Automation of the alignment process of a solid state laser resonator

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Resonator alignment is the most challenging step in the manufacturing of solid state lasers. Reduced dimensions and the high precision needed for achieving high output power efficiency make this procedure complicated to automate. A completely automated alignment of the resonator would significantly reduce costs and manufacturing time.

The resonator of a new Micro-slab solid state laser with a design for an automated assembly was successfully aligned with a new micromanipulator in a flexible automated cell [1]. The developed procedure consists in two consecutive steps; a passive and an active [2].

Passive alignment, which is based only on the geometry of the system, is performed by optically amplifying the misalignment of the mirrors. This is done with the help of a low power reference laser which is reflected by the resonator mirrors to a screen; there the misalignment can be calculated in reference to the orientation of the front face of the laser crystal. Using a camera and image processing methods, this method was successfully incorporated in the system. Both mirrors conforming the Long-Radius Hemispherical resonator are first aligned by this method to after that perform the active alignment, manipulating only one of the mirrors.

The active alignment consists of sampling the output power at different mirror orientations. First, power samples are obtained following an "X" path to get the approximated orientation for the maximum output power. From this maximum, the algorithm searches for a higher output power around the previous maximum. This way, the number of power samples is dramatically reduced; hence, saving a considerable amount of time. In Fig.1, it is shown the power distribution for different resonator misalignments (a) and the results of one active alignment scan (b).

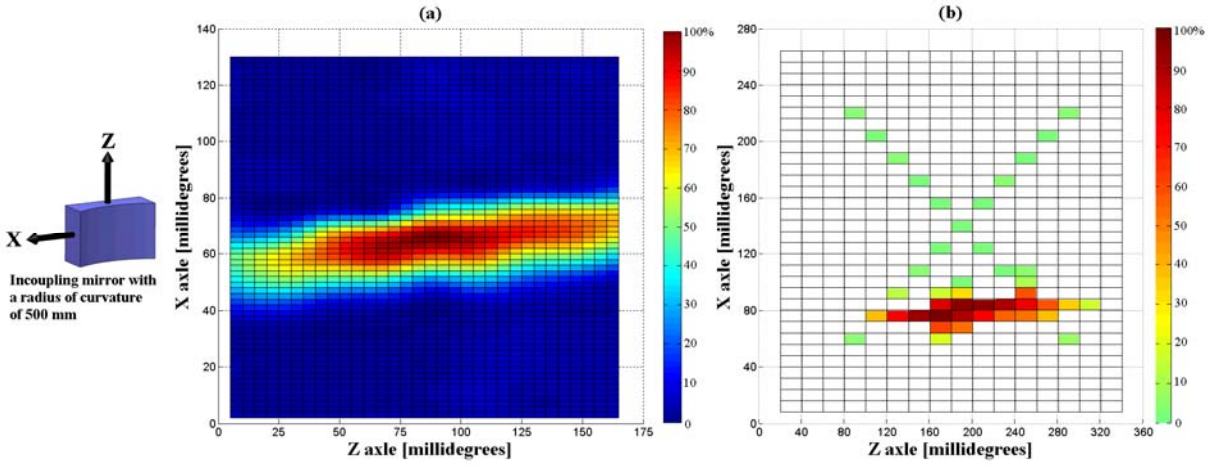

Fig.1 (a) Output power for different resonator misalignments, (b) Result of one "X" scanning strategy test.

The passive alignment method already described achieves a parallelism of approximately ± 40 mdeg, providing an appropriate starting point for the active alignment.

Regarding the active alignment, each complete "X" scan takes about 1 to 2 min using a fast response power meter (response time < 1 second). The "X" scan is repeated as many times as needed reducing the step size each time until the desired parallelism is achieved. For this particular laser the "X" scan is repeated four times, using an step size of 0.5 mdeg in the last scan. Hence, the active alignment takes between 4 and 8 min.

The transfer of the already acquired knowledge to an industrial application could have a positive impact on manufacturing time and cost, as well as on the laser quality.

More details about the reference and measurement setup, as well as the alignment algorithms, the flexible assembly cell and the key automation components will be presented.

References

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[2] Mathias Mohaupt, Erik Beckert, Ramona Eberhardt and Andreas Tünnermann, "Alignment procedures for Micro-optics," [book auth.] Svetan Ratcher. *Precision assembly technologies and systems*, (Springer, Chamonix, 2010).