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# Beam Distortion Compensation in High Average Power Solid State Lasers

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**Abstract.** In the recent years, the use of adaptive optics (AO) devices has been very beneficial for many scientific and industrial fields, such as astronomy, ophthalmology, gravitational waves interferometry, etc. High power lasers with good beam quality, high average and peak power, and high energy are crucial for many of those applications. Master Oscillator Power Amplifier (MOPA) configuration is a good approach to sustain the beam quality of a lower power oscillator. However at high repetition rates, due to the increasingly high thermally induced effects, the power amplifiers in the MOPA architecture are starting to distort significantly the input beam quality of the master oscillator.

This work is focused on beam distortion compensation of high average, high peak power solid state laser oscillators and amplifiers by the use of a piezoelectric deformable mirror (DM) with a control feedback loop featuring a genetic algorithm. The experimental setup consists of a master oscillator, a two stage power amplifier (MOPA architecture). The DM was used for forming the input beam in the amplifier chain. As an oscillator we used a passively $Q$-switched Nd based microchip that generates 1 ns pulses with energy of 200 $\mu$J, at 0.75 kHz repetition rate. Using two lens objectives the beam diameter was insured to be 10 mm, 2 mm and 3.5 mm at the DM, first and second amplifier respectively. In the first amplification stage a 4 pass scheme was utilized though the use of two polarizers and a Faraday rotator. The first amplifier module was side pumped in a threefold configuration by 400 mJ of pump energy at 808 nm and the second module was side pumped in a fivefold configuration by 360 mJ of pump energy at 808 nm. In the second amplification stage only two passes were made. At the output of the amplifier a glass wedge was introduced. The low intensity reflection from the wedge was propagated through a lens with focal length of 400 mm and at the lens focal spot a CCD camera was placed the signal from which was used for the feedback loop that optimizes the curvature of the deformable mirror. The beam quality from the oscillator is almost diffraction limited with $M^2$ factor around 1.1. After the 4 pass amplification the M2 factor deteriorates to 1.9 in the major axis and 1.3 in the minor axis We used the available

software performance metrics that gave desirable results (improvement of the $M^2$ factor), and after that optimization we were able to reduce the $M^2$ factor to 1.3 in the major axis and 1.1 in the minor axis.

## References

[1] S. Sinha, J. D. Mansell, R. L. Byer, "Deformable Mirrors for High-Power Lasers", Proceedings of SPIE Vol. 4493 (2002).