LD Pumped Solid State Lasers and their Application

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1. Introduction

Light and in particular Laserradiation becomes more and more important as a tool in the material processing. The entire characteristic of the laser beam especiallly the contact free input of energy into the materials, which can be controlled by quantity, time and locality is the reason that many production machines were replaced by lasers This requires powerful and reliable lasersources.

2. Company

Jenoptik Laser, Optik, Systeme GmbH developes and manufactures lasersources, optical components, and subassemblies, sensores and measurement systems.

The Laser Division and the subsidiary JENOPTIK Laserdiode GmbH focus on the

"High Power Diodelasers"

and the

"Diode Pumped Solid State Lasers"

The lasers are used in the industry, medical industry and display technology .

The Jenoptik company offers

Multimodelasers up to 100 W beam power, cw

"high brightness" Nd:YAG-Lasers up to 70 W beam power

"high brightness" Nd:YAG-lasers based on "thin disc technolgy"

optional equipment to be completed to a marking system and for material application (hardware and software)

custom-made diode-laser systems

I would like to focus on the diode pumped solid state lasers, the diodelasers and in particular the application of welding of plastics.

3. Diode pumped solid state lasers

More and more the diode pumped solid state laser substitutes the lamp pumped one because of the following advantages:

Increased beam quality on comparable dimensions of the laser

Possibility of extended peak power by means of q-switch mode

Compact design

Higher efficiency (> 10%)

Lower running and service costs

Generally it can be distinguished between two main design principles of solid state lasers. Figure 4 shows the design of a diode pumped solid state laser based on a rod crystal.

The Nd:YAG rod is located in the center and pumped transversally by means of a diode stack (see chapter 3). The available beam power varies between 30 up to 90 W and is characterized with the multimode beam. This source suits to the main applications of marking plastics and metal (see chapter 4).

For a wider range of application the resonator can be extended and the beam quality increased The JOL-RB 70 combines best beam quality with high beam power and is used for high speed deep engraving application.

A new resonator design shows figure 7. The laser crystal is fixed on a heat sink and pumped via fibre. In accordance to the reflecting optics a high brightness beam can be generated. Additionally this design offers the use of peltier cooling instead of water cooling that reduces the running costs also. (see figure 8). However, this laser is available up to beam power of 8 W.

4. Diodelasers

Because of its small dimensions and the high efficiency the diodelaser will substitute current laser applications of the CO_2 lasers and the solid state lasers also. I will cause a basic change of the lasertechnique and find new application fields anyway.

Providing a successful use of the diodelaser it requires a basic understanding of the design, beam and operation characteristics.

Diodelasers of at least 10 W beam power consists of semiconductor stripes (100 mm width) called laser bar. On top of it there are a number of emitters according to figure 10.

All of them generate a laserbeam, which has different beam characteristics in the main two directions.

In the fast axis the laser beam has a high beam quality (diffraction limited) and leaves the emitters on an angle of about 60-90 °. With suitable optics attached the beam can be paralleled and later on be focused. In practice a parallel laser beam can be generated to an unlimited width.

The characteristics of the beam in the other direction is totally different, called slow axis. In spite of the fact that the angle of the beam in this direction is much lower than of the other direction the laser beam shows a multimode characteristic.

However, the same beam comprises opposite characteristics in the different directions and must be adapted (collimated) to a common one of the same characteristic in both direction. That leads to a less beam quality that limits the application field at the moment. First tests succeeded to show the deep penetration welding.

For generating the laserbeam the diodelaser is supplied by high electrical current between 10 and 60 A. The laserpower follows the current directly. So, it can be steered and controlled with high dynamic characteristic.

Because of the high power density of the diodes it requires an excellent cooling system of each bar. Actively cooled bar are soldered on a heat sink with direct water cooling. Passively cooling means that the heat sink is cooled on an additional device attached.

Passively cooled diodelaser leads to lower power of the diodes. On the other hand it offers an easy integration of it in the laser head.

Because of the high voltage of the emitters it is required to manufacture the diodes under clean room conditions and run it shielded.

5. Applications

Marking metals

The identification and marking of metals by means of a laser is a widely accepted application. The marking effect is achieved in different ways.

In surface engraving, the material is evaporated by short high-energy laser pulses directed to the work surface. As a rule, beside a hollowing-out, this process produces a raised rim and discoloration.

Discoloration of the workpiece at the marking site without surface damage is successfuly performed in marking of steel components by annealing. This kind of laser marking requires an appropriate carbon content of the steel.
Colour changes by laser marking are also possible on hard metals.
Another technique of metal marking is based on the partial removal of paint and surface refinement coatings.

Marking plastics

The identification and marking of plastics by means of lasers increasingly replaces imprinting and labeling. Laser marking reduces retooling expenses and the need for stock keeping and makes production equipment more flexible.
Laser marking techniques commonly used today are based on material changes of fillers and dyes by laser exposure at the marking site.
Likewise well-known is the technique of specifically doping difficult to mark thermoplastics with absorbing additives. The additives must not significantly affect the other material properties.
Laser marking is particularly successful if the material to be marked was chosen for its suitability to laser marking already during product development.

Engraving metals

Today, in the manufacture of injection moulds and printing plates often q-switched solid state lasers are used. These lasers produce very short laser pulses of high power that metals are converted to plasma state and expelled from the workpiece.
In this way, it is possible to locally engrave metals.
The deflection of the laser beam by means of scanners allows fast, precise and very variable machining of target surfaces.
The desired engraving depth can very accurately be achieved by multiple machining operations.
The same principle of laser engraving can be utilized to obtain the durable identification of parts with rough surfaces or high wear.

Trimming

Today, electronic circuits, passive electronic components and quartz crystals are frequently trimmed by means of lasers.
By specific structuring of an electronic component by means of the laser beam, its electric value is changed. In combination with a measuring device, the exposure process is continued until a specified value or switching point is achieved.

Laser cutting and punching of non-metal materials

Cutting and punching of paper, plastics, fabrics and fleece materials by means of mechanical tools involves high tooling costs.
By the use of suitable laser systems, initial and consumable costs become completely irrelevant.
Particularly with frequently changing product ranges and difficult materials, the use of lasers will soon result in cost savings.

Examples:
Perforating documents
Cutting of fleece material in motion
Weakening of packaging material in motion
Concealed pre-defined breaking points on 3D objects (e.g. dashboards)

Brazing and welding metals

Brazing and welding with high-power diode lasers is used, for instance, for joining sheet metals in automotive and plant manufacture.
Both techniques feature very high quality of joints and high process speed.
Particularly hard soldering offers the advantage of good gap bridging, as with this technique fillers are used.
High-power diode lasers are available with a beam power of up to 2.5 kW at the fiber end.
The combination with a robot provides additional applications in automotive industry and machine building.

Soldering with diode lasers

For selective soft soldering, diode lasers are used. These lasers can very flexible be customized to any soldering job. Manually guided soldering processes are automated and result in both improved quality and increased productivity. Moreover, we will readily advise you in integrating the diode lasers into your production line and offer sensors for significant process parameters and the acquisition and control of soldering temperature.

6. Welding plastics with diode lasers

Laser welding of thermoplastics features high quality of the weld and high process safety. There are two main techniques available: contour welding and simultaneous welding. It requires different laserheads and laserbeams.

Both techniques have in common, that one of the materials to be joined is transparent to laser

radiation, whereas the other material absorbs laser light.

When the absorbing part is melted, the transparent part placed upon it is indirectly melted, too, and thus both materials are welded to each other.

In contour welding, the laser beam is guided along the joining contour. With this technique, either the laser beam or the materials to be joined are being moved. The laser beam may be delivered to the working site through a fiber (fiber-optic light guide) and focussing optics. Furthermore, it is possible to scan with the laser beam across the materials to be joined.

In simultaneous welding, the diode lasers in the welding head are arranged individually to fit to the joining contour. Both materials to be joined are shortly exposed so that the materials are melting and welded to each other.

7. Prospect

New laser generations will open new application fields. With the thin disc laser very precise markings become true on a new economic basis. Further steps in diodelaser technology will additionally widen the application of this laser also. So, the century of the photon comes.

Jenoptik Laser, Optik, Systeme GmbH has gained extensive experience in the production of diode pumped solid state lasers and diode lasers and readily advice you in integrating them into your production line.