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TITLE

Accuracy and beam pointing stability of surface mounted optical elements

ABSTRACT

A standardized optical mount based on a symmetric tripod structure has been developed for an automated assembly procedure. It allows to achieve submicron positioning accuracy and a beam pointing stability of 27 ± 70 µrad.

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Accuracy and beam pointing stability of surface mounted optical elements

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Considerable efforts are presently being made in the fabrication of miniaturized optical devices. Several groups are working on concepts relying on passive alignment techniques based on surface mounting onto integrated waveguide structures[1] or Si-bench technology[2]. Another automated assembly technique for small optical components based on standardized holders and on-line alignment of the optical elements has been developed in our laboratory[4].
Briefly, this optical surface mounted devices (O-SMD) technique consists of a flexible 2-dimensional arrangement of an universal tripod holder on a planar mounting plate. The holder configuration and some characteristic dimensions are shown in Fig.1. The compliant structure allows to align the optical elements during the mounting process in all 6 degrees of freedom and to attach them to the mounting plate in a one step procedure by laser point welding. The optical elements are interconnected by free-space propagation of the light with a beam diameter of up to 8 millimeters. Flexibility, simple handling, high packaging density and low cost make this well established assembly technique suitable to both mass production and rapid protoyping of small optoelectronic devices. The technique has been successfully used for mounting optical devices such as a collimator, a miniature scanning Fabry-Perot resonator or a compact all solid-state green laser. However, problems were encountered with the assembly of devices requiring very high angular beam precision adjustments, such as, e.g., beam combiner devices, and with devices operated in environments with large temperature variations (> 70 °C).

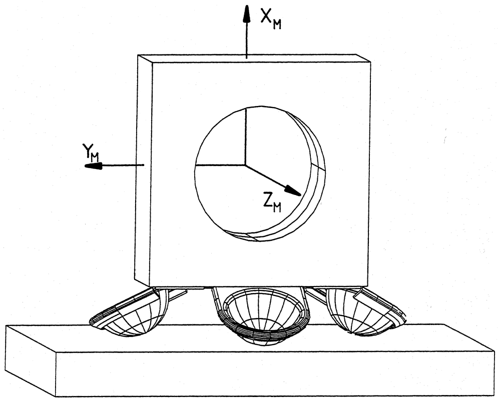

Fig. 1 : Laser point welding of optical mount

•dimensions: 10 x 10 x 4 mm^3

•adjustment ranges:

•vertical translation (x) ± 0,5 mm

•horizontal translation (y, z) not limited

•orientation (α) 360°

•tilt and yaw rotations(β, γ) ± 7°

In this paper, we report on a new symmetric Invar tripod with considerably improved thermal and mechanical properties. Both, the stability of the mechanical precision during the attachment procedure (post weld shift) and angular stability during thermal cycling have been investigated and improved by a factor 26 and 2, respectively.

The attachment accuracy is characterized by linear and angular displacements (beam pointing stability). The amplitude and repeatability of the displacements influence the final accuracy. Linear displacements are essentially limited by the repeatability of the process since an automatic correction of the position can easily be performed prior to the welding process. Angular displacements are usually limited by repeatability and amplitude since implementation of an automated amplitude corrections mode encounters more difficulties. Three contributions affect the amplitude and the repeatability of the total displacements:

- slipping effect of the tripod's legs during the welding process (stick-slip effect)
- laser welding spot shrinkage during cooling.
- elastic relaxation of the three legs after gripper's release.

Amplitude and repeatability of each contribution has been measured and minimized. Linear and angular displacements are not sensitive to the same principal parameters. Linear displacements are mainly (90%) sensitive to the slipping effect and to the shrinkage than to the elastic relaxation. In opposition, angular displacements are mainly (90%) sensitive to the elastic relaxation rather than to the other parameters.

The repeatability of the slipping effect had been minimized in the conventional technique by lowering the lateral friction between the legs and the base plate. This had been achieved by finishing the adjustment process by an upward movement. Another technique much more easier to implement has been developed with this approach: By vibrating the legs of the tripod with a piezoelectric transducer at a frequency of about 1 kHz, the friction between the legs and the plate is considerably reduced and similar results in the standard deviation as with the old technique are achieved.

The repeatability of the laser welding spot shrinkage has been improved by inserting a ring with a diameter of 2 mm and a thickness of 0.2 mm on each of the three feet in order to lower the contact pressure between leg and plate.

The repeatability of the elastic relaxation after the gripper's release has been improved by making sure that all the three feet have the same stiffness and that they press equally on the plate. In addition, a symmetric version of the tripod with an angle of 120° between the legs has been developed. This allowed to reduce the amplitude and the standard deviation of the angular displacement considerably. The following results with respect to amplitude and the standard deviation have been achieved:

vertical: $\Delta y = 15\ \mu m \pm 0.7\ \mu m$; lateral: $\Delta x = 0\ \mu m \pm 0,1\ \mu m$; angular: $\Delta\beta = 27\ \mu rad \pm 70\ \mu rad$

The values for the vertical and lateral displacements are the same as those obtained with the previous technique. The 15 µm vertical displacement has been compensated in the mounting procedure prior to the welding process. The beam pointing stability has been improved by a factor of 26 for the amplitude and by a factor of 3 for the standard deviation.

The stability of the attachment during thermal cycling has been investigated with a theodolite and an interferometer . A typical test device for angular measurements consisting of two plan parallel mirrors mounted on two tripod holders is shown in Fig. 2. Thermal cycling between -20°C and +60°C has shown an angular stability of about 30 µrad. No hysteresis has been observed concerning the angular stability.

In conclusion, an improved version of the tripod holder allowed to considerably improve the beam pointing stability of the tripod holder. This allows to extend the field of applications of this technique to optical systems with more stringent angular specifications such as, e.g., spatial beam combiners and long distance free space optical transmission systems.

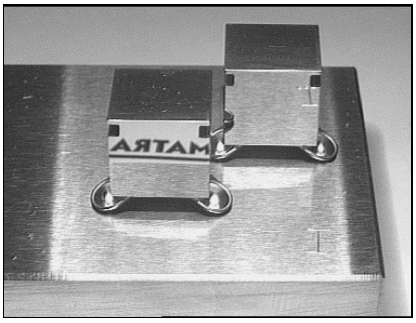

Fig. 2: plan parallel mirrors for angular measurements

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