THE WORKHORSE OF LASER PROCESSING

Greg Blackman on where CO_2 lasers excel in materials processing

In the world of laser processing, it's the fibre laser that grabs the headlines. The laser processing subcontractor, ES Precision, is about to buy its eighth laser system, a high-power fibre laser that will extend the firm's metal cutting capabilities, among other uses (more on page 30).

As a specialist in laser marking, however, ES Precision has to work with various different materials, and for that it requires different lasers. The firm runs five different types overall: fibre, CO_2, vanadate, YAG and frequency tripled vanadate (a UV laser). Two of its seven – soon to be eight – galvo laser workstations are CO_2 machines.

Andrew May, a director at ES Precision, highlighted the flexibility of its CO_2 lasers.

Trotec

Trotec's GSL1400 digital laser label converting machine

One job its 200W CO_2 laser machine is used for is to mark, cut and perforate Beiersdorf's Tesa labels, the kind used for automotive vehicle identification number (VIN) labels. The marks are made by ablating the top layer of the tape, revealing the layer beneath in a different colour. The marks are high resolution, meaning a lot of data can be placed on a small label; they are tamper evident, in that, once placed, the label cures in air in 12 hours and the only way to remove it is to destroy it; and they're weather and UV resistant, so suitable for outdoor use.

The same laser machine also cuts the label – as far as the backing layer, akin to kiss-cutting in conventional label production, but it's a digital process so changing the shape of the cuts is easy to do. It also perforates the web, both the label and backing material, so that sets of labels can be torn off. The three discrete processes all happen on a reel-to-reel spooling workstation.

'The world of CO_2 lasers continues to be dynamic,' May said. 'Fibre lasers haven't really impacted the low-power CO_2 laser

"CO_2 lasers haven't had to evolve… they've still got a very healthy market and they're the right tool for the job"

Beiersdorf and ES Precision

Beiersdorf's Tesa labels marked by CO_2 laser

Trotec

Labels can be laser marked on a reel-to-reel spooling workstation

market. In one sense CO_2 lasers haven't had to evolve over the last two decades; they've still got a very healthy market and they're the right tool for the job.'

Stephen Fazeny, CTO for laser sources at Trotec, added that the CO_2 laser market is still growing at a rate faster than GDP and faster than the standard machine tool market. 'The CO_2 market has a future because CO_2 laser applications are replacing some mechanical non-laser applications,' he said.

Working with ceramics is another area where CO_2 lasers are used and, May said, 'they're frankly the only obvious choice for nearly all organic materials.' Jobs like cutting leather trim for cars or thin plastics for automotive dashboards. The longer 10.6µm wavelength of CO_2 lasers is better absorbed by organic materials than the 1µm fibre laser wavelength, which results in a cleaner cut.

Kristen Hill, senior product line manager at Novanta, recalled a customer that came to them after trying to cut foam with a fibre laser, which had severely burned the material. 'We were able to cut the material with a Synrad CO_2 laser with very minimal discoloration, and the customer was happy with the result,' she said. Synrad is one of the Novanta brands.

On the other hand, solid-state lasers have replaced CO_2 lasers in the field of sheet metal processing, where the 1µm wavelength is better absorbed by metals. 'CO_2 is more or less gone for metal processing in the kilowatt power range,' Fazeny confirmed.

In addition to being preferable for processing metals, fibre lasers have a factor of 10 smaller spot size than CO_2 →

CHALLENGES OF BAND-SELECTED CO_2 LASERS

Standard CO_2 lasers emit at 10.6µm, but other CO_2 wavelength bands are available that might prove advantageous for processing thin films, for instance. Luxinar offers 10.6, 10.25 and 9.3µm sealed CO_2 laser sources ranging from 80 to 450W.

In thin films less than 100µm, processing speed can be enhanced using the correct wavelength, while the heat-affected zone can be the decisive factor for moving to a different wavelength on films greater than 250µm.

In any case, the optics used in the laser cavity to select the wavelength have to be carefully chosen.

Band-selected cavity optics need robust coatings with a high flux density, proximity to RF discharge and the ability to suppress the neighbouring branch without reducing gain at the required wavelength.

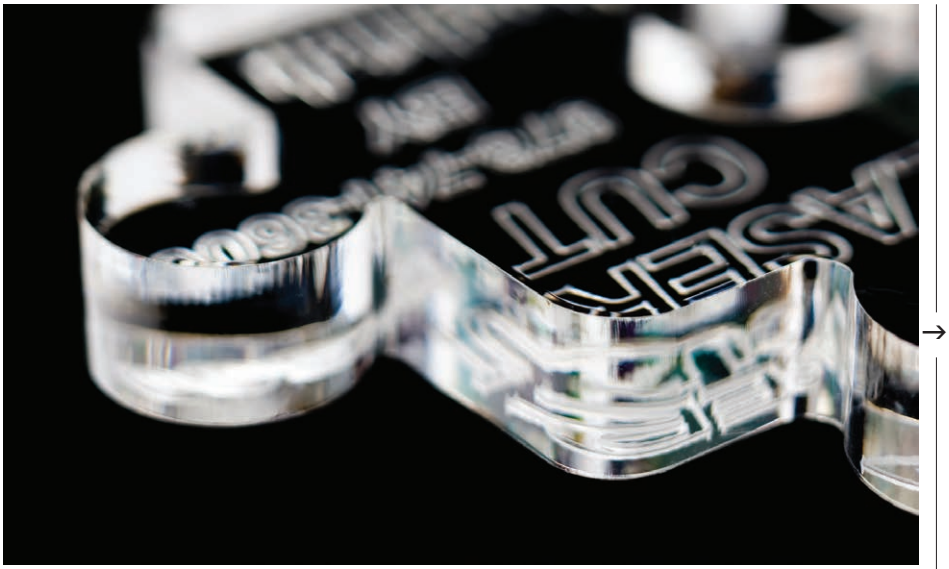
Polarisation, absorption in air and loss are the main integration challenges for wavelength band-selected CO_2 lasers, Luxinar advises.

The firm states that standard 10.6µm dielectric mirrors can depolarise circular polarised light, whereas isolation mirror solutions are lambda specific.

At 9.3µm, especially at high powers, lens effects due to absorption distort the beam; these can be removed by nitrogen purging or by moving dry air.

Loss per surface on standard 10.6µm AR or AR transmissive optics is approximately 3 to 5 per cent at 9.3µm operation, and can cause back reflections or heating of optic mounts.

Novanta



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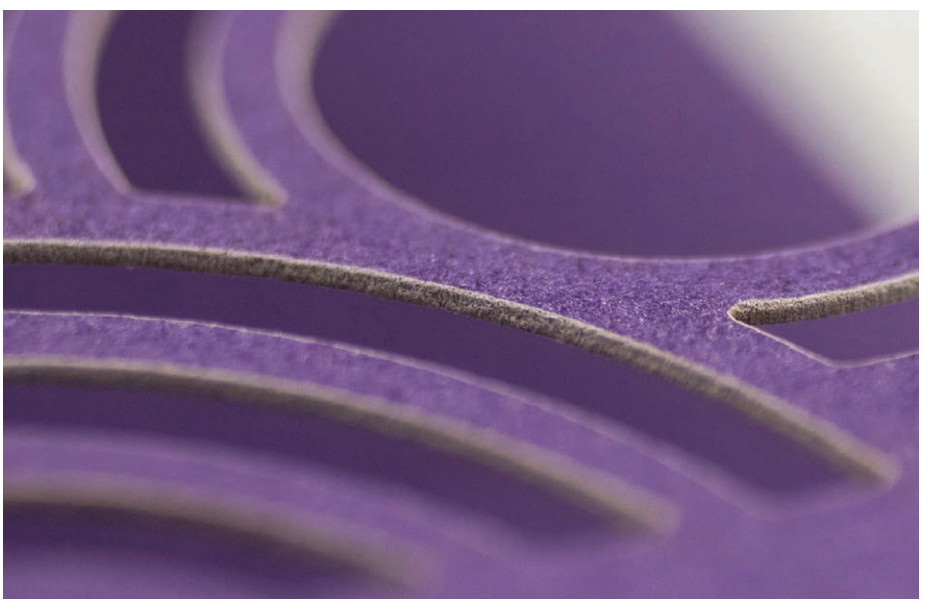

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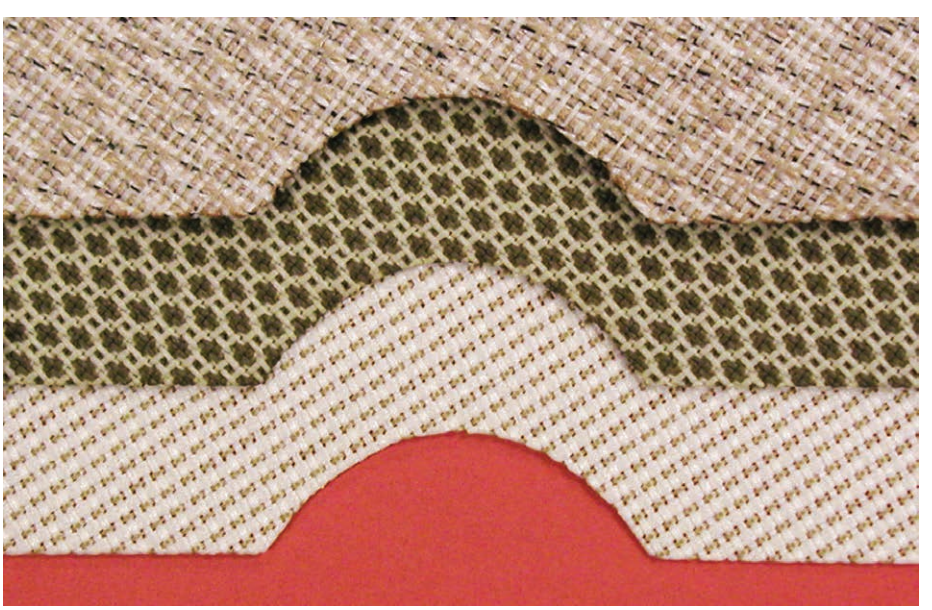

The CO_2 laser wavelength is suited to working with materials such as acrylic, paper and textiles

"As long as there are materials that need to be marked or cut, we anticipate continued growth"

→ lasers, and are therefore good for micro-processing. But for all other materials in the macro range – plastics, laminate, acrylic, textiles, wood, paper – Fazeny suggests CO_2.

The larger spot size from a CO_2 laser can be an advantage for applications like marking, engraving or cutting, because it makes the process more forgiving. The focus position, for instance, is less sensitive to disruption with a larger spot.

Trotec provides laser machines for engraving, cutting and marking. One example is a dedicated workstation for processing paper and cardboard for the printing industry, along with a machine for marking and cutting roll-to-roll labels. 'In these machines you want to use several hundred watts, because these processes are high speed,' said Fazeny. 'This is a growing market for CO_2 lasers. Traditionally the printing industry used die-cutting for high-volume batches. But now, with the laser and the digital workflow from design to part, it's cost effective even for just one piece. That's a big driver for lasers, in general, and also for CO_2 lasers.'

Other markets include marking sell-by codes on food labels and perforating food packaging, along with PCB marking where a CO_2 laser can mark the board's surface without damaging the copper circuitry underneath. May added that fading and patterning jeans 'has been massive'.

Further technology development

CO_2 lasers are considered the workhorses of the industry because they've been around for so long. But the technology is still progressing. Novanta's Hill noted a number of advances that the company is working on, including: a smaller laser footprint; smaller, integrated RF drivers; more efficient operation and higher output power; longer lifetimes and increased reliability; and more wavelengths in the 9 to 10µm band.

There's also been progress made in academic research with chalcogenide fibres for CO_2 laser transmission. This work, if it comes to light, would open up fibre delivery for CO_2 laser systems, which at the moment isn't possible.

Hill said Novanta's R&D teams are

optimising Synrad lasers for different materials and processes, and that the biggest driver is increasing throughput, as well as requests for processing larger fields of view or larger materials. She said there are several opportunities to replace manual or contact-based processes, whether that's replacing ink with laser marking or blades with laser cutting.

Novanta's CO_2 laser portfolio ranges from the 5W Synrad 32-1 with integrated RF for marking, to the Synrad i401 with 400W average power for high-speed cutting and drilling. In addition to Synrad lasers, Novanta also provides CO_2 laser sub-assemblies that include Cambridge Technology scanning optics. Hill said: 'In addition to defining the right peak power or wavelength for a given application, we're focusing R&D efforts on optimising the entire beam delivery sub-assembly.'

Trotec's Fazeny said that, in the low-power CO_2 field, the biggest push forward in the last decade has been to make the sealed technology very reliable. All power levels less than 1kW are typically sealed lasers. They are shipped with a gas fill, meaning there are no running costs, as is the case with fast-flow CO_2 lasers, which have high gas consumption.

The first generation of sealed metal lasers have lifetime issues because their gas mix deteriorates slowly, which means power is lost over time – it is a slow drop, Fazeny explained, and typically the laser requires a gas refill after a few years. This has now improved with the advent of the ceramic core resonator, as opposed to the traditional metal resonator. The O-rings in a metal resonator are a weak point that can fail and leak gas over time. Also, there is interference from metal particles, which collect on the optics, making the resonator mirrors blind after a number of years.

'At Trotec we are now using the ceramic core lasers from Iradion in the US,' Fazeny said. 'There is no metal inside the resonator, even the electrodes are external. This overcomes the lifetime issue of the metal core resonator; Iradion has brought the sealed CO_2 lasers to perfection. There's no need for any refill anymore.'

In addition, the ceramic resonator has 75 per cent less thermal expansion than a metal body, Fazeny noted. Therefore, during the first 10 minutes of operation there is much less power, mode and pointing fluctuation.

Also, the Iradion CO_2 lasers are driven by RF power and use a single-chip design. The RF driver uses the same power transistors used for mobile communication base stations, which are simpler and much more reliable. 'The chance of failure is definitely less,' Fazeny remarked.

In terms of price, CO_2 lasers are comparable to fibre lasers, Fazeny continued. 'Fibre laser price has dropped dramatically over the last 10 years, but it settled somewhere in the range of the CO_2 laser,' he said. 'You don't need to decide by price, you can decide by application.'

Hill noted that Novanta's order volumes for Synrad CO_2 lasers are higher than ever at the moment, with many customers exceeding pre-pandemic levels. 'As long as there are materials that need to be marked or cut, we anticipate that we'll continue to see growth,' she concluded.

"This work would open up fibre delivery for CO_2 laser systems, which at the moment isn't possible"

LASER PRAYERS ANSWERED FOR TIBETAN STONE CARVING

A mani stone engraved by a Luxinar CO_2 laser

Buddhists practice the ancient tradition of mani stone carving in Tibet, using hammer and chisel to inscribe mantras or art into stone, traditionally the six-syllable mantra of Avalokiteshvara, Om mani padme hum.

Now, stone carvers in the Yushu area are turning to lasers to do the engraving.

Chinese laser provider CKLaser began investigating using CO_2 lasers to engrave stone when it approached Luxinar's China office in 2012. Luxinar makes CO_2 lasers, and CKLaser wanted to use the laser source as an alternative to mechanical processing.

The traditional method is to work by hand, but in the last decade mechanical tools, such as small electric drills and grinders, have been used to produce larger volumes of the carved slabs. The laser speeds up this process, with the advantage of no tool wear, no need to pre-line or outline the slabs, and the ability to inscribe precise designs and patterns.

'Characters are carved by scanning the laser beam across the stone with a galvo scanner,' Dr Louise May, senior applications engineer at Luxinar, said. 'Depth can be controlled by adjusting the intensity of the beam as it passes across the substrate to produce 3D effects.'

May added the effect does depend on the type and composition of the stone, with the process working better with some stones than others. 'Laser-induced localised heating can cause vitrification of certain minerals in the rock, resulting in poor engraving with a glass-like appearance,' she said. However, if these glass-forming elements are not present, there is material removal to produce a deep engraving effect. Initial demand from CKLaser was for Luxinar's SR 25i and SCX 35 sealed CO_2 lasers – 250 and 350W respectively – but Luxinar now also has demand for its 450W OEM 45iX laser source.