



Lasers for Materials Processing

Any Material. Any Process.

Superior Reliability & Performance

COHERENT

The Right Laser Solution for Your Application.

Materials processing experts face a wide range of choices in determining the right laser for their production needs.

Nanosecond or picosecond; ultraviolet, green or infrared; CO₂, DPSS or fiber lasers. Choosing between these lasers can be a challenge.

At Coherent, we know there is no one best laser for every application. With more than 50 years of laser expertise, Coherent provides the broadest selection of laser technologies available from any company, enabling us to deliver the optimum solution for your application, no matter what its requirements.

With a global network of applications and process development engineers, we work with you to determine the right laser for your process needs.

And, our worldwide service and technical support infrastructure will ensure optimum laser performance on your production line.



Laser Materials Processing Applications



Annealing:

Annealing is widely used to improve the characteristics of materials, in particular thin films, with applications extending from wafer scale to large substrates. Laser annealing can activate dopants for advanced CMOS circuitry, sensors, IGBT, 3-D integration and more. Excimer lasers are widely adopted for the crystallization of amorphous silicon films used to form the polysilicon layers that provide the electrical functionality for high resolution displays. Laser crystallized polysilicon also provides the stability required to drive OLED displays. Depending on the materials and layer structure of the thin films, different laser wavelengths, pulse widths and power levels are used. The VYPER excimer laser is our "workhorse" to anneal 100 nm a-Si film on large glass substrates that enables production of high resolution displays. UVblade systems are also used for fast and gentle separation of flexible displays resting on polymer films from their rigid glass carriers. Its large format processing beam is capable of releasing hundreds of flexible displays every minutes.

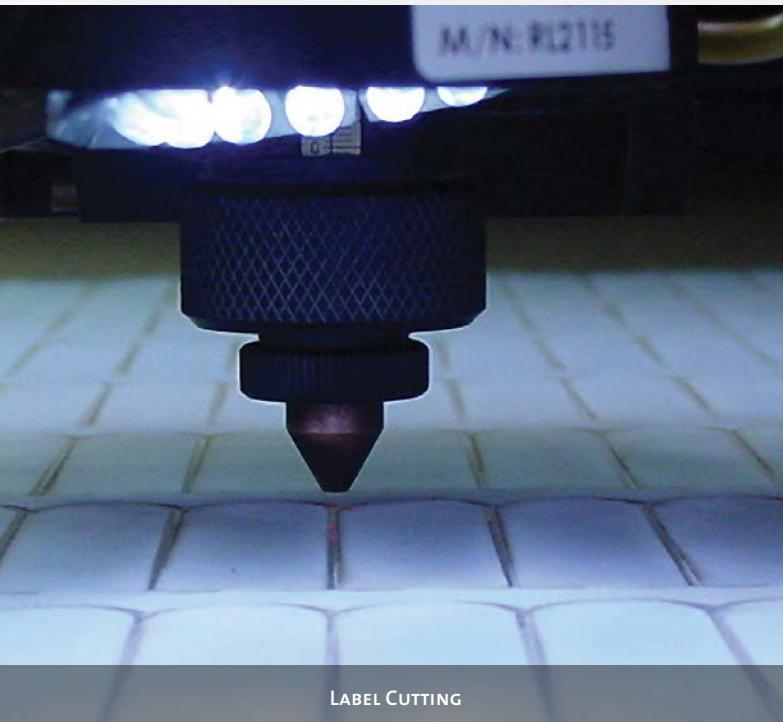
Welding:

The main benefit resulting from using a laser for this technique is high processing speeds with no tool wear due to a contact free process. The process leaves low heat affected zones and low part distortion resulting in small welding seams with very little need for post processing. A high degree of automation display manufacturing including process monitoring, control, and documentation enable excellent product quality and repeatability. Typically any metal that can be welded by conventional technology can be welded by a laser. For keyhole welding, materials with a higher thickness-to-width aspect ratio are welded with 1 μm wavelength from a HighLight FL-Series fiber laser. Sheet metal up to 2 mm can be heat conduction welded using a HighLight D-Series direct-diode laser. In addition, a selection of plastics can be successfully welded using a transmission welding process. The ideal laser for this process is the HighLight FAP System. Glass welding is a growing application in the display manufacturing to provide the perfect hermetic sealing of AMOLED displays. Our HighLight FAP systems are widely adopted in industry for this frit welding process.

Cutting:

Laser cutting is a mature industrial process with high flexibility, non-contact and stress free processes that produce finished parts direct from the tool. Laser cutting is a very precise process, with excellent dimensional stability, very small heat affected zone, and narrow cut kerfs. Various technologies are used in this process depending on the type of material to be cut. Plastics, ceramics, fiber-reinforced materials, and organics such as leather, fabric, paper, wood and others are processed ideally with DIAMOND CO₂ lasers. Its wavelength of 10.6 µm offers optimal absorption to cut by evaporation or melting

non-metal materials. While the 10.6 µm wavelength from DIAMOND CO₂ lasers offers the ability to cut plastics and metal materials, HighLight FL-Series fiber lasers emitting 1 µm wavelength are the optimal tool for cutting metals including high reflective materials like Aluminum, Copper, Brass or Stainless Steel. Other brittle and transparent materials open the opportunity for ultra-short pulse and UV lasers. For example the cutting of glass and sapphire with inner/outer contours and bevel is very effective using our high power ps-laser products.



LABEL CUTTING



GLASS MARKING

Marking and Engraving:

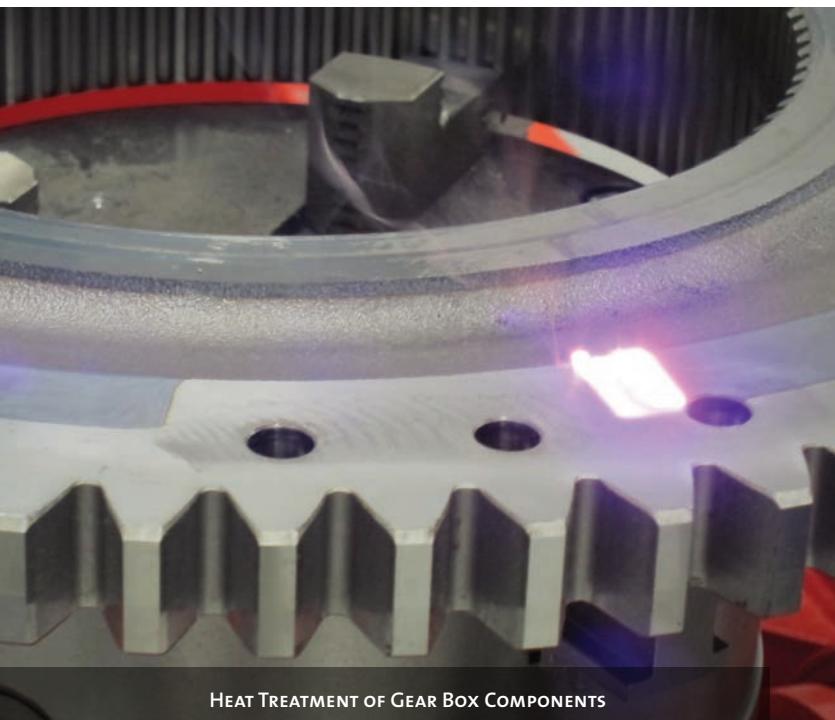
Lasers are commonly used for marking and engraving of materials. There are a wide range of applications found in the automotive, electronics/semiconductor, aerospace, medical, consumer products, gift & trophy, and food/beverage industries. It is a very flexible, basically maintenance-free process, and the results are very precise, creating sustainable marks on a large variety of materials. It is also low in consumable cost. When marking metal surfaces, the high peak power of a 1 µm laser, such as a MATRIX DPSS laser, engraves into the metal surface and creates the desired contrast. When marking plastics, the exact color of the mark is highly dependent on the additives found in the plastic. If a high quality mark with high contrast or color change is required, a 1 µm, 532 nm or 355 nm wavelength from the MATRIX Series is used. A CO₂ laser like the DIAMOND C-Series, emitting a 10.6 µm wavelength can, in most cases, engrave without color changes based on the melting of the material. Typically a CO₂ laser with 10.6 µm is used for marking organic materials like wood, paper, cork, leather and horn and

creates a dark contrast. The CO₂ laser also removes paint or discolors fabric effectively. Glass marking is supported by our DPSS lasers as well as excimer lasers depending on the characteristics of mark being inside the glass or laser etched onto the surface.

Heat Treating:

In laser heat treating or case hardening, a spatially well defined beam from a High Power Direct-Diode Laser is used to illuminate a work piece. The light causes rapid heating that is highly localized to the illuminated area and does not penetrate very deep into the bulk material. The bulk heat capacity of the material typically acts as a heat sink for the extraction of heat from the surface therefore enabling self-quenching. Coherent direct-diode HighLight D-Series and fiber laser HighLight FL-Series lasers enable rapid processing, precise localized control over case depth/hardness, minimal to no

part distortion, superior wear and corrosion resistance, and increased fatigue strength. Part geometry and carbon content (min. 0.3%) significantly influence the results that can be achieved with a laser heat treat process.



HEAT TREATMENT OF GEAR BOX COMPONENTS



LARGE AREA & HIGH DEPOSITION RATE CLADDING

Converting:

Lasers are an established tool in converting lines and are widely used within many different industries. Lasers are used in the food industry to score soup, coffee or beverage pouches creating an easy open function. They are also used to drill foils for vegetable packages making them breathable. And cigarette strength is controlled through the drilling of cigarette paper. Other applications for lasers are in the medical industry where they are used to cut components like blood testers. Digital printing lines or production lines also use lasers for kiss cutting of labels and for grinding paper. In most laser converting cases, organics and plastics are the materials being processed thus making a DIAMOND CO₂ laser, emitting a wavelength of 10.2 μm, the ideal laser source.

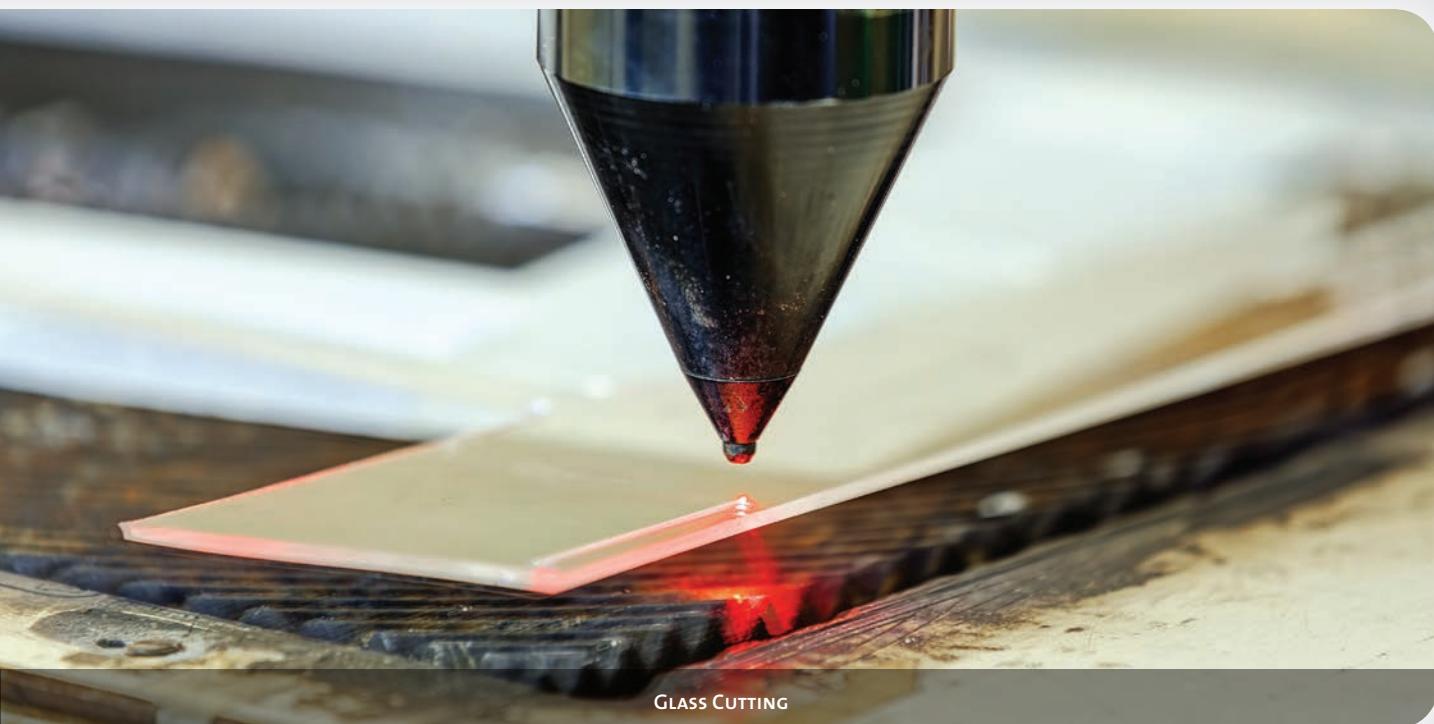
Cladding:

Cladding is a well-established process used in a variety of industries for improving the surface and near surface properties of a part (e.g. wear, corrosion or heat resistance), or to re-surface a component that has become worn through use. The 1 μm wavelength of modern and efficient high power solid-state lasers, like the Coherent HighLight D-Series direct-diode and the HighLight FL-Series fiber laser, are very well absorbed by most metals. The HighLight D-Series and FL-Series offer superior overall clad quality, reduced heat input, minimal part distortion and better clad deposition control resulting in reduced dilution, lower porosity and better surface uniformity than traditional technology. The high quench rate of the direct-diode laser cladding process produces a finer grain structure in the clad leading to better corrosion resistance. Finally, the line beam shape of the free-space direct-diode (D-Series) laser can process large areas rapidly with a high degree of control over clad width and thickness, while also delivering lower operating cost and easier implementation than other methods.

Rapid Prototyping:

Rapid Prototyping is used in applications where design prototypes or a low volume of complex parts are required to be fabricated quickly without the need of complex tooling. The process is differentiated between Stereolithography (SLA) using an epoxy polymer and Selective Laser Sintering (SLM) using metal or ceramic powder. In both the SLA and SLM processes, a 3-D CAD model is sliced into many layers like a stack of cards then transferred to the SLA or SLM tool. The laser beam is steered by a galvanometric scanner head and builds up the part layer by layer. After each layer is processed, polymer or powder is then

deposited on top of the part and the next laser processing step begins. SLA typically uses a low power UV wavelength like from a MATRIX UV laser to selectively harden a photosensitive epoxy polymer in a bath to form a part. SLM builds up a part from polymer or metal powder by using a sealed off CO₂ laser such as a DIAMOND C-Series laser or a 1 μm fiber laser.



Glass/Sapphire Cutting:

The demand for thinner glass used in mobile electronic devices is increasing. Mobility is a must in these markets and has driven the need for ultrathin glass, strengthened glass, sapphire, rounded contours, slots, button holes and bevels that enable new design features. Lasers are playing a pivotal role to bring these trends to cost effective volume production by providing distinct advantage over traditional mechanical scoring, grinding and polishing. The non-contact laser process is fast, precise and achieves higher bend strength compared to mechanical processes. Also, laser processing uses no water, oil or chemicals and leaves no particle or artifact on the sheets. This ensures high yield and less process steps. The range of materials and cutting tasks has led to a variety of processes such

as full body cut, laser scribing, ablation and non-thermal processes such as filamentation. CO₂ lasers provide the highest speed for straight cuts with perfect edge quality. The non-thermal processing of picosecond lasers come to play for ultra-thin glass, strengthened glass or sapphire with rounded corners, inner holes and slots.

Laser Products for Materials Processing



Diode-Pumped Solid-State Lasers:

MATRIX is a family of diode-pumped, solid-state (DPSS), Q-switch lasers, available in 1064 nm, 532 nm and 355 nm wavelengths. MATRIX is optimized for cost-sensitive applications requiring high throughput and that do not allow compromises in process quality. The lasers are manufactured utilizing Coherent's PermAlign technology which guarantees best optical alignment and stability. For pumping, Coherent's AAA pump diodes with MTBFs of >40,000 hours are applied. The result is reliable, hands- and maintenance-free operation over thousands of hours.

The Helios series Q-switch lasers are based on master oscillator power amplifier (MOPA) architecture and provide the best balance of cost and power considerations. Helios lasers are available at 1064 nm, and 532 nm at several output powers.

With installations in the thousands, the AVIA is the most widely adopted high power Q-switched laser for materials processing.

This family of diode-pumped, solid-state products, is available in wavelengths of 355 nm and 532 nm. Average powers to 40W and repetition rates to 300's of kHz, means AVIA has a broader selection of configurations than any other laser in its class.

Every aspect of the design and manufacturing of AVIA lasers is specifically targeted to ensure product uptime and availability, that ultimately results in more consistent processing and higher throughput for equipment in high precision micromachining applications.

Excimer Lasers:

Excimer lasers are pulsed (ns) gas lasers that emit, UV wavelengths such as 193 nm, 248 nm and 308 nm, depending on which specific gas mixture is operated in the laser. Coherent's few-Watt Excistar laser is used in glass marking and similar applications, whereas 100W to multi-kW excimer lasers provide unparalleled throughput on large areas. The unique advantages of Excimer lasers are their

short wavelength that is directly generated without frequency conversion, the lasers high energy per pulse e.g. up to 4 Joules, and their high power up to 2.4 kW in the interesting UV wavelength range.

Fully automated operation with precision control of the output energy and power is a unique feature of Coherent's entire Excimer line. Full metal ceramic construction of the laser tube, solid-state pulser, advanced gas management and fully integrated data logging are

some of the other key features which are the basis for the ease-of-use and high longevity of Excimer lasers.

Applications of Excimer laser covers a large range and take advantage of the short wavelength of these lasers, giving unique interaction with materials, even those that are fully transparent in the visible spectrum.

Products for the Materials Processing Market:

The following table illustrates how our laser portfolio matches to key materials processing applications.

| | DPSS Pulsed nsec | Ultra-short Pulsed | CO ₂ | Excimer | Fiber | Direct-Diode | Laser Machine Tools |
|------------------------|------------------------|-----------------------|-----------------|---------------|-------|--------------|---------------------------|
| Thin Film Annealing | M, P, S | S | M, P | M, P, S | S | M, P, S | |
| Cutting | M, P, S | M, P, O, B, S | M, P, O, B | | M | | M, P, O |
| Converting | | | P, O | | | | |
| Drilling, Patterning | M, P, O, B, S | M, P, O, B, S | M, P, O, B, S | M, P, O, B, S | | | |
| Marking & Engraving | M, P, B | M, P, B | M, P, O, B | P, B | | | |
| Welding | B | B | M | | M | M, P, B | |
| Cladding/Heat Treating | | | | | M | M | |
| Rapid Prototyping | M, P | | M | | M | | |
| Surface Treatment | | | | M, P, B | | | |

Legend

M - Metal P - Plastic O - Organics B - Brittle S - Semiconductors



VYPER: 1.2 kW EXCIMER LASER

CO and CO₂:

Coherent's DIAMOND E-Series and J-Series lasers are sealed, pulsed CO₂ systems with a built-in RF power supply, which increases reliability and simplifies integration. A full suite of on-board diagnostics enables proactive maintenance to minimize downtime and reduce the overall cost of ownership. These lasers deliver a combination of high peak power, and fast rise-and-fall times at average powers of 100's of Watts. Their excellent beam quality and high pulse frequency make the DIAMOND E-Series and J-Series are ideal for a wide range of materials processing applications. DIAMOND C-Series and GEM-Series CO₂ lasers are rugged, highly efficient, continuous-wave OEM units

providing output powers up to 100W. Their ultra-compact air-cooled or liquid-cooled design makes them the highest output power per unit volume of any sealed CO₂ laser available commercially. Their excellent mode quality and power stability makes them ideal for high-speed and very sensitive processes. The superior reliability of DIAMOND C-Series and GEM-Series lasers result in very low cost of ownership, making them the laser of choice in the most demanding industrial applications. Coherent's new generation of carbon monoxide (CO) lasers offer enhanced processing characteristics for materials processing applications ranging from glass cutting and via drilling, to fractional skin resurfacing.



Fiber Coupled Diode Systems:

Coherent HighLight FAP systems are engineered to deliver exceptional reliability, convenience and superior process uniformity for demanding, high throughput industrial applications like soldering, plastics welding and remote heating. In particular, the system offers excellent output characteristics, such as high power stability and a fast, jitter-free rise time. Utilizing a turnkey, modular fiber delivery system, the HighLight FAP minimizes setup and downtime, thereby decreasing cost of ownership in harsh industrial environments. Fully-automated remote operation enables machine and factory integration.



HIGHLIGHT FAP SYSTEM: DIODE LASER FOR PLASTIC WELDING AND SOLDERING

Direct-Diode Lasers:

Coherent's HighLight D-Series of direct-diode lasers deliver multiple kW's of power and an increased range of "smart" output beam shapes, making it the ideal source for heat treating, cladding, and welding – all at faster speeds, greater deposition rates and larger areas. Free-space beam delivery preserves the inherent brightness of the diode laser source and enables the use of an optical system with a large working distance. In conjunction with large tophat beam shapes, it increases production speeds to new benchmark levels, allowing larger areas to be processed in a single pass. HighLight D-Series uses high efficiency

direct-diode array technology which offers ~45% of optical to electrical efficiency. The design is cost effective based on its field proven and reliable bar based architecture.

HIGHLIGHT FL-SERIES:
ADVANCES IN FIBER
LASER TECHNOLOGY



Fiber Lasers:

All major components of the OEM design of Coherent HighLight fiber lasers are designed and manufactured within Coherent from the diodes to the active fibers. Based on field proven and reliable bar based architecture, the modularity of the HighLight fiber laser offers field serviceability options for customer's technicians. Coherent HighLight fiber lasers are available in multiple power levels starting with 1 kW. Customers can choose between multiple QBH connected delivery fiber diameters, however, its connector is delivered as a standard. The beam profile is optimized for cutting and welding applications. When processing highly reflective materials like copper or brass no back reflection protection is required for the laser.

Ultrashort Pulse Lasers:

The Rapid family of industrial picosecond lasers integrate a oscillator with one or more amplifier stages within a rugged, compact laser head. And, because this robust configuration enables an average power of up to 100W, Rapid series lasers can deliver high material removal rates. Rapid series lasers also support "Burst Mode" operation, proven to dramatically increase the ablation rate when processing materials having free electrons, such as steel, and tungsten carbide. Rapid and HyperRapid also come with a choice of IR/Green/UV wavelengths.

RAPID: PICOSECOND LASERS FOR INDUSTRIAL MICROPROCESSING APPLICATIONS



MONACO: FEMTOSECOND LASERS FOR INDUSTRIAL MICROPROCESSING APPLICATIONS



Femtosecond Lasers:

Coherent Monaco femtosecond industrial laser is designed and tested for 24/7 high uptime environments. The laser provides 40 μ J/pulse at 1 MHz to enable current and future throughput requirements in materials processing applications. Homogeneous materials such as glass and metals, as well as processing of complex, layered-structures are readily addressed with Monaco's sub-400 fs pulselwidth. Additionally, a variable pulselwidth to >10 ps, coupled with a micro-burst mode, enables the tailoring of pulses for the exact requirements of an application. Ideal for making high finesse holes and cuts with unsurpassed surface quality and negligible heat affected zones.



Laser Cutting and Machining Tools:

Coherent's Laser Machine Tools are powerful, laser cutting systems that are designed to be accurate and easy to use. Built on a sturdy, lightweight steel frame, they are ideally suited for a variety of applica-

tions including cutting & engraving of sheet metal, plastics, wood, and sign & graphic materials. Simple multilingual user interface and job loading software simplifies work set up and increases productivity.



META:
LASER MACHINE TOOLS

Additionally, the system features automatic focus, advanced capacitive height sensing and a fully integrated machine vision system. All Coherent's cutting tools incorporate its low maintenance, sealed, pulsed DIAMOND CO₂ lasers offering the flexibility cutting metal and plastics in the same setup. No dies or expensive re-tooling is necessary when cutting parts using a cutting tool that then leads to increased profits on short runs. With a faster turn-around and lower costs, customers will be able to take on more jobs, be more competitive, and ultimately generate new business with more customers.

Industrial-Grade Reliability and Support

Reliability by Design:

In many demanding manufacturing applications, the high cost of production downtime makes reliability the single most important requirement for processing equipment. For machine tools that use lasers, this means that the true long-term cost of ownership is far more dependent on uptime and service characteristics than the laser's initial purchase price. Many of Coherent's lasers are designed following HALT protocols, where qualification, in excessively harsh conditions starts, from the component level. HASS processes are integrated in manufacturing to track any weakness or non-conformance. These severe screening is ultimately saving time and money on the short and long term by maximizing laser uptime. That's why every aspect of the design, manufacturing, and field servicing of Coherent lasers is specifically targeted to maximize product uptime and immediate laser availability. Our decades of laser experience has led to product designs that consistently meet rigorous 24/7 operating requirements.

Support You Can Count On:

With cutting-edge technology and world-class technical support, we ensure the successful integration and 24/7 operation of Coherent lasers – even when performing the most precise processes under the most demanding industrial conditions. Overall, our combined sales, customer service and technical support capabilities give you the resources of a global corporation with the responsiveness of a local business.

With over 40 years of experience as the leader in developing industrial lasers and supporting industrial laser applications, you can depend on Coherent for superior reliability and superior performance from every product, backed by superior customer service every time we work with you.

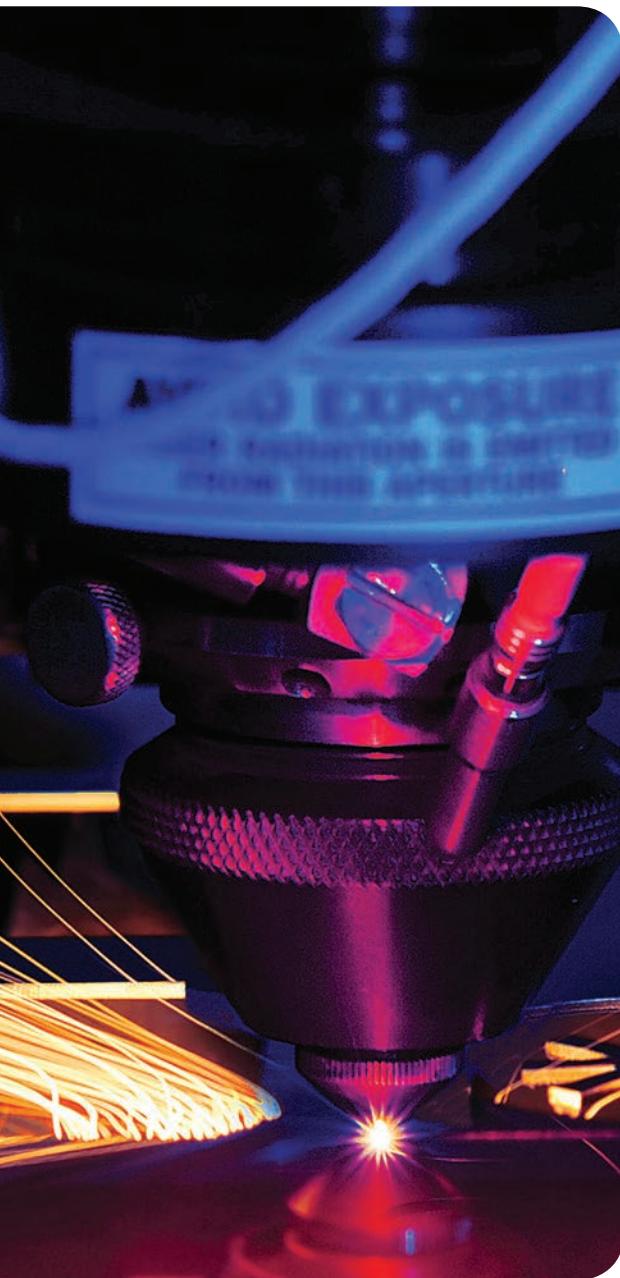
Safe Supplier Value:

With more than 50 years in business, you can rely on us being your long term partner and count on the value we bring to your business. Vertical integration on key components (e.g. semiconductor, crystals) and using quality management practices is the basis for the reliability our products are known for. As a global company with worldwide offices, we provide the logistics and support structure needed by our customers.



As a leading supplier to the materials processing industry we are committed to new product developments. These developments include expanding our portfolio in areas where they add value for our customers. A recent example is in the area of fibers, where we built expertise from the component and assemblies level all the way up to fiber laser systems. If your application is not addressed by one of the solutions from our current portfolio, we look forward to discussing your needs, and helping you to evaluate new developments and alternative technologies.



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