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A 1.047-μm GLS-23 neodymium phosphate glass amplifier

T.T. Basiev, A.G. Papashvili

***Abstract*. The gain of a GLS-23 neodymium phosphate glass is measured at a wavelength of 1.047 μm of a $Nd^{3+}:YLiF_4$ laser. Linear gains of 0.035 – 0.036 cm^{-1} are obtained for the active rod of length 13 cm pumped by 225 J, which points to the possibility of fabricating high-power lasers at this wavelength.**

Keywords: *neodymium phosphate glass amplifier, gain.*

It is well known [1, 2] that laser phosphate glasses are one of the best solid-state materials used for highly efficient amplification of high-power laser radiation and energy (up to $10^3 - 10^4$ J). Conventionally they are used to amplify radiation from master oscillators operating at the wavelength close to the maximum of the gain band ($\lambda = 1.053$ μm) such as a $Nd^{3+}:YLiF_4$ laser emitting σ-polarised radiation.

However, high-power laser radiation with a longer or shorter wavelength is required for a number of applications of laser physics. Thus, we showed earlier that pumping at 1.047 μm leads to a drastic increase in the gain and efficiency and expands the tuning range of $F^{-2}:LiF$ colour-centre lasers [3, 4].

Pico- and femtosecond terawatt amplifiers [5, 6] have been developed based on wide-aperture $F^{-2}:LiF$ colour-centre crystals for the past few years, in which 1.053-μm GLS-23 glass laser systems are used for high-power nanosecond pumping. The change in the nanosecond pump system from $\lambda = 1.053$ μm to 1.047 μm would allow one to increase substantially the gain and efficiency of pico- and femtosecond $F^{-2}:LiF$ colour-centre amplifiers.

In this paper, we studied the possibility of application of laser phosphate glasses as 1.047-μm amplifiers. As a probe radiation, we used nanosecond π-polarised pulses from a 5–15-mJ, 1.047-μm $Nd^{3+}:YLiF_4$ laser. As an amplifying stage, we used a pump cavity with the active element made of a GLS-23 phosphate glass of diameter 8 mm and length $L = 13$ cm.

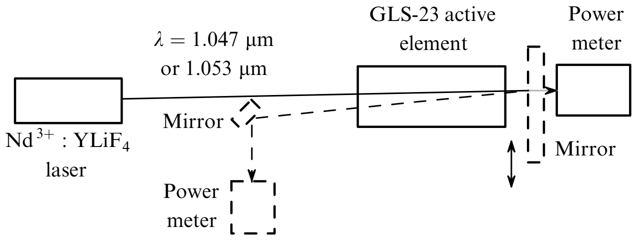

Figure 1. Scheme of the experimental setup for measuring single-pass (solid lines) and double-pass (dashed lines) amplification.

Figure 1 shows the optical scheme for measuring the gain. The gain G was determined as a ratio of the energy $E^*_{\rm pr}$ of a probe pulse propagated through the amplifier during pumping to the energy $E^0_{\rm pr}$ propagated through the amplifier in the absence of pumping, i.e., $G = E^*_{\rm pr}/E^0_{\rm pr}$.

Measurements of the gain of a 1.047-μm or 1.053-μm $Nd^{3+}:YLiF_4$ laser in the single-pass and double-pass schemes were compared. For the constant energy of the probe input nanosecond signal, we obtained a dependence of the output energy $E^*_{\rm pr}$ on the pump energy $E_{\rm pump}$ of the GLS-23 amplifier flashlamp (Fig. 2).

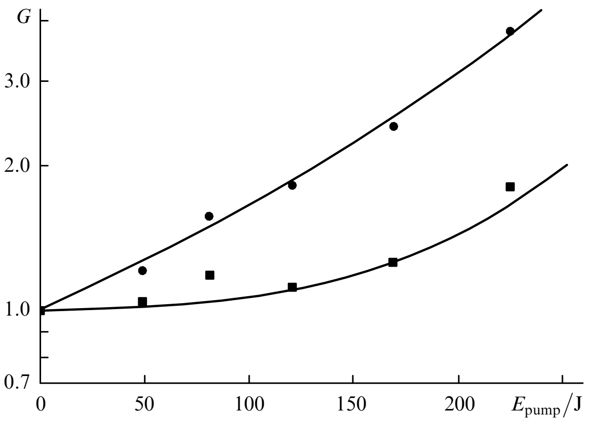

Figure 2. Dependences of the gain of a single-pass amplifier on the energy of the flashlamp pumping the amplifier at 1.047 (■) and 1.053 μm (●).

One can see from Fig. 2 that both at 1.053 μm and 1.047 μm the gain increases nonlinearly depending on the pump energy.

Figure 3 shows the experimental dependences of the energy $E^*_{\rm pr}$ on the energy $E^0_{\rm pr}$ of the probe (nanosecond) pulse for the single-pass amplification for a delay of the probe pulse by 150 μs with respect to the onset of the discharge of a 225-J, 200-μs pump flashlamp.

T.T. Basiev, A.G. Papashvili Laser Materials and Technology Research Center, A.M. Prokhorov General Physics Institute, Russian Academy of Sciences, ul. Vavilova 38, 119991 Moscow, Russia; e-mail: alex@lst.gpi.ru

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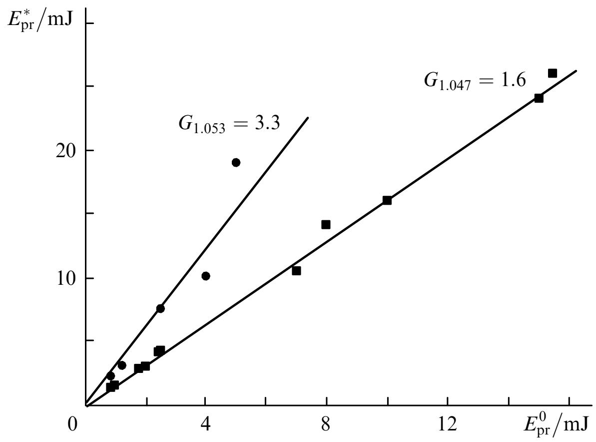

Figure 3. Dependences of the energy E^*_{pr} on the energy E^0_{pr} for a delay of the probe pulses by 150 μs with respect to the onset of the discharge of the pump flashlamp and at 1.047 (■) and 1.053 μm (●).

The gains for radiation at 1.053 ($G = 3.3$) and 1.047 μm ($G = 1.6$) were determined from the obtained data.

The gains G in the double-pass scheme turned to be 10 and 2.5 at 1.053 and 1.047 μm, respectively. The linear gains determined by the expression $K = \ln G/L$ for both cases ($L = 13$ cm for the single-pass amplification and 26 cm for double-pass amplification) coincide and yield 0.089–0.09 cm^{-1} at 1.053 μm and 0.035–0.036 cm^{-1} at 1.047 μm.

The expected gain upon an increase in the length of the amplification channel up to 220 cm (a four-pass GLS-23 glass amplifier with the active element of diameter 40 mm and $L = 55$ cm) can be estimated from the above data. By neglecting nonactive and radiative losses at 1.047 μm, we can expect the gain of about 10^3, which is close to the value obtained in [5] and makes it possible to fabricate a high-power 1.047-μm, 10-J pump laser.

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