LUMONICS

laser

INNOVATIONS FOR MATERIALS PROCESSING - Vol. 2 - Issue 1

Texcel, Inc., delivers on-time, quality fabrication for high-tech customers, using flexible laser workstations.

Flexible Laser Systems Deliver Flexible Manufacturing for Texcel

by Mike Heglin
Sales Director, Nd:YAG Laser Products
Lumonics Corporation,
Industrial Products Division

Located in the heart of New England's high-tech corridor, Texcel, Inc., receives a steady stream of exotic components from customers who come to Texcel for advanced laser manufacturing solutions to their challenging fabrication needs.

A diverse customer base brings components to Texcel that include microelectronics for defense and communications, biomedical implant devices, and aerospace products, including high-temperature, jet-engine parts.

Typical laser services at Texcel range from development and prototype work to short- and medium-range production runs. And its customers have the strictest standards for precision and quality. As a result, Texcel has managed its success by devloping the ability to turn around complex, short-run orders efficiently — with near-zero defects.

High-integrity manufacturing

Texcel's high-integrity manufacturing services are applied to production of components that share one or more of the following:

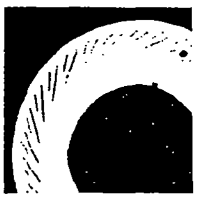
- High-integrity welding of high-temperature alloys or dissimilar metals
- High-precision, low-distortion, spot welding
- Complex cutting in exotic metals and ceramics
- Drilling and trepanning in high-hardness alloys, ceramics, and plastics

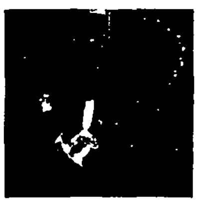
Texcel was founded in 1987 by a group of engineers, each of whom had over 10 years experience developing laser-based fabrication techniques. Much of their background had been in creating laser solutions to replace cumbersome, traditional processes. Out of this, Texcel has grown to be one of the leading laser-based component fabricators in the Northeast. The company also builds laser materials-processing systems for customers.

"Job-shop" R&D

Texcel's experience and technical resources are so highly regarded that it serves as the "de facto" R&D center for some clients. Customers recognize that Texcel's experience in precision fabrication can save precious time in the development of new products, so the company is often asked to assist in the evaluation of materials and fabrication techniques for customer R&D programs.

Texcel's Nd:YAG laser workstations (left) are used for close-tolerance manufacturing of components that range from 0.125 inch-thick laser-machined stainless steel (below) to laser-welded microelectronic components of stainless steel (bottom) and titanium (far right).





"Glovebox" sealing systems

Critical fabrication performed for Texcel's customers often requires specially designed controlled-atmosphere glovebox sealing systems. The company designs and fabricates its own systems which are equipped with process control computers and software. In addition to several CO_2 laser systems, Texcel operates one hermetic-sealing-applications laboratory and one general-purpose, laser-workstation laboratory, each incorporating a Lumonics JK701 pulsed Nd:YAG laser, rated at 400 watts average power.

The JK lasers are used for a wide range of precision welding, cutting and drilling applications, including hermetic sealing. Welded assemblies with very low leak rates, on the order of 10^{-9} cc/sec of helium (measured per MIL STD 883C), are routinely produced by Texcel, using the JK lasers.

The glovebox laser sealing system is operated in an electrostatic-discharge laboratory (ESD) for maximum protection of electronic assemblies during processing. Joseph Lovotti, Vice President and General Manager, observed, "The ability to remotely control the laser simplified the job of integrating the JK lasers with our glovebox systems. We had freedom to place the power supply outside the lab, which made it easier to control the environment in the immediate work area. For future expansion we have the option of fiberoptic beam delivery, servicing multiple gloveboxes from the same laser."

Precision micro-welding

Much of Texcel's work is precision welding of component enclosures and electrical connections within delicate circuitry. "The electronically programmable power supply on the Lumonics JK lasers gives us precise control over the laser's energy. We can tailor pulse shapes precisely, to achieve a sound weld, while minimizing the heat-affected zone," observes Ken Phillips, responsible for Manufacturing Engineering. "More importantly, we have complete computer control over the laser welding program. Our customers get a more reliable component. We get production efficiency."

Texcel's high-output Lumonics lasers produce the energy density needed for high-speed cutting and drilling of exotic materials, including titanium, molybdenum, and even ceramics. Yet, the programmable, solid-state power supply permits Texcel to use the same lasers to join very fine wires in a biomedical device with a micro-spot weld, or to weld titanium cases on biomedical implant devices such as pacemakers and defibrillators.

Reliability — more than up-time

Texcel is now running two production shifts per day. Operating 16 to 18 hours per day requires a laser system that is reliable, but able to deliver consistent results as shifts and operators change. Texcel chose the JK700 Series lasers because of their demonstrated reliability, and because their operating ease made shift-to-shift consistency possible.

Flexibility is the bottom line

For Texcel, the most critical asset of the JK701-equipped workstations is flexibility. The lasers are capable of processing virtually all the materials used by their customers, and the solid-state programmable laser controls have given them flexibility to create and run widely different control programs for various processes.

Switching from one fabrication project to another is usually done in a matter of minutes. "We can start in the morning, welding titanium biomedical devices while electronic relays are in the bakeout cycle. When they are done in the ovens, we'll switch to welding a few dozen Kovar relay devices. Meanwhile, in the next lab, an identical laser is being used for drilling and complex shape cutting of metal parts," says Rob Dickson, Sales Engineer.

That kind of flexibility has given Texcel the ability to serve many different technology masters at once — and succeed. ■

When Lasers Hit the Road

Applications of lasers in automotive electronics

by Trudy J. Auty
Market Development Manager, Electronics Industry
Lumonics Ltd.
Rugby, England

Laser materials processing, once considered an exotic technology, has been used with great success in automotive applications since the early 1970s. Manufacturing engineers find that when fabrication methods are reconsidered in light of the advantages of lasers, significant improvements are the usual result. The following examples of laser applications to automobile components are excerpted from a paper by the author presented at the Laser Systems Applications in Industry conference, November 7–9, 1990, in Turin, Italy.

Spot welding of molybdenum headlamp components

As far back as 1974, Thorn EMI Lighting used laser techniques to realize significant cost savings in the fabrication of tungsten-halogen headlamps. Early production of Thorn EMI's headlamp used resistance welding to join a molybdenum shield to its support frame. This method of joining: 1) required a platinum braze at the interface, which added $45,000 U.S. in extra cost for annual production of two million units; 2) was slow and of poor consistency, because of electrode wear and sticking; 3) reduced lamp life, because residual platinum interfered with the halogen tungsten-replacement cycle.

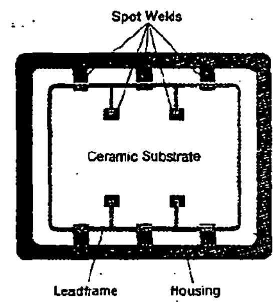
Thorn EMI's research led it to laser spot-welding, using a 20-watt, Nd:YAG laser that produced strong, consistent welds without platinum braze. Two welds per lamp were made in a fraction of the time needed for resistance welds. The laser was easily integrated into a pick-place-weld, rotary-index-table system, yielding part-to-part cycle times of just three seconds.

This one laser application saved Thorn EMI approximately $43,000 U.S. annually in materials alone, (even allowing for the cost of laser maintenance). Line speed and production yields increased dramatically, and lamp life was extended appreciably. These economies and consistent high quality of the lamps produced contributed significantly to Thorn EMI's domination of the market for more than a decade. The original JK lasers used in this production line are still operating two shifts per day, 15 years later.

Laser spotwelds yield near-zero defects

A U.S. automotive electronics manufacturer, disappointed with the inconsistency of resistance welds used in fabricating a voltage regulator, found laser spot-welding achieved the consistency and quality needed. Component quality was critical; the company could not tolerate defective parts failing in the field.

The component required a total of 10 spot welds to join a lead frame to contact points on a ceramic circuit board, and to the component's housing. Resistance welding gave inconsistent weld depth at connections, resulting in joint quality ranging from open welds (no connection) to holes blown right through the contact point. The company then evaluated a laser solution consisting of two, 250-watt, JK701 Nd:YAG lasers per CNC workstation. Fiber-optic beam-delivery systems simplified laser/workstation integration and were also used to split two beams into four working beams at the workpiece. Two such workstations were built, each capable of ten spot welds per component, processing four complete components in 1.8 seconds.

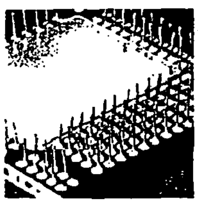


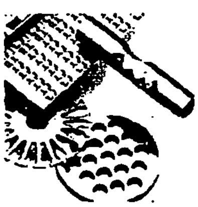
These units run three shifts per day, and the manufacturer's yield results show parts achieving 99.5% acceptance (the yield data include defects resulting from several process steps in addition to the laser spot welds). Most importantly, the manufacturer has not had a part returned from the field since the laser-welding system was installed. ∎

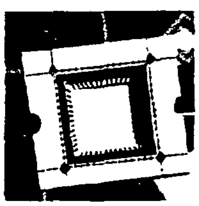
Laser Processing: What Laser Is the Right One for Your Job?

Part II of II: Fundamentals for specifying the right laser system

By Steven A. Llewellyn
Vice President, Sales and Marketing
Lumonics Corporation,
Industrial Products Division







Each year, hundreds of companies add laser-based machine-tool and fabricating systems to gain increased flexibility and productivity over the systems they had been using. The advantages of laser processing are numerous, but are most striking when a process has been configured to take full advantage of the special capabilities of laser tools [see the example in Part I of this article, printed in the previous issue of Laser Pulse. Ed.]. These include:

- High part-to-part consistency
- Non-contact processing that simplifies tooling
- Higher process speeds
- Versatility to process many materials with one tool
- Lower thermal distortion in processing
- Simplified integration with automated controls
- High degree of process cleanliness
- Low maintenance

Once a company has determined that some area of its operation could benefit from laser processing, the best laser system must be selected for the anticipated application. The selection of laser type and size, and the choice of supplier involve more detailed consideration than can be addressed here, but arriving at a basic determination of your needs is relatively simple, once the performance "envelope" for various lasers is understood.

The basic considerations

The issues to be considered include:

1. Process
2. Material
3. Laser type/wavelength/ power
4. Process speed and quality
5. Operating environment
6. Economic considerations

There are a number of industrial-laser types capable of efficient materials processing. Table 1 is a brief summary of the most common types.

	CO_2	Nd:YAG	Nd:Glass	Ruby	Excimer
Wavelength (in microns)	10.6	1.06	1.06	0.694	0.308*
Average Power	0.5 to +20kW	0.5 to 2kW	to 100W	to 30W	to 150W
Continuous Wave	YES	YES	NO	NO	NO
Pulsed	YES	YES	YES	YES	YES
$ per Watt Output	100	250	1,300	3.000	2,000

* for Xenon-Chloride laser. The wavelengths of excimer lasers vary from 0.157 microns to 0.351 microns depending on the lasing gases used.

Table 1

Laser characteristics

The operating characteristics of a laser, like it's wavelength, available power, and its ability to operate in pulsed or continuous-wave mode, are significant determinants of how the laser can be best used. Many of these characteristics are unique to lasers, often are functions of optical laws, and may be less familiar or completely foreign to manufacturing and production engineers with experience in mechanical, electrical, and electronic systems. Companies considering lasers for the first time should simply remember that these devices have their own ground rules, "shop wisdom," and applications folklore to be assimilated as part of the applications-engineering process.

To summarize a great deal of applications engineering experience, here is a general overview of the most common applications for the two most commonly used industrial-laser types: CO_2 and Nd:YAG. The optimum laser type is shown for each application, taking into consideration the materials and requirements typical for each process...

Table 2 is meant to give a basic guide to optimum laser performance in a variety of applications. Individual analysis of your processing needs

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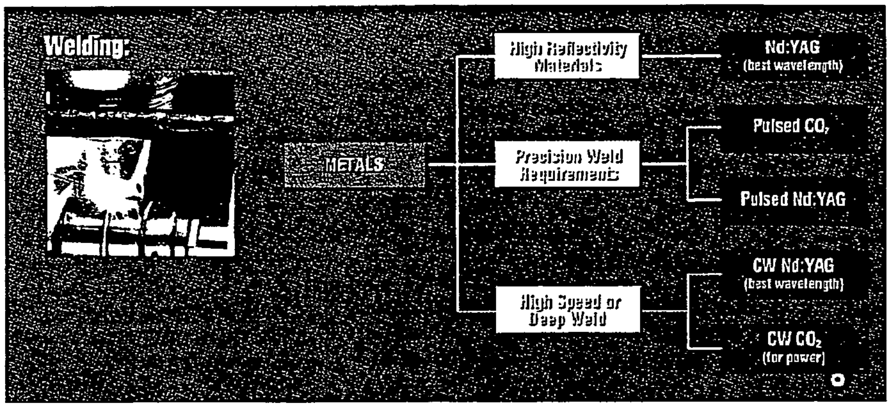

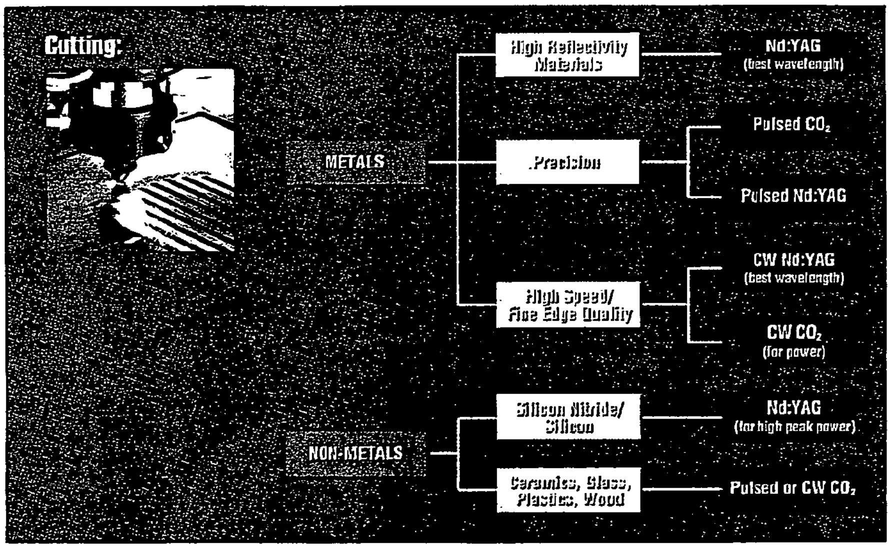

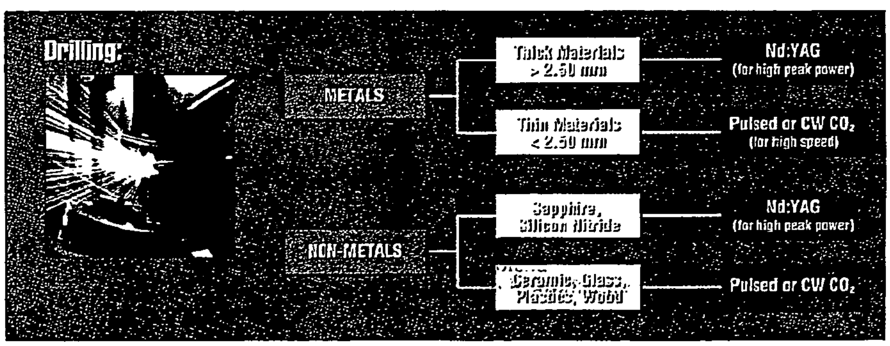

Table 2

should be done with a competent laser vendor. You should look for a vendor who has several different laser types to offer, so that the final solution will most closely match your process needs.

Problem materials

Here are some "problem" materials which deserve a brief discussion. Highly reflective, highly conductive metals, including aluminum, copper and gold, do not absorb enough of the longer-wavelength energy from CO_2 lasers for efficient processing. Superior processing is performed with a Nd:YAG laser, whose shorter-wavelength energy is more readily absorbed by these materials.

Conversely, materials transparent to visible light waves, such as glass and most plastics, are not cut or drilled efficiently with Nd:YAG lasers. This is also true of alumina ceramics, commonly used as component substrates in many hybrid electronics packages. Processing these materials is the domain of the CO_2 laser, whose long-wavelength energy works effectively with glasses, ceramics and plastics of all types. But, in addition to the wavelength of the laser energy, other operating characteristics affect the suitability of lasers for different tasks.

Continuous-wave vs. pulsed energy

Continuous-wave energy is commonly used in laser welding and cutting, particularly where process speed is important. Pulsing the laser, usually by electronic means, can allow increased peak power from the device. This additional energy can be used in welding and cutting to reduce heat-affected zones, and in drilling for superior

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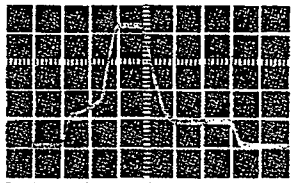
material vaporization and molten metal removal.

Pulse shaping

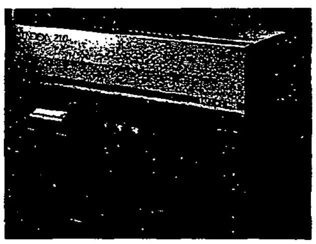
In many welding applications, and for some drilling operations. the ability to pulse the output of a Nd:YAG laser, and do so in a controlled manner, offers definite process advantages. All the process parameters of today's Nd:YAG lasers can be independently-controlled in real time, on a pulse-to-pulse basis. Pulse shapes, frequencies, and energies can be controlled and varied as needed by the computer controlling the machine process.

The ability to shape pulses, even in an open-loop system, can allow metallurgical and process problems to be overcome. A pre-welding pulse shape can precede the main part of the welding energy to preheat the material or to clean the weld surfaces. Energy can be delivered in a post-welding portion of the pulse shape to anneal difficult-to-weld alloys, in order to overcome post-weld cracking problems. In some drilling applications, pulse shaping can be used to minimize sidewall flare of deeper holes by drilling the hole with multiple pulses, rather than one high-energy burst.


Pre-heat pulse with shaped top to blend into normal weld pulse, also shaped to blend into post-weld annealing pulse.

Beam delivery strategies

One of the great advantages of Nd:YAG lasers is their



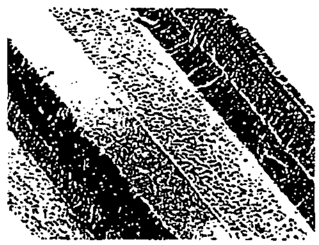
Excimer lasers

Used primarily for processing organic materials and thin films, excimer lasers are used widely for precision etching of polymers, masking, adhesives, and even thin metallic films.

They are used in the manufacture of printed circuit boards, and are the primary means for the large-scale production of precision microminiature plastic components.

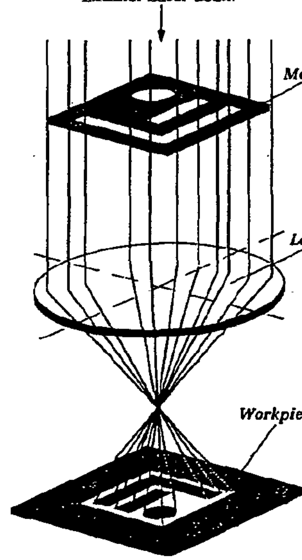
Excimer lasers emit their energy at ultraviolet wavelengths, delivered in pulses as short as 10 nanoseconds, with output energies of a few hundred millijoules per pulse.

Unlike CO_2 and Nd:YAG lasers, which use extremely high energy densities to vaporize dense materials, excimer lasers make use of an intense ultraviolet beam to breakdown or "ablate" long-chain organic molecules. As a result there is no heat-affected zone, as with other laser types, in which delicate components may be damaged.

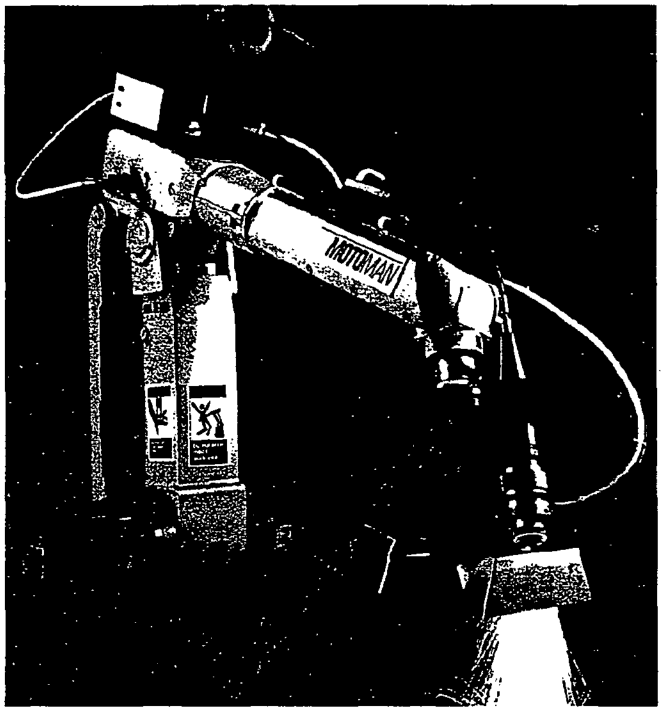


Another difference between excimer lasers and their high-energy cousins is in the application of the laser beam to the work surface. Nd:YAG and CO_2 lasers focus their beams into spots, as small as 0.001 inches in diameter, to achieve the energy densities required for processing. Excimer-laser energy is projected on the work surface as a broad beam – like a movie projected onto a screen. A precision mask, which carries the pattern to be etched into the work surface, is inserted between the beam and the workpiece. Energy from the excimer laser is pulsed to remove thin layers of the workpiece, a few micro-inches at a time.

The excimer's stationary beam, focused through a precision mask, and the capability for ultrafine depth-control, makes it possible to machine the most intricate patterns with extreme accuracy and with high part-to-part consistency.



The ability of the Nd:YAG laser to deliver beam energy to the workpiece via compact, flexible, fiber-optic beam-delivery systems simplifies integration of the laser into a production line.



ability to deliver energy to the workpiece via fiber-optic systems. This is another function of the Nd:YAG's shorter operating wavelength. The laser's energy can be transmitted through a high-grade, industrial, fiber-optic assembly with virtually no measurable energy loss, and without damage to the optics. Costly beam-diverting mirrors, and cumbersome beam tubes, that are difficult to construct in a production-line setting, and which require precise alignment and regular maintenance, are eliminated. A Nd:YAG laser can be located up to 150 feet from the workstation, connected by a simple, rugged, optical-fiber cable. The cable can be run much like any utility hook-up to the work enclosure.

Those absorption characteristics which make the CO_2 laser an excellent processor of glass and ceramics prevent its energy from being conducted through a fiber-optic system. In the typical CO_2 application, the laser is usually located adjacent to the workstation, so that relatively simple optics and "plumbing" will be required to route the beam to the work enclosure. ■

Lumonics Corporation,
Industrial Products Division
12163 Globe Road
Livonia, Michigan 48150, USA
Phone: 313-591-0101
Fax: 313-591-0046

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