Design and Manufacturing of a Laser Diode Beam Assembly with Respect to Laser Fine Welding with Nd:YAG-Lasers

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A novel laser diode beam assembly (LDBA) has been designed and manufactured with respect to laser fine welding using Nd:YAG-Lasers. As a necessary prerequisite of both welding seam quality and the optimisation of the optical functionality of the LDBA was the development of an intensity scanning system (FineScan) and its integration into the laser fine welding station with pulsed Nd:YAG-Lasers [1][3].

1 Introduction

This paper discusses the problems arising in the manufacturing process of devices in which opto-electronical, micro optical and precision mechanical components are assembled and joined by laser fine welding. The production of a laser diode beam assembly (LDBA) is used for demonstrating solutions of these problems. The main difficulties are caused by the necessity of having to align the system components primarily concerned with optical functionality. For the LDBA, the first component in the device assembly is a laser diode which is normally toleranced in the direction of light emission. This results in the alignment of the components following this light source having to be carried out in such a manner that the light propagation through the LDBA device is kept parallel to the optical axis. This leads to a required angular displacement related to the symmetrical axis of the LDBA. Therefore a previously developed laser fine welding system (1) has been enhanced by a fine scan system for enabling the optical alignment of the LDBA.

2 Design of LDBA with Respect to Laser Fine Welding

As a new joint technology, laser beam welding offers a multitude of enhanced constructive possibilities in device design. Not only the low energy input or the possibility of welding with one-sided access, but also the application to a great variety of materials and material combinations are important advantages of laser beam fine welding. The prerequisite for laser fine welding is to design the device shape and to make material selection in such a manner that functional and quality requirements of the weldable components are guaranteed. Moreover the manufacturing process has to be carried out with high accuracy and reliability. For the repetition accuracy of alignment it is necessary to clamp the components in specially designed precision clamp tools.

Weldability and welding seam quality (mechanical properties, gas-tightness) depend strongly on the optimised process parameters, laser parameters, material composition, precise structural design of the components (edge preparation and gap tolerance) and the use of a precision handling system. Taking account of these conditions, a laser diode beam assembly (LDBA) was designed consisting of a laser pigtail, interface connector (IC) and a light collimating output coupler (Fig. 1). The LDBA is a novel device made of high-grade steel with different surface properties. The IC was constructed in such a way that all welding seams are carried out as butt joint, except the fillet joint of the gas inlet.

The Butt joint configuration makes design and alignment of optical components much easier as well as avoids the time consuming focusing procedure of the welding head. In particular, the fillet joint configuration is sensitive to deviations during the welding process, which can lead to a mismatch of the components to be welded.

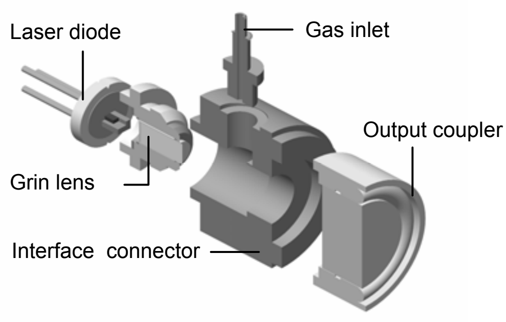

Fig. 1 *Blown-up drawing of LDBA.*

3 Control and DAQ-Program FineScan

To correct the pigtail beam direction deviation, the relative position of the output coupler to the interface connector has to be displaced out of the symmetric axis. Therefore it is necessary to know the exact position where the output intensity has its maximum intensity $I_{MAX}(x,y)$. For this reason the 2D-intensity distribution of the output beam is measured and the position of the maximum intensity $I_{MAX}(x,y)$ is determined. This is realised by a system which consists of a motion-controller, a micro-handling system, a photo detector (PDA55), a computer with a PCI-Multi I/O card and a specially developed software FineScan. The PDA55 is a silicon photo detector designed for detection of light signals in a frequency range from zero to 10 MHz with high Signal to Noise Ratio.

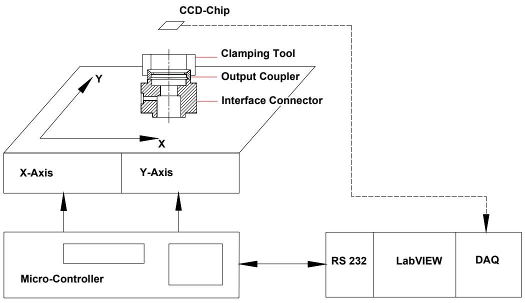

Fig. 2 *Schematic alignment set-up.*

The software FineScan (LabVIEW) controls the micro-handling system via motion controller and provides the data-acquisition during the area scanning process (area of 2 mm^2). FineScan offers a rough scan and fine scan mode depending on the step width as well as manual motion control mode. The measurement process is divided into two steps. First a low resolution scan is looking for the area, where the maximum of light intensity is located. Secondly a high resolution scan is applied for determining the exact position of the maximum.

Fig 3. shows a typical 2-dimensional intensity distribution of a laser diode after a fine scan process (resolution of 32x32 measuring point by a lateral step width of 50 µm) in different representations.

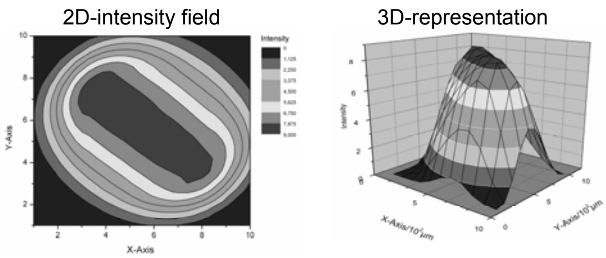

Fig. 3 *2D-Intensity scan (area 2 mm^2, Fine scan mode).*

The scanning field data (intensity distribution) is detected for each position in the scan field (x, y-coordinates) by a Silicon photo detector is be stored as ASCII-File. Evaluating the detected 2-D intensity distribution FineScan generates the position coordinates of the maximum intensity and the motion instructions for the handling system. During the area scan process, the output coupler of the LDBA (Fig. 4) is clamped by the clamping tool in a fixed position, while the X-Y micro-stages manipulate the motion of the interface connector in the X-Y plane (Fig. 2).

4 Laser Fine Welding of LDBA Output Coupler by Means of Nd:YAG Lasers

For fine welding of the LDBA, a commercial pulsed solid state Nd:YAG laser is used. The laser beam is guided via a fibre to the welding head inside the welding station [1]. Fig 5 shows the laser fine welding station with intensity detector PDA55 and the alignment set-up.

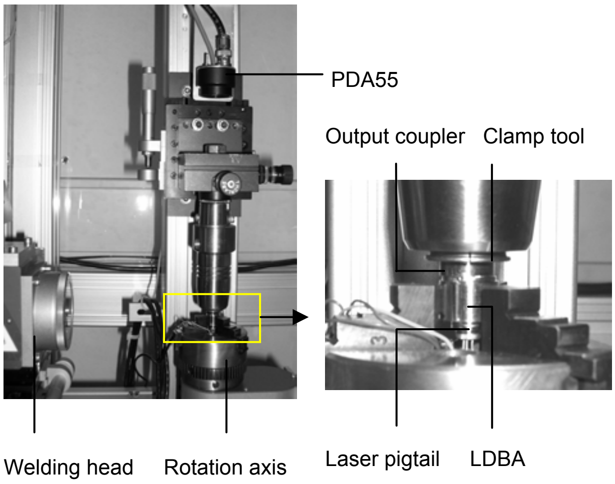

Fig. 4 *Laser fine welding station with pulsed Nd:YAG-Laser (left) and LDBA alignment set-up (right).*

The first step of alignment is to insert the output coupler into the precision clamp tool and move it close to the flange 4 of interface connector. Subsequently FineScan performs the 2-dimensional area scan and provides the intensity distribution of the laser pigtail (see Fig. 4.) The Position of the maximum intensity $I_{MAX}(x,y)$, which is calculated out of the intensity profile, is converted direct into instructions to the micro-handling system. To fix the output coupler a tack welding procedure is carried out at various positions around the interface connector (IC). Finally a continuous welding seam is performed by complete revolution (360°) of the LDBA [2].

References

[1] Buenting A., Parkin R. M., Kreitlow H.; Laser Fine Welding Station with Nd:YAG-Lasers, ICOM 2003, Loughborough University, UK, ISBN 1-86058-420-9

[2] Duley W. W., Laser Welding, John Wiley & Sons Inc., (1999), ISBN 0-471-24679-4

[3] Trumpf Laser, Manual HL 204P (1998)