The compact and robust optomechanical design leads to stable laser operation in varying environments. The use of solid-state laser diodes for pumping of Yb medium significantly reduces maintenance cost and provides long laser lifetime.

**Menhir Photonics** offers ultrafast mode-locker lasers at 1,5µm wavelength. These lasers offer pulse width below 200 fs and fundamental pulse repetition rates that can be chosen from 250 MHz up to 2.5 GHz. These systems are hermetically sealed and all-in-one (laser and electronic is one box). **Menhir Photonics** products have been designed to achieve ultra-low-noise performances combined with high-reliability and robustness.

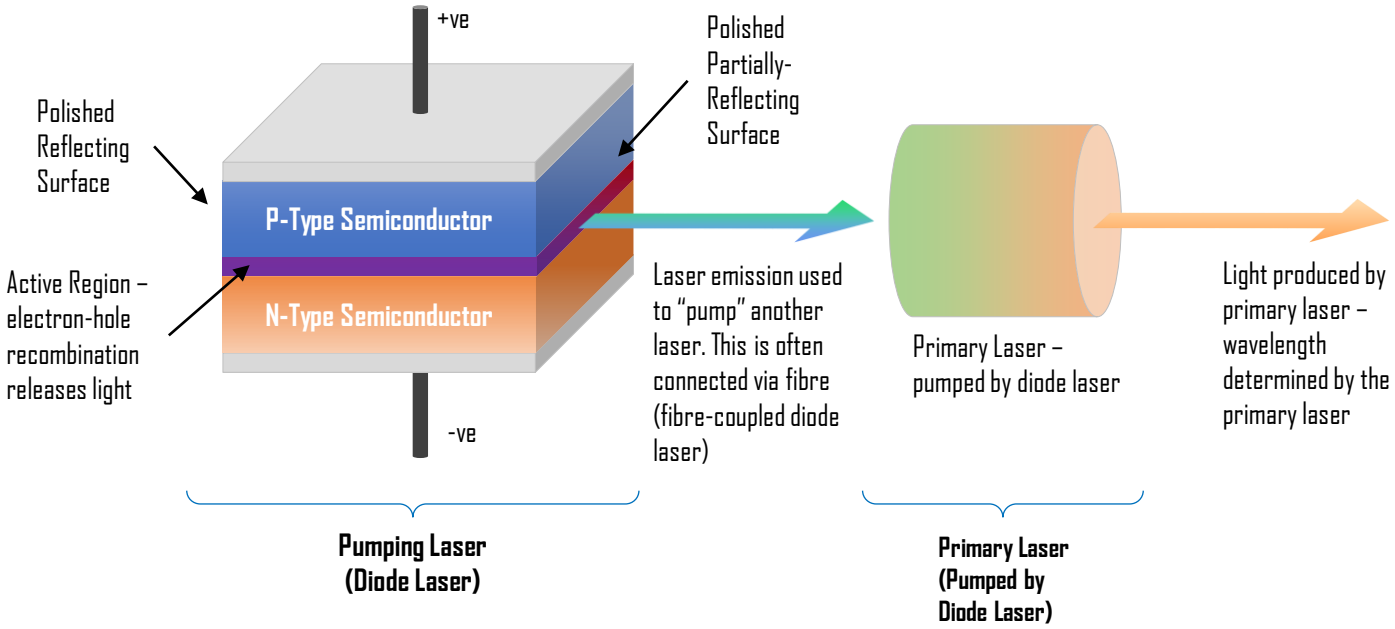
**Menlo Systems'** femtosecond fiber lasers based on Menlo figure 9® patented laser technology are unique in regard to user-friendliness and robustness. **Menlo Systems** offer solutions for scientific research as well as laser models engineered for OEM integration. From the shortest pulses to highest average power beyond 10 Watts and pulse energy beyond 10 µJ, **Menlo Systems** have the solution for your application ranging from basic research to industrial applications.

With more than 15 years of experience, **TOPTICA** provides high-repetition femtosecond lasers based on erbium- and ytterbium fiber laser technology. **TOPTICA** offers systems for OEM integrators as well as customised solutions for scientific customers, ranging from compact fiber-based seeders / oscillators to custom-tailored high-power amplifiers.

Completely passively cooled ultrafast fiber laser **Aalto** is perfectly suited for multiphoton applications like two-photon microscopy. The pulse durations below 50 fs lead to an increased signal-to-noise ratio and a better resolution and scan depth compared to longer pulses. The ultrafast fiber laser **Tidal** is a high power version of the **Aalto**. A power level of >3 W and <50-fs pulses result in peak power values above 2 MW.

# Diode Pumped Lasers

# Diode Pumped Lasers




Diode pumped lasers work by using light produced from a diode laser (left side of diagram) to provide light which causes population inversion in the primary laser. The primary laser is then able to emit laser light of a given wavelength. Lasers "pumped" using a diode laser are therefore referred to as *Diode Pumped Lasers.* Diode lasers are used for pumping due to their high electrical-to-light energy conversion efficiency.

The diode laser is electrically "pumping" electrons and holes into the p-n junction resulting in significant recombination of the electrons and holes. Engineering the p-n junction enables light of a specific wavelength to be emitted. By polishing the edges of the junction, a resonance cavity which reflect the light back and forth is formed. The light emitted from the recombination is therefore able to stimulate more emission: the fundamental lasing property.

# Applications

## Manufacturing

Welding, Cutting, Drilling, Soldering, Marking, Surface Modification

## Medical

Imaging, Cutting Soft Tissue in Surgery, Spectroscopy

## Metrology

Position Measurements, 3D Scanning, Time Measurements

## Communications

Optical Data Transmission

## Military Applications

Anti-missile Weapons

## Science

Laser Cooling, Optical Tweezers

# Advantages of Diode Pumping

## 1 Power Efficiency

- High electrical-to-optical efficiency of the pump source
- Electricity and cooling demands reduced

## 2 Narrow Optical Bandwidth

- Makes it possible to pump directly certain transitions of laser-active ions without losing power in other spectral regions

## 3 Beam Quality

- Beam quality of high-power diode lasers not good, however, it often allows for end pumping of lasers with very good overlap of laser mode and pump region, leading to high beam quality and power efficiency

## 4 Low-Power Lasers

- Diode-pumped low-power lasers can be pumped with diffraction-limited laser diodes
- Allows very low-power lasers to be made with reasonable power efficiency
- Important for battery-powered devices

## 4 Lifetime

- Generally long lifetime compared with discharge lamps

## 5 Compact

- Pump source, power supply and cooling arrangement are compact

## 6 Wide Range of Gain Media

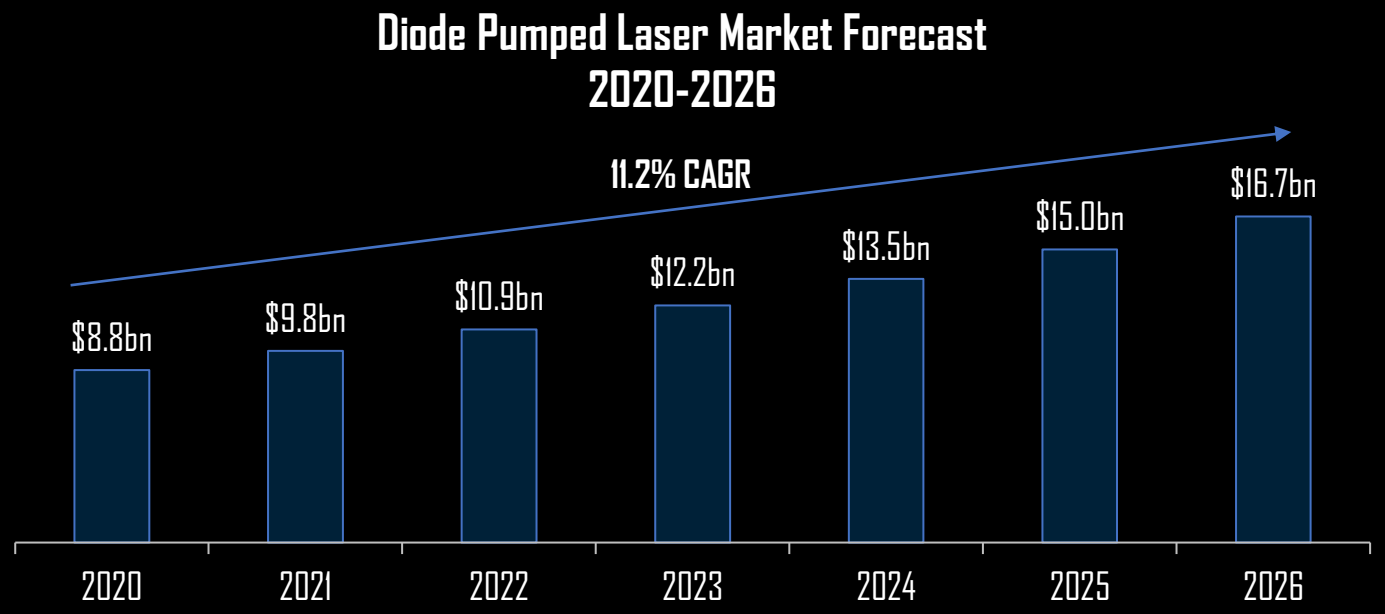
- Possible to use variety of gain media for different wavelength regions

## 7 Low Noise

- Laser diodes tend to have low intensity noise, leading to overall low noise of the diode-pumped laser

# Diode Pumped Laser Market

According to the laser-focus world, the market for laser materials-processing systems grew by an incredible 50% from 2016 to 2018. In 2019, one of the key trends is the rise of VCSEL technology for applications like facial recognition in smartphones. VCSELs are a type of laser diode that offers superior beam properties, thermal stability, and device scalability compared to products like Fabry Perot laser diodes.




*Source: Mordor Intelligence*

*Drivers:*

- Adoption of high-power laser diodes in autonomous vehicle technologies drives the market. LiDAR systems are the key to the development of autonomous vehicles. Research institutes, photonics companies, and traditional suppliers of automotive parts are currently positioning themselves with new LiDAR technology to play a part in this market in the future
- Fraunhofer Institute for Microelectronic Circuits and Systems IMS presented a Flash LiDAR Instead of directing the laser beam onto a rotating mirror for a 360 degrees view
- The use of lasers for directed energy (DE) applications is increasing, while diversity in requirements and technology is continuously evolving with high-power laser weapons becoming a significant component within the United States' defense arsenal

# Selected Diode Pumped Laser Companies

**AeroDIODE** offers high-power laser diodes with up to 150 W output at 808 nm, 915 nm, 976 nm or 1064 nm – available as stock items or assembled with a turn-key laser diode driver with air-cooled temperature regulation. Versions with a high-power optical fiber connector or with a 3-mm output collimator are available.

**Alpes Lasers** manufactures laser diodes emitting at wavelengths from 1.45 to 2.15 µm with powers up to 50 mW. They are offered either as chip-on-carrier or encapsulated in a low power TO-66 package with collimated or divergent free-space beam output.

**Brolis Semiconductors** develops a range of mid infrared laser products and system solutions. Combining the unique know-how in long wavelength material epitaxy and mid infrared laser chip technology. Products are divided into four main groups: high-power CW multimode laser diodes, single-TE00 mode laser diodes, broadband gain chips and single-frequency lasers.

All **Cobolt** diode lasers are manufactured using proprietary HTCure™ technology and the resulting compact packages and robust optical assembly provide a very high level of immunity to varying environmental conditions along with high reliability. With proven lifetimes from many thousands of units installed in the field, the **Cobolt** diode lasers have proven to deliver unmatched reliability and performance both in laboratory and industrial environments, which is reflected in market leading warranty terms.

**CryLaS** designs, manufactures and markets diode pumped passively Q switched solid state laser and continuous wave laser at emitting wavelengths as 213 nm, 266 nm, 355 nm, 532 nm and 1064 nm for use in industrial and scientific applications. **CryLaS** provides compact plug & play laser sources with excellent optical properties, high reliability and low cost of ownership.

**Frankfurt Laser Company** offers a wide range of diode-pumped solid state laser products, including the smallest DPSS laser heads, low-cost modules, low power and high-power laser systems and high quality single longitudinal mode laser systems with different power output and wavelengths.

# Selected Diode Pumped Laser Companies

**Integrated Optics** (IO), is an ISO certified manufacturer of the "World's Smallest" MatchBox CW DPSS laser and diode modules and Multi-Wavelength Combiner series. The ultra-compact MatchBox series consists of span a wavelength range of 405nm – 1550nm, and are utilised for a variety of spectroscopy and LiDAR applications. At the core of their technology is a proprietary optics assembly process based on robotics and unique software solutions that have optimised throughput and increased quality and repeatability.

**Laser Quantum** manufactures a wide range of diode-pumped solid-state lasers with wavelengths and powers from 473 to 1064 nm, 25 mW to 16 W. **Laser Quantum** guarantee high reliability, compact size and long lifetimes, suitable for a large variety of applications.

**nanoplus** designs and produces distributed feedback lasers in the entire wavelength range from 760 nm to 14000 nm. **nanoplus** offer laser diodes (760 nm - 3000 nm), interband cascade lasers (3000 nm - 6000 nm) and quantum cascade lasers (6000 nm - 14000 nm). The lasers are used for high-precision measurements in industry and research. Applications include industrial process optimisation, oil & gas, environment, defense, safety, automotive, health, space and research.

The low noise version of the **Oxxius** LaserBoxx LBX Series laser diode modules operate from 375nm up to 1064nm, ideal for bio-photonics and industrial applications. Contained within a compact, industry standard sized package, these lasers are the ideal addition to the laboratory or for integration into original equipment manufacture (OEM) instruments.

**Quantum Light Instrument** lasers are optimised to produce nanosecond pulses with up to 120 mJ energy per pulse, at up to 5 W average power. Air-cooled, water-free and cost-effective solution for wide range of applications, including LIBS, LIDAR, TOFS, micromachining and others.

**Teem Photonics** offers air-cooled diode-pumped passively Q-switched lasers – the Microchip laser series and the more powerful Powerchip laser series. Higher average power versions are based on a MOFA architecture, i.e., using a fiber amplifier. All can generate intense sub-nanosecond pulses. Available emission wavelengths are 1535 nm, 1064 nm, 532 nm, 355 nm, 266 nm and 213 nm.

# Investment + M&A Trends

# M&A, Investment Trends and Drivers in Photonics

**TRENDS**

- Photonics is still immature compared to Electronics
- There is no one dominant material type for Photonics, and advances in material properties and processing methodology are continually disruptive in Photonics and especially the laser industry
- Disruptive advances tend to happen in smaller innovation groups rather than the very large Tier 1's
- Product run sizes are only just starting to break into the millions per year unlike electronics where multimillion run sizes are common.
- Integrating the dissimilar materials required to make an optimised photonics system are nowhere near as well developed as those for integrated electronics. Consequently, the advantages of wafer scale integration is only just starting to come to fruition in Photonics and is still in its very early days for Lasers
- Photonics is still driven by esoteric knowledge. Limited groups of engineers combining, system knowledge, software, photonic, electronics, RF, mechanical, production engineering in a single cohesive team tackling a pressing market problem
- Growing realisation from financial investors that for the right teams and ideas, there are very strong returns for what are now small ticket investments

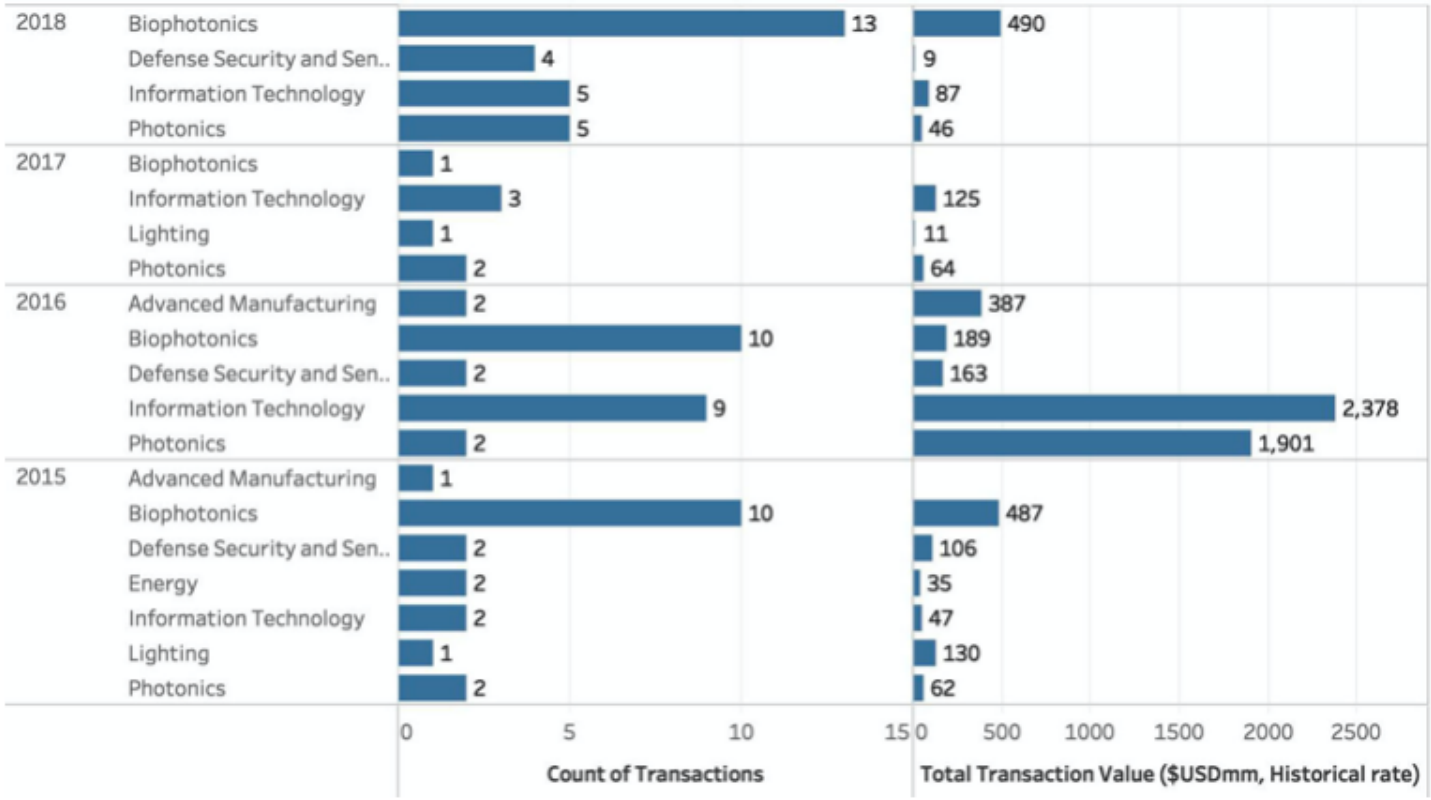
**ADDITIONAL DRIVERS**

- Vertical Integration
- Large-scale mergers between Photonics companies (Lumentum/Coherent, Lumentum/Oclaro, II-VI/Finisar, Cisco/Acacia, NVIDIA/Mellanox)
- Semiconductor companies combining with Photonic companies. That barrier is breaking almost faster than the barriers between photonics companies at a technical execution level
- Specialisation of equipment companies
- Trade war between USA and China, with Europe as the main winning recipient
- Photonics companies are internationalised at inception. It is almost impossible to be regionally localised
- Regulatory review – as photonics is seen as critical and also not that well understood by those outside the industry. Photonic investment and mergers and acquisitions attract a higher degree of regulatory scrutiny than other transactions

# Chinese Investment in US Photonics

In the 1990's, a western narrative was that Chinese companies had inadvertently killed the laser industry. By flooding low quality products onto the market at apparently less than cost, just as western laser companies were trying to wean themselves off tempting Darpa contracts that were winding down as the western world wound down the SDI (Star Wars program). This is now a very distant memory and the Laser industry has changed beyond all recognition. Western firms lead a surge of innovation that Asian players struggled to keep up with; growth and gross margin returned as new markets were found. By the mid 201X's there were strong Asian investment dollars flowing into the USA as Asian companies paid to catch up. This came to an almost complete halt in 2019 due to the USA/China trade war.

## China Investments & Acquisitions of US Photonics Companies




*Source: CERES*

Asian companies have turned towards Europe as a response. However, it is unlikely that long-term this rupture between the USA and China will persist as it is difficult to think of the laser industry (which has become internationalised in a mature way) proceeding without these international flows of capital persisting and strengthening.

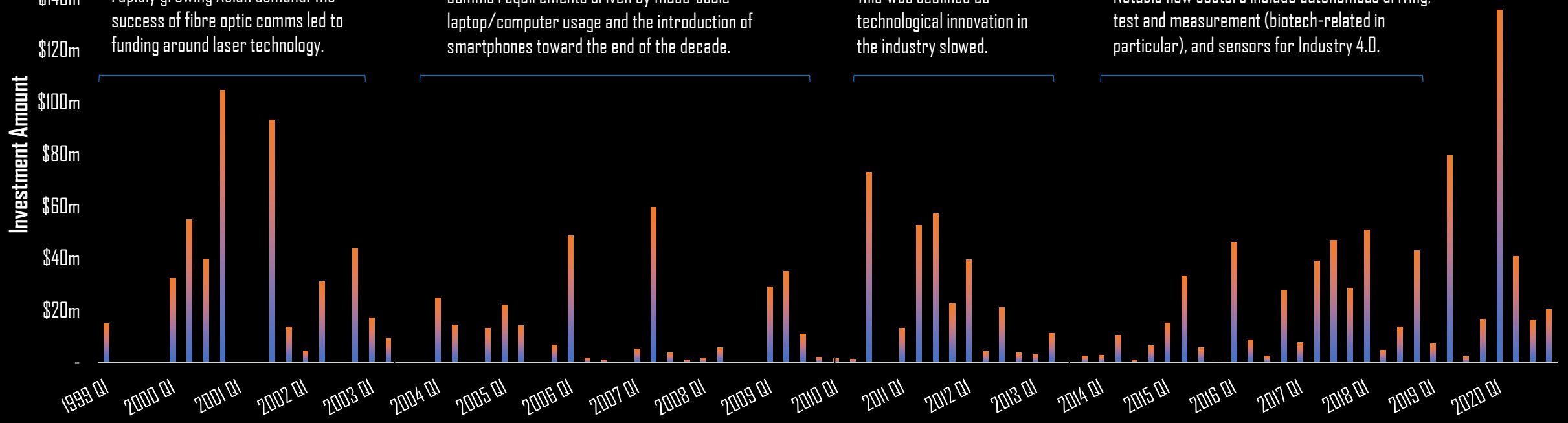
# Laser Start-up Investment History

High investment corresponding to millennial tech bubble.
Growth considerably linked to large investment flows due to 1999-2001 speculative rush from privately financed submarine optical comms cables constructions, and massive growth of Pacific cables to service rapidly growing Asian demand. The success of fibre optic comms led to funding around laser technology.

Activity limited following the tech bubble collapse, but resilient due to the rise of optical comms requirements driven by mass-scale laptop/computer usage and the introduction of smartphones toward the end of the decade.

Increased activity linked to lowered cost of capital as Quantitative Easing methods allow investment to thrive.
This was declined as technological innovation in the industry slowed.

Overcoming of technical hurdles and expansion of application horizon has vastly increased over the last 5 years.
Capital flows to realise greater potential of lasers have been increasing and are likely to continue.
Notable new sectors include autonomous driving, test and measurement (biotech-related in particular), and sensors for Industry 4.0.



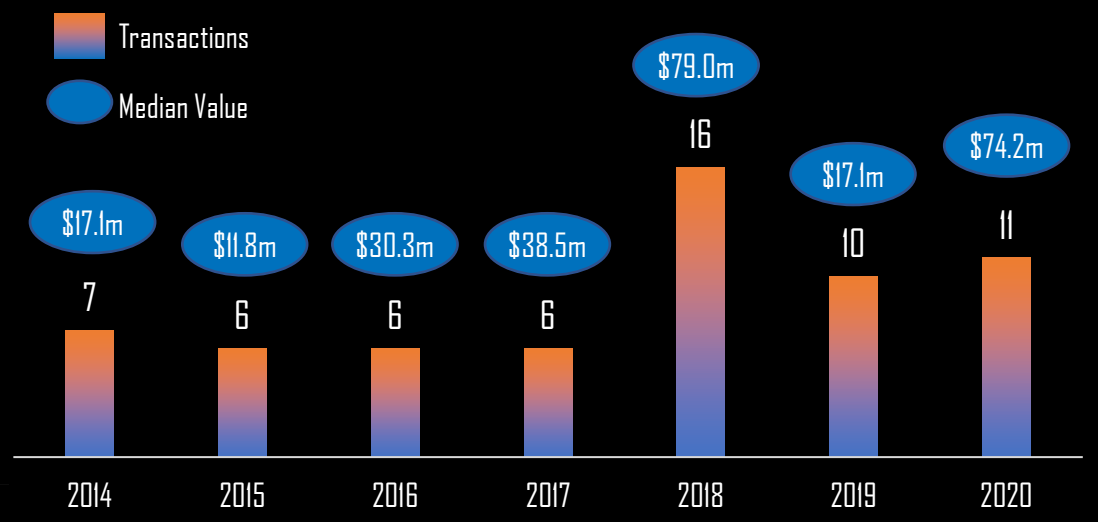

*Source: Crunchbase*

**Capital flows that were international were disrupted due to the trade war between US and China (2018), but this has been more than compensated by quantitative easing measures coming into effect.**

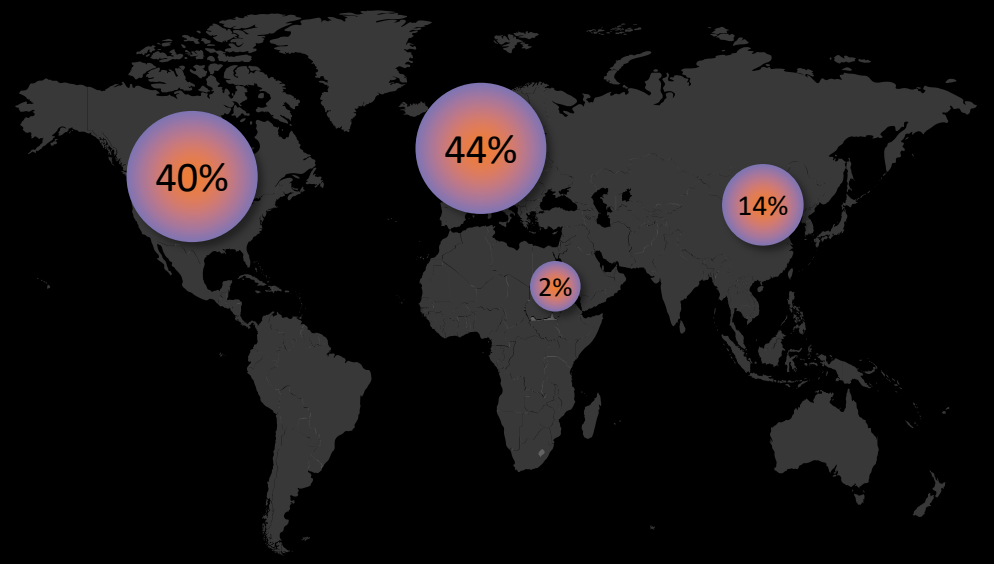
# Laser M&A Trends

- Europe shows clear lead in laser M&A, both for start-ups and larger buyers - TRUMPF most acquisitive in the region
- Companies involved in industrial applications, particularly marking and cutting applications, are the most common among the M&A targets
- Although the COVID-19 pandemic has significantly impacted the global economy, the laser industry remained largely resilient with some outperforming the market significantly
- Extraordinarily strong and distributed pseudo-governmental research agencies, become comfortable with allowing tech to spin-out for economic advantage. Only other place this happens is in China
- A factor contributing to the resilience is the growth of lasers for biotech-related test and measurement – an area which has seen large capital flows compared to prior years
- First wave of VC in newly European states replicating the early wave of VC in US

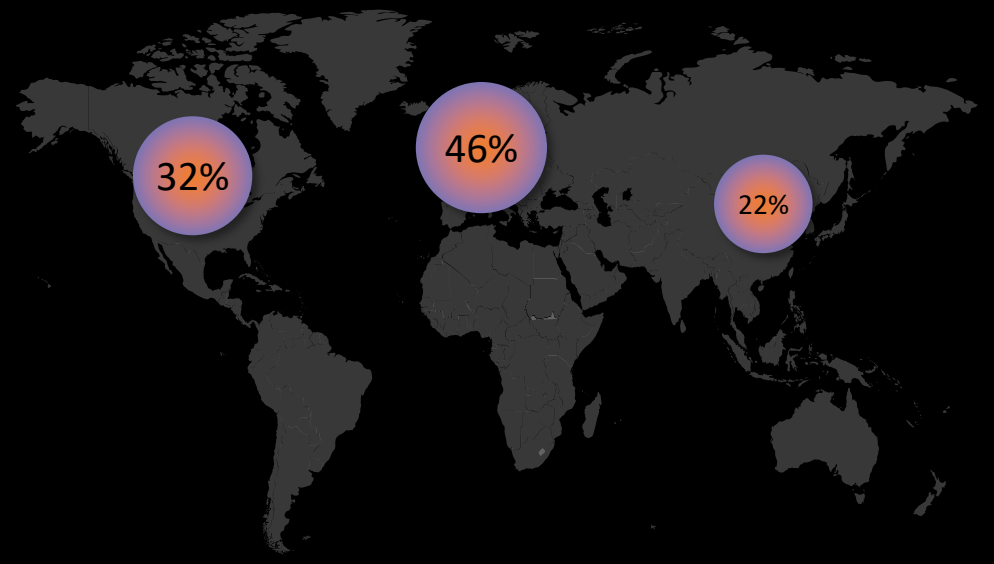
## Laser M&A Transactions, 2014-2020




## Laser M&A Target Regions, 2014-2020




## Laser M&A Buyer Regions, 2014-2020



# Coherent Case Study

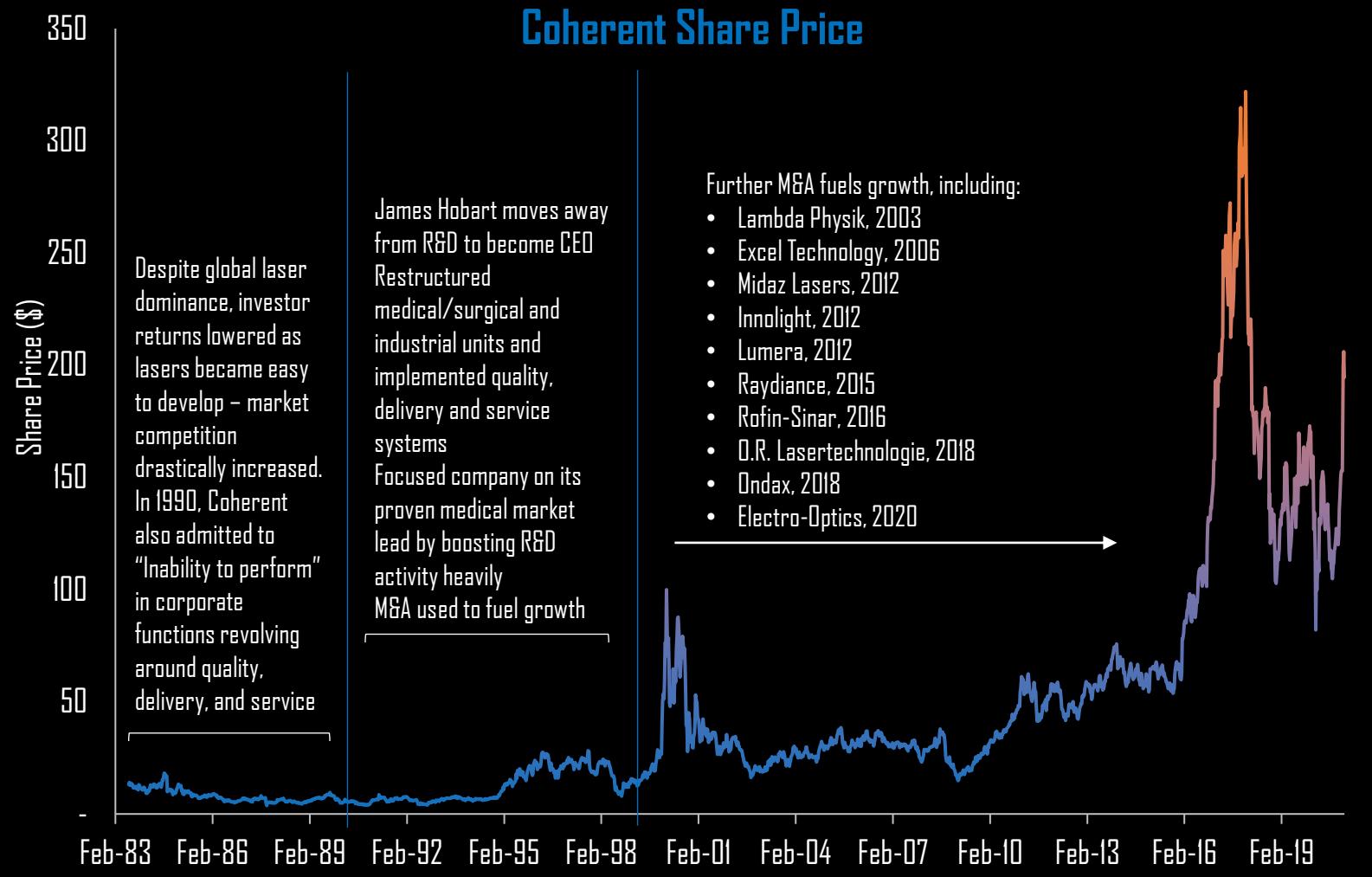
12th February 2021: II-VI submit bid for Coherent ($260 per share), 24% premium over Lumentum's initial offer

## Origins: Coherent Radiation, May 1966

James Hobart determined to use lasers for welding and cutting applications
Developed the first commercially available $CO^2$ Laser products Increased revenue from $0.5m in 1966 to $6m in 1970

Initial Public Offering in 1970 (market data not available until 1983)

1970s Market Expansion from industrial laser family to medical and scientific applications




*Source: S&P Capital IQ*

## Exit: Lumentum Acquisition

**$6.2bn**
*January 2021*
EV / Revenue: 4.6x
EV / EBITDA: 46.6x

Direct synergies:
- Telecom/datacom
- 3D sensing

Expansion of Tangential Businesses:
- Precision manufacturing
- Scientific & medical instrumentation

*8th February 2021
MKS propose rival bid for Coherent

# RCL's View of the Future

While the trend to wafer-scale integration is underway, it will be multiple decades before wafer-scale integration becomes the dominant laser manufacturing technique, if ever.

Similarly, RCL see no diminution of the rate of innovation in materials, design and production methods for lasers. Photonics in general (lasers in particular) will achieve 50,000hours of operation without failure, which is the minimum expectation for conventional electronics.

While the flight towards ever shorter pulse length is most likely done, the drive for higher power, with increasing flexibility on pulse rep rate and wavelength, will continue. Similarly, the drive to ever shorter wavelengths is also set to continue.

The realisation that investment dollars can trigger strong returns for minimal outlay, compared to other investment areas coupled with a healthy M&A market for tech tuck-ins and buy & build PE plays, will encourage heightened investment in laser companies across Europe and the USA. The emergence of mature, internationalised Asian companies competing on an equal basis will also contribute significantly to an increasingly globalised industry.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Mike Powell is the Managing Director and Partner of RCL. He has 15 years experience advising companies internationally on M&A, financing, and corporate strategy. Mike's speciality is photonics and efficiency technologies, bringing 30 years of senior level experience in leading, advising, managing and negotiating corporate projects and transactions for both private and public companies.


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