Double Channel Faraday Isolator with Single Optical Element for High-power Unpolarized Lasers

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Abstract—Thermal depolarization in TGG-based Faraday isolator for 2 spatially separated beams was calculated. Depolarization reduced 6.7 times in the slab geometry of the magneto-optical element relative to 1-beam Faraday isolator

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Faraday isolator (FI) is one of the important components of laser systems, but it is one of the optical devices that are most influenced by thermal self-action because of the relatively strong absorption ($\sim 10^3 \text{ cm}^{-1}$) in the magneto-optical elements (MOEs). The absorption-induced nonuniform cross-sectional temperature distribution leads to linear birefringence (photoelastic effect) and transmitted beam wavefront distortions (thermal lensing). These factors limit the maximum working laser power of the FI [1], [2].

With the development of high-power laser systems, such as fiber lasers, disk lasers, there is a need in a Faraday isolator for unpolarized light. Also beams without cylindrical symmetry, with square/rectangular intensity distribution are developed. In such cases no analytical expressions for the depolarization can be obtained.

So a three-dimensional numerical model for thermal depolarization investigation has been developed. It calculates temperature distribution and thermal stresses in the element with the finite element method. Based on this refractive index changes related to the photoelastic effect and depolarization can be calculated.

We calculated and experimentally measured thermally induced depolarization in a scheme of FI for unpolarized light where isolation is provided for the two orthogonal polarizations in one MOE. Depolarization is proportional to squared laser power [3], so if beams are fully separated depolarization is reduced 4 times. In case of propagation of beams in one element

Selection of the optimal distance between beams passing through MOE makes temperature profile more flat that reduces mechanical stresses and therefore reduces thermally induced depolarization. Calculation shows that the additional reduction of the thermally induced depolarization can reach 1.5-2 times.

Experiment and numerical simulation were performed for the following parameters: slab-shaped MOE, with a length of 30 mm, width of 20 mm and height of 8 mm. Beams were 5 mm in diameter (at the level $1/e^2$). The optimal distance between the beams was calculated as 9 mm.

![Fig. 1. Depolarization experimental dependence on power for one beam (circles) and for two beams (circles) in MOE.](image)

![Fig. 2. Temperature distribution (in K) for one beam (a) and for two beams (b) in MOE.](image)

Thus, a model for numerical calculation of depolarization in complex beam profile is created. For "double-channel" FI a possible increase in the degree of isolation 6-8 times relative to traditional FI is shown, it will help to development of unpolarized powerful lasers.

REFERENCES

