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Attainment of a high gain in a disk amplifying stage with neodymium phosphate glass elements

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***Abstract*. An efficient reflecting coating made of a MIRO foil with an oxide layer is fabricated, which enhances the reflection of radiation of pump lamps in the head of a high-power neodymium laser and allows a gain $g_0 = 5 \times 10^{-2}$ cm^{-1} to be achieved.**

Keywords: *neodymium glass laser, disk element, efficient reflector, gain.*

The possibility of obtaining a high output energy density in the NIF [1], LMJ [2], and ISKRA-6 [3] large-scale laser facilities is mainly determined by the energy stored in the active medium, i.e., by the linear gain g_0 of a small signal in power amplifying stages.

Being a continuation of the work [4] devoted to measurements of the small-signal gain and carried out on the LUCh facility, this paper presents the results of experiments on an increase in g_0 due to improving the efficiency of the reflectors in the pump system of the amplifying modules.

We used in the pump system of a high-power laser the 0.5-mm thick MIRO foil coated with an oxide layer, which increased the reflectivity up to 95 % [5]. Apart from the high reflectivity, the MIRO foil is easy to manufacture, inexpensive, and has a long service life, which is important for large-scale laser facilities. Its resistance to radiation from pump lamps ($\tau_p = 350$ μs) was tested with a flat reflector installed at a distance of 8 mm from the pump lamp at operating light fluxes of $\sim 5 \times 10^4$ W cm^{-2}. No appreciable change in the reflectivity in the operating spectral region and no coating sputtering (to an accuracy of ±3 %) were observed in a run of ~300 experiments.

After preliminary tests of MIRO foil samples, the foil was mounted on all of the reflecting elements of the amplifying module and lamp holder (the interlamp rhombic reflectors were also made of the laser-welded MIRO foil). As a result, the measured light flux from the the lamp holder increased by ~15 %.

After the foil had been mounted, the gain in a separate stage was measured. The optical layout of the experiment and the technique of recording and processing the data were similar to those described in Ref. [4].

The gain g_0 was measured when amplifying cw 1.053-μm laser radiation with a beam diameter of 15 mm. The radiation was injected into an amplifier consisting of seven amplifying modules with disk elements (DEs) and, after passing through the amplifier, was focused to an FD256 photodiode, in front of which an interference filter ($\lambda = 1.053$ μm, $\Delta\lambda_{0.5} = 0.05$ μm), an IKS filter, and a frost-glass diffuser were installed. The signal at the amplifier output was recorded by a Tektronix-3052B oscilloscope with a time constant of ~30 ns. The signal gain was determined from oscillograms: $K_0 = U(t)/U_0$, where $U(t)$ is the signal level during pumping and U_0 is the signal level of the cw laser before pumping. The error in determining the gain was within ±2.5 %.

The signal gain was measured as a function of the energy value consumed by the pump lamp and the transverse coordinate of the disk element.

The results of gain measurements obtained after processing the oscillograms are listed in Tables 1 and 2. Figure 1 shows the gain g_0 versus the electric energy E_p supplied to the lamp. The same dependence obtained for the same pump system with reflectors made of polished D-16 duralumin and CT12X18H10T steel is plotted for comparison. As we see, g_0

Table 1. Results of measuring the gain at the DE centre at various pump energies.

Charging voltage/kV	Electric energy supplied to the lamp/kJ	g_0/cm^{-1}
18	5.4	0.037
20	6.7	0.042
22	8.1	0.046
24	9.6	0.050

Table 2. Results of measuring the gain over the DE aperture at a charging voltage of 22 kV ($E_p = 8.1$ kJ).

Distance from DE centre/mm	g_0/cm^{-1}
0	0.046
20	0.045
40	0.044
60	0.045
80	0.044

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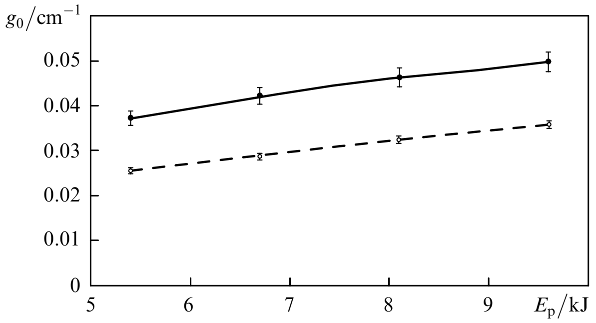

Figure 1. Linear gain g_0 for the centre of the DE as a function of the electric energy supplied to the lamp. The dashed curve is the data from Ref. [4].

has increased by a factor of 1.45 and reached 5×10^{-2} cm^{-1}. Note that the linear dependence $g_0(E_p)$ is still observed for operating pump energies in the range of 5.4–9.6 kJ, which confirms the efficient operation of the cladding applied to the ends of the active element. The high gain $g_0 = 5 \times 10^{-2}$ cm^{-1} was obtained earlier in USA [6, 7] and China [8].

Figure 2 shows the horizontal distribution of the gain g_0 over the disk-element cross section and the dependence of g_0 for previous reflectors [4]. The behaviours of these curves are similar except for the gain, which is ~1.45 times higher for the MIRO reflectors.

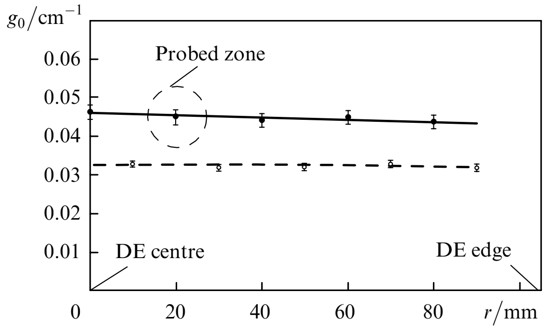

Figure 2. Distribution of the linear gain g_0 over the DE cross section from the centre to the edge (r is the coordinate of the probed zone). The dashed curve is the data from Ref. [4].

Thus, due to the use of more efficient MIRO reflectors ($R = 95\,\%$), the gain in the amplifying modules of the LUCh facility has been increased to 5×10^{-2} cm^{-1}. The gain g_0 depends linearly on the pump energy and is virtually constant over the slab aperture.

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