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Recent advances in high-power fundamental mode thin-disk lasers using intra-cavity deformable mirrors

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Abstract content
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Thermally induced aberrations are limiting power scaling of solid-state lasers. The concept of the thin-disk laser was developed in order to mitigate this so-called "thermal lensing". By scaling the gain medium down to a thin disk, a highly efficient back-side cooling scheme can be applied, minimizing the amount of thermally induced aberrations in the pumped laser crystal. This enables the design of high-brightness lasers with a broad dynamic stability range. In fundamental-mode operation, however, the aspherical components of the remaining wavefront distortions arising from the strong temperature gradient at the edge of the pump spot lead to diffraction losses which limit power scalability. These aspherical wavefront distortions can be compensated for by intra-cavity deformable mirrors. For this purpose, we have developed pneumatically deformable mirrors consisting of fused silica substrates with an annular groove applied from the back side. If pressure is applied from the back side of the mirrors, the HR-coated front surface of the mirrors is deformed in a way that closely matches the super-gaussian shape of the aspherical components of the wavefront deformations induced in the thin-disk laser crystal. The magnitude of the deformation is linearly dependent on the applied pressure, which can be controlled very precisely. Hence, the mirror can be accurately tuned in order to effectively compensate for the wavefront deformations generated in the laser crystal at a large range of different pump powers. In recent experiments, we have successfully demonstrated the use of these mirrors in a thin-disk laser resonator. With output powers of up to 815 W from a single disk at close to fundamental-mode operation (M² < 1.4) reported so far, power scaling beyond the 1 kW is within reach. The results of further experiments currently in progress will be reported during the workshop along with a full characterization of the mirrors

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