Automotive Needs for Traceability and Part Identification Satisfied by Laser Marking

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In the manufacturing of automotive vehicles, Industrial lasers are used in large numbers for welding, cutting, heat treating, micromachining, and marking. This paper will explore the role of lasers for the critical task of part identification, information marking necessary for quality assurance and traceability

A typical car or truck is made up of 1000s of small and large components. In addition to the engine, body and suspension components; there are numerous sensors, electronic and electrical components and many other safety, environmental, measuring and control devices. The automotive industry has been moving aggressively to ensure that, if a recall or unexpected component warranty issue occur, they have the means of quickly identifying pertinent information about that component, such as the source of manufacture, material heat lot, date of manufacture, vendor and inspection records. This information is encoded into 1D and 2D codes permanently etched directly on the part or on a label at the time of casting, machining, molding or forming.

Figure 1. Typical vehicle using extensive laser marked components

Why lasers for marking?

This information is critical if there is a problem with the part. It will allow the part to be quickly isolated and the issue resolved. Laser marking systems provide unique advantages to applying these traceability marks to a variety of different parts. Some of the advantages are; noncontact marking, low heat input, high speed, low maintenance, and environmentally responsible processes.

Figure 2: Plastic


Figure 3: Metal

Noncontact Marking

When using lasers to apply traceability marks, the part is never physically touched. Lasers use high-intensity beams of light to introduce very targeted heat effected zones. By using light, the chance of foreign material contamination is eliminated. This also allows for less movement of either the part or the marking head. When using a pin stamp or etch unit, the mark stylist must be retracted so the part can proceed down the assembly line. A laser will normally be about 200 mm away from the part while marking (depending on focusing optics being used). The elimination of movement aids in process time and reliability of the entire marking cell.

Low heat input

Laser light beams are high-intensity beams of light that apply heat to a targeted area of the part. The characteristics of laser beams allow the beam to apply enough heat to generate a change in color while minimizing the amount of heat that escapes into the surrounding material. This small “heat effect zone” allows parts to be laser marked with little to no impact to the surrounding structure. This is especially critical when marking small, sensitive parts, such as circuit boards, sensors, and other electronic components.

High speed

Lasers are capable of marking some materials at linear speeds of over 3,000 mm/second. They are able to apply marks at these speeds because the energy is applied to the material at the speed of light. This allows the target material to be heated almost instantaneously to temperatures that can vaporize metals. Since laser beams are light, there is no mass to move as there would be in a pin stamp, scribe system, or stamp system. This allows the mark to begin instantly once the part is in place or even to mark the part while it is moving, thereby never stopping the line for marking.

Low maintenance

Over the last 7-10 years, laser systems have undergone a transformation from large, power-consuming machines to smaller, sleeker, and more energy-efficient systems. Today's Fiber and Nd:YVO4 (Vanadate) systems can go 10's of 1,000's of hours between diode maintenance. These systems are air cooled and therefore have eliminated the need for water chillers. Without water pumps and fittings to fail, the reliability of the systems increases exponentially. With thousands of hours between PM's, maintenance is needed only once every few years of operation allowing for more uptime, more productivity and more profit.

Environmentally-responsible processes
Lasers do not need chemicals, such as inks, to create marks on most substances. The lack of chemicals minimizes the impact to the environment because no chemicals need to be disposed of or cleaned up. This reduces operating costs and increases reliability in addition to being environmentally responsible. In addition to no need for chemicals, the reduced power consumption of the new styles of lasers mean a reduced drain on our natural resources that are consumed to supply electricity.

Solid state and gas laser marking systems have been available for a number of years and are proven rugged tools extensively used in the automotive industry. Lasers can operate at different wavelengths and power levels and also offer the flexibility and reliability required by the demands of this industry. Literally all metals and non-metals being used in the automotive industry can be marked with laser. By controlling the power and pulse frequency, marking depth can be varied up to 1.0 mm deep and text smaller than 0.010" in height can be legibly marked.

The surface finish has some bearing on marking contrast and vision readability of the marked code, however, marking techniques are used to improve the contrast on even "as cast" surfaces that permit vision systems to accurately and consistently read 2D codes.

Plastic materials can be etched using a CO2 laser if good contrast is not required. The use of a Nd:YAG, Nd:YVO4 or fiber laser can cause the surface color of plastic materials to be changed in many cases because of a thermal/chemical interaction. This interaction can produce various shades of dark marks in light colored plastic and various shades of white or grey marks in a dark plastic. The exact effect, however, needs to be tested. If the desired contrast is not achieved directly an additive can be mixed in the plastic that will enhance the color change.

Computer control and special software make these lasers perform as simply as your personal computer and printer. The software permits easy interface to a central data source to download a job file, production information and inventory control information. The system can easily be interfaced to a vision system to verify that the correct information has been marked by the laser. The vision software then communicates the information to a data base file for quality control and future retrieval.

A typical laser marking system consists of the laser head, power supply, galvo scanning head, computer and part handling system. The basic laser generator and scanner head is shown in Figure 2.

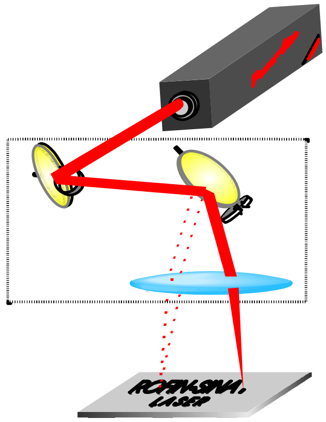


Figure 2. Basic laser components

Types of marking lasers in the automotive industry

Lamp Pumped Lasers. *SMP 65, SMP 100, PowerLine 100, PowerLine 130*

Only a few years ago the only pulsed Nd:YAG laser choice available was operated with one or two high power arc lamps as shown in Figure 3. Different models produced from 50 to 130 watts. Pulse frequency was limited to about 40 kHz. These lasers are large and operate with an efficiency of about 4%. The lamp pumped laser system requires an external water chiller to remove heat from the resonator. Lamp based systems are still available and for certain applications remain the best solutions.

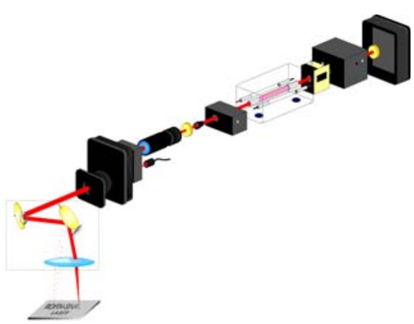


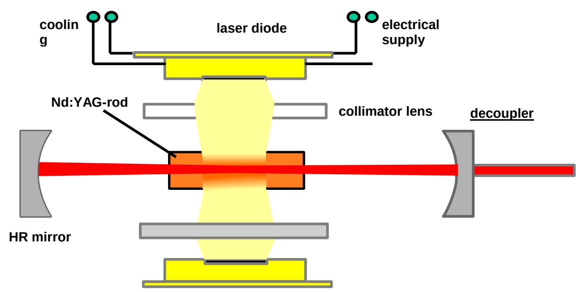
Figure 3. Lamp pumped Nd:YAG laser and the SMP100 system

Benefits include:

- High power for deep engraving.
- Ready upgrade to old lamp pump lasers.
- Low operating cost

Diode Pumped Lasers – *SMD-50D,75D, RSM-30D, 50D, 100D*

About 7 years ago, the first high power diode pumped Nd:YAG lasers appeared on the market. These lasers offered comparable laser powers to the arc lamp pumped lasers but replaced the lamps with a solid state device called a diode bar.



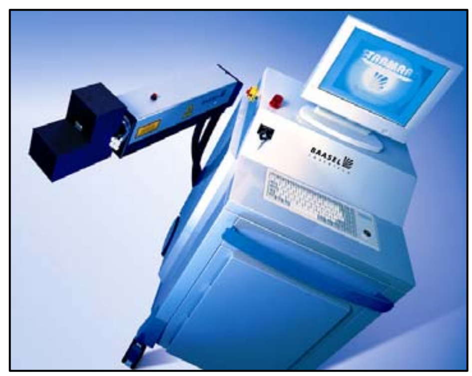


Figure 4, Diode pumped Nd:YAG laser and the SMD system

Benefits include:

- Excellent beam quality produces high quality marking.
- Efficiency of the laser is increased 10x because the diodes emit light at a single wavelength matching absorption band of the Nd:YAG crystal.
- Small footprint
- Diode bar operating life is measured in 10,000s of hours instead of 100s of hours with a lamp.

End Pumped YVO4 Lasers E10, E20, E30, E40

A new family of low power marking lasers has been developed around the YVO4 (Vanadate) crystal resonator. The crystal is pumped from the end "End Pumping" instead of the side. End pumping produces a low divergent beam which produces a smaller spot sizes. These compact lasers deliver power from 10 to 40 watts and operate at pulse rates up to 200 kHz. The pump diode module, which has an operating life of up to 30,000 hours, is located outside of the laser head and easily replaceable with normal hand tools. The pumping light is delivered to the end of the crystal thought a small diameter fiber optic cable. The laser head does not need to be opened when a replacement diode module is installed. The warranty on the diode pack has been increased and is currently 2 years with unlimited hours of operation.

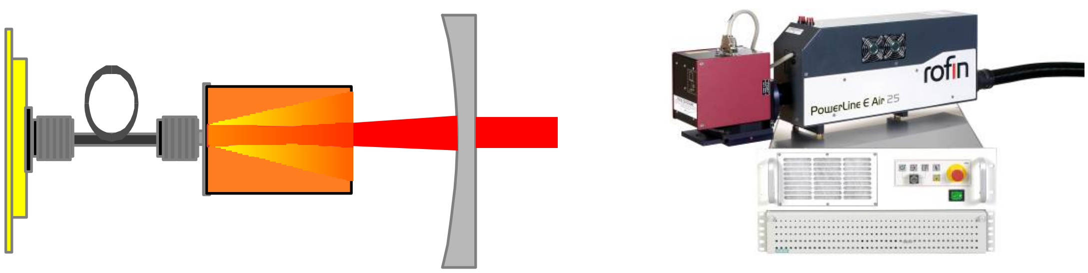


Figure 4, End pumping used in our E series of diode pumped YVO4 lasers with the E25 air cooled system.

Benefits include:

- Diodes emit light at a wavelength that is absorbed directly into the Nd:YVO4 crystal. The E10 Air and E25 Air systems are air cooled so no water cooling is required.
- The end pumped configuration is more efficient than lamp pumping.
- Diode life is approximately 30,000 hours.
- The laser beam generated by a diode is of higher quality than that of lamp systems which typically results in faster mark times, higher production rates, higher energy density beam
- Superb marking of metals: anneal & engraving applications
- Superb marking of polymers: superior contrast capabilities

Fiber Lasers – F20

This laser sets itself apart from diode pumped and lamp pumped lasers because the active laser medium is not a rod nor crystal but an optical fiber. As with all solid state lasers the fiber will only function as a laser source if it is doped with a rare-earth element. For YAG and Vanadate lasers it is Neodymium (Nd) but for a fiber laser it is erbium or ytterbium. This makes the fiber into a so-called “Active Fiber”. Special treatment of the active fiber is necessary to produce Bragg gratings that replace the traditional dielectric mirrors found on conventional lasers. Pumping energy is delivered to the active fiber through a bundle of glass fibers fused to individual laser diodes. The active and pump fibers and the diodes are connected together by thermal splicing or fusion. This produces a reliable system but it also means that no parts of the laser resonator can be replaced or repaired. If a problem develops usually the whole laser generator unit needs to be replaced. Because of its design, fiber lasers are inherently very reliable with a long operating lifetime in excess of 30,000 hours.

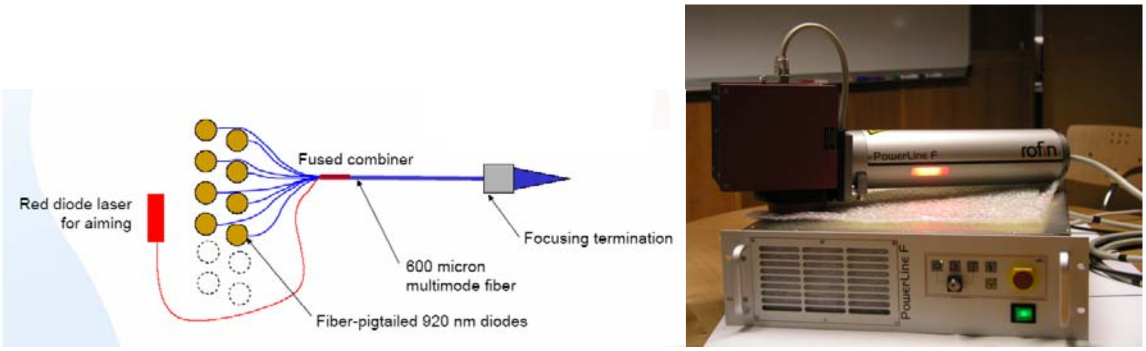


Figure 5, Fiber laser pumped but individual diodes and the F20 system

In conclusion, lasers offer a number of advantages for applying traceability marks to automotive parts. Advantages such as non-contact marking, low heat input, high speed marking, low maintenance and environmentally friendly process make lasers a great choice for applying these marks. These advantages are enhanced by the fact that there are a number of different styles of lasers that can be selected from to match your application. By matching the laser to the application, the efficiency of the process is maximized along with the productivity. Lasers look to be the future of traceability marking in the automotive industry.