A PRIMER ON LASER MA

By Wayne Penn, Alabama Laser

LEAN MANUFACTURING MAKES PART TRACEABILITY PARAMOUNT, MAKING LASER MARKING MORE CRITICAL THAN EVER FOR MANY APPLICATIONS. THE LASER MARKING MARKETPLACE IS VERY FRAGMENTED AND PRICE-COMPETITIVE, ENOUGH TO CHALLENGE EVEN THE MOST EDUCATED BUYERS. HERE ARE SOME BASICS TO CONSIDER BEFORE INVESTING IN THAT FIRST SYSTEM.

To be competitive in a lean environment, part identification and traceability are vital during manufacturing. Industrial laser marking essentially falls into one of two categories – one as a standalone laser-engraving tool, and the other (more likely) as a customized laser-engraving tool married into a manufacturing process integrating either conventional machining methods or, preferably, an existing laser-cutting system.

The laser marking marketplace is very fragmented and price-competitive, enough to challenge even the most educated buyers. To address this challenge, a user should educate himself on three basic factors: the hardware, the process and new technology.

HARDWARE

The user must know the key differences between traditional CO_2 and Nd:YAG lasers. First, CO_2's 10.6-micron wavelength hovers in the infrared spectrum, making most materials transparent and visible, actually opaque, to the infrared beam. Plastics have a high absorption to this beam while metals have a fairly high reflectivity.

For organic materials such as plastics, CO_2 could be a good choice. The user must decide if CO_2's high absorption is worth its additional bulk. Engraving IC chips with a plastic base may call for a CO_2. Note, though, that 1-micron wavelengths, provided by less-bulky Nd:YAG systems, can mark plastics. Before making a choice, consider the power requirement. If low, a high-peak-power pulse is not necessary. CO_2 lasers do not have the energy density necessary to mark carbon steel.

CO_2 works well for marking organic materials, such as plastic bottles or semiconductors, with repetitive bar codes. The operation utilizes a masking system to etch the bar code into a template. The CO_2 laser fires through this template and burns the pattern into every plastic piece.

This application typically uses a compact TEA (transversely excited atmospheric pressure, or "pulsed") CO_2 laser. A masking-type system spreads the power over a broad area – say, a few centimeters for the bar code – that shadows the mask pattern into the plastic. The plastic's marking threshold is low enough to allow the pulse to mark the material. Though the pulse actually has a very high TEA power, it is masked, not focused on one spot.

CO_2 lasers tend to carry more masking. Nd:YAGs tend to carry more galvometer scanning. There are two types of galvo scanners: raster and vector. Raster scanning, the slower process, operates like a television. It builds an image pixel-by-pixel, scanning out the entire field. This uses a focused spot with high energy density – the exact opposite of the low-energy density created by masking.

Vector stroking, the faster process, is like plotting on a computer. Working with an Nd:YAG laser that absorbs better in metals than a CO_2, the galvo scanner vector-plots marks. This process is ideal for marking alphanumeric characters (usually always vector-scanned), especially when high speed is required.

Always consider the writing speed of the galvos – how fast it can stroke out the character's shape – the laser's power and the material. Move too fast without enough power, and the laser doesn't leave a mark. Laser marking at a high speed requires more laser power and a fast galvo scanner. The number of heat calories necessary to produce a mark varies depending on the energy threshold of a given material. For example, marking anodized aluminum requires fewer calories than deep-cutting steel, whereas evaporating metal altogether requires the highest power.

When vector scanning, the laser only needs to scan the character location, as opposed to scanning the entire field for every character with a raster. Rastering works best on applications where every pixel is built in an array field, such as very complicated bar codes, 2D matrix codes or photographs.

Consider a 1 cm surface area requiring a few alphanumeric characters. The area to be removed for those character marks makes up only 1 percent of that centimeter, so the beam should move directly to that 1 percent. Vector scanning minimizes dwell over the 99-percent inactive surface area. Rastering, on the other hand, works well when 50 percent or more of the area is being marked.

ARKING

An Nd:YAG vector-scanning laser is preferred for most metal product identification. On applications involving alphanumerics along with bar codes, the vector can first stroke out the characters, then color in the bar locations – a method far more efficient than raster scanning.

Vectors don't scan a line, they simply draw characters. But if characters become complex, vectors become very complicated as well. This is when rastering may be an option. Rasters are ideal for engraving plaques with artwork and other detail. The laser scans line-by-line, turning on-and-off, building the image.

No rules of thumb are available to narrow down applications by raster, vector, CO_2 or Nd:YAG. At the end of the day, actual marked samples still determine the best system selection.

ECONOMICS

Manufacturers use laser marking because either the application cannot be done any other way (dot peening, contact marking, etc.), or the application requires faster and/or more flexible marking. These factors determine the initial capital outlay. Off-the-shelf laser metal marking systems can be up to $100,000 or more, depending upon system power, the scanner speed, the spot size, how it is packaged, its enclosure and how it is customized (for a line, etc.). Fully customized systems can run more than $100,000.

The initial economic outlay remains the greatest cost factor in laser marking. After the initial investment, operating costs include consumables and possibly an operator. Non-contact marking creates little wear, so consumable costs are minimal regarding optic cleaning, lens and mirror replacements and gases.

The benchmark of laser process efficiency is beam-on time. A line running 1 hour with the beam on 30 minutes operates at 50-percent utilization. Improving utilization might involve product flow, material-handling speed, or possibly multiplexing the laser with multiple engraving heads.

A multiplexing laser costs more than those off the shelf. Given the application, do economics justify one custom multiplexing process or two off-the-shelf systems? At some point there will be a cross over, perhaps when the need to integrate markers across three or four lines arises.

NEW TECHNOLOGY AND FUTURE CAPABILITIES

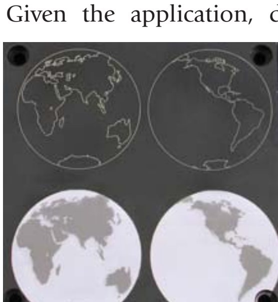
On the horizon, multiplexing technology should become commonplace. Future laser engravers will involve a single laser multiplexed to a number of engraving heads, each performing on a respective production line, using a percentage of the beam's on-time capacity. This concept presents enormous savings and introduces a new technology currently being developed for higher efficiency and flexibility: the fiber laser.

A vision for fiber optics is to bring all signals into a home using one fiber. That technology isn't here yet, but advanced fiber amplifiers already exist. Born in the telecommunications business, these amplifiers are very sophisticated and highly reliable through advanced diodes and other technology.

Now being developed for industrial applications, the laser integrates with a galvo scanner to create a laser marker capable of running either raster or vector processes. The fiber lasers available – yttrium, ytterbium, erbium – are all derived from a rare-earth element. Instead of the hard resonator or mirror cavity used in traditional lasers, fiber lasers' lasing medium is fiber, which can be rolled up like fishing twine. The beam generates inside the solid-state fiber. The user doesn't erect mirrors, doesn't align them with the hard optical resonator and doesn't need to service these hard components. No chiller or water cooling is required for most systems.

Compare this to an Nd:YAG laser that requires cleaning and aligning of optical components, changing of flash lamps or servicing the diode pump, along with other periodic services to the resonator over operating intervals of 500 to 1,000 hours or more. These costs are well-known and relatively low. However, the fiber laser boasts 1 million operating hours or more before service is necessary, an order of magnitude improvement in durability. This technology can be pushed harder and still attain lifetimes of 100,000 hours. After 100,000 hours, the user simply disposes of the laser. (Note: If a user hasn't achieved ROI after 100,000 hours, the user should never have bought the laser in the first place.)

Instead of flash lamps, a fiber laser uses a laser diode. Certain Nd:YAG lasers also use diode pumps featuring arrays of many tightly packed diodes, creating a thermal management issue. Product life cycles for these lasers are still being improved. A user can trace the fiber-laser life cycle very accurately because the technology separates the pump force. The fiber laser essentially segregates the pump diodes. Each cools individually, greatly improving diode life. The diodes lase into a transmission fiber that pipes the photons, or pumped energy, through the lasing fiber. This pumped energy directly buckles into the fiber that, in turn, lases it with a very high beam quality. Such quality allows



There are two types of galvo scanners: raster and vector. Raster scanning, the slower process, operates like a television. It builds an image pixel-by-pixel, scanning out the entire field. This uses a focused spot with high energy density – the exact opposite of the low-energy density created by masking. Vector stroking, the faster process, is like plotting on a computer. This process is ideal for marking alphanumeric characters (usually always vector-scanned), especially when high speed is required. Here, a vector image is shown on top and a raster image is on bottom. Photo courtesy of Alabama Laser vector and galvo scanning to focus down to 1 nanometer (0.001 micron) with a long focal length, creating a very crisp, accurate character at much greater speed and high energy.

The beam's resolution makes these crisp characters possible. Resolution controls spot size; spot size controls energy density; energy density controls mark quality and what material can be marked – and metal requires a high energy density. Without such density, the beam will reflect off the metal surface.

Even if the resolution remains the same, the ability to add more power increases significantly. If more power is needed, the user simply adds more fiber lasers. There is some loss of ink quality, depending upon the power range. Nd: YAG markers are generally measured in the 10s of watt power range – 10, 20 up to 50 watts. Fiber lasers can readily go up to 150 watts with the same order of beam quality as Nd:YAG. Coupling five or six times the available power with the speed of raster-galvo-scanners, the fiber laser makes the same mark in a shorter period of time. A shorter marking cycle means more marks on more lines.

Already introduced in some applications, the fiber laser should make a commercial impact within the next several months. The technology significantly impacts metal processing – both cutting and welding – because of lower maintenance.

SHOP OF THE FUTURE

Fiber lasers give us a glimpse at the potential shop of the future. Envision a multiplexed fiber laser – essentially a photon workhorse – pumping laser energy through "spigots" strategically placed about the shop floor. For welding, the spigot would open only slightly. For cutting, another spigot would open a bit more. One laser generator could be distributed across the entire plant to perform multiple manufacturing operations.

Think of plant power running lights, computers and motors. That's 20th Century technology. This century may see manufacturers bringing not only electrons through power sockets, but also photons through spigots — running virtually every metal-processing machine on the shop floor, from metal marking to welding to cutting.

F&M

Wayne Penn is President of Alabama Laser(Munford, Ala.), a manufacturer of custom and standard laser cutting and welding systems, beam-delivery equipment and specialized laser R&D services. He can be reached at 256-358-9055 or wmp@alspi.com. For more on marking, visit www.fandmmag.com .

FOR MORE INFORMATION

Alabama Laser
P.O. Box 55
Munford, AL 36268
Phone: 256-358-9055
Fax: 256-358-4515
www.alspi.com