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Development of a Cryogenic Disk Laser System for Application in High-Field Science and Industry

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Abstract

Tabletop Yb:YAG laser systems can be applied in treatment of micro cracks on the surface of solids through laser shock pinning. The repetition rate of such laser systems is mainly limited to thermal lensing. An elegant technique to increase the repetition rate towards 1 kHz is cryogenic cooling of a disk with a high aspect ratio. Due to a higher absorption cross section at 77 K, the pump laser can be efficiently absorbed in a double-pass geometry. The main drawback of this approach is a higher level of ASE compared to lasers operated near 300 K. To suppress ASE in a high-gain amplifier, a well-known technique is cladding the disk by Cr^{4+}:YAG or parabolic treatment of the edge of a disk. In this talk, through ray tracing of ASE photons inside a disk and solving rate equations, we show that a disk with an optimized bevelled edge can also closely perform to the aforementioned techniques and yield a pulse energy of 100 mJ at 1 kHz. Towards fabrication of such a cryogenic disk, we report bonding of thin optics onto metallic heat sinks using a two-component epoxy compound. Through optimizing the bonding process, we could achieve a surface profile with a PV deviation less than 60 nm, which is necessary to obtain a high beam quality in a multipass amplifier. Testing the bonded optics by a thermal shock in a range of 77-520 K did not result in any cracks or delamination. We also found a way to further improve the surface profile of the disks by a thermal shock at 77 K leading to a smooth spherical surface.

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