CONFORMAL OPTICAL ELEMENTS FOR WAVEFRONT DISTORTION CORRECTION IN YAG:ND ACTIVE ELEMENTS

R.K. Nasyrov¹, Yu.D. Arapov², V.P. Korolkov¹, A.G. Poleschchuk¹

¹ Institute of Automation and Electrometry SB RAS, Novosibirsk, Russia
² VNIITF, Snejinsk, Russia

Wavefront distortion correction in large YAG:Nd active elements is one of key problems for high-power solid-state lasers fabrication. These lasers are applied in wide fields of technological and scientific tasks. Active elements of YAG:Nd crystals are mostly used in high power lasers. Russian industry uses Czochralski crystal growth technology for AE fabrication which allows to get cylindrical rods with optical quality (Strehl ratio >0.9) in diameter of up to 10 mm. Rods with diameter of 20 and 45mm can be also fabricated. However, optical quality still remains at low level. Non-uniformity of refraction index inside AE leads to wavefront distortions. For large crystals non-uniformity starts to be critical and makes impossible its application for lasers. We have measured wavefront quality several YAG:Nd rods with 20 mm diameter by means of Fizeau interferometer. The average quality was less than 0.25λ (RMS) at 633nm wavelength (Fig. 1). It corresponds to Strehl ratio below 0.7. These measurements have demonstrated that direct usage of rods with diameter of 20mm and larger as active elements is not possible.

Fig. 1. Interferogram and phase map of best rod from measured ones. RMS=0.4257 waves.

To compensate the wavefront distortion we designed individual correctors for each AE as conformal optical element which is an optical element with continuous phase function defined by external condition having non-optical nature. In our case the condition is non-uniform refraction index distribution after crystal growth. Laboratory of diffractive optics in IAE SB RAS manufactured the correctors from fused silica plane substrates by half-tone photolithographic technology [1] and reactive ion-plasma etching of fused silica through photoresist mask. Fig. 2 shows the results for three rods compensated with COEs.

Fig. 2. Residual wavefront distortion for three YAG:Nd rods compensated with COEs.

Optical testing of AE with fabricated correctors show that wavefront error was reduced from 0.45λ to 0.025λ (RMS) at the average, and Strehl ratio was increased up to 0.9. Also we have experimentally defined that radiation damage threshold of COE exceeds 10 J/cm² for pulse laser radiation with 1064nm wavelength and 4ns pulse duration.

Thus we have demonstrated that designed and fabricated correctors permit to use 20 mm diameter YAG:Nd crystal rods as active elements for high power pulse lasers.

This study was performed under partial support of interdisciplinary project №112 of Siberian Branch of the Russian Academy of Science, project 24-8 of the program of fundamental researches of Presidium of the Russian Academy of Sciences, and RFBR projects №12-02-00974-a и №12-02-01118-a.