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LETTERS TO EDITOR

HIGHLY EFFICIENT Nd:Cr:GSGG LASER WITH SIDE-PUMPING BY SOLAR RADIATION

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Қуёш энергиясини 1 м^2 диаметрли параболик концентратор фокусидаги концентрацияланган қуёш нурланиши оқими ёрдамида оптик дамланганда (накачка қилинганда) самарали иссиқлик тарқалишини таъминлайдиган юпқа пластинка шаклидаги Nd:Cr:GSGG фаол элементи асосида лазер нурланиш энергиясига айлантиришнинг юқори самарадорлигига эришиш имконияти кўриб чиқилди. Тадқиқот лазер тизимининг компьютер симуляцияси ёрдамида амалга оширилди.

Рассмотрена возможность достижения высокой эффективности преобразования солнечной энергии в энергию лазерного излучения на базе активного элемента Nd:Cr:GSGG в виде тонкой пластины, позволяющей обеспечить эффективный теплосъем при поперечной накачке концентрированным солнечным излучением в фокусе параболического концентратора диаметром 1 м^2. Исследование проводилось методом компьютерной симуляции работы лазерной системы.

The possibility of achieving high efficiency of converting solar energy into laser radiation energy on the basis of the active element Nd: Cr: GSGG in the form of a thin slab allowing providing an effective heat output during side pumping by concentrated solar radiation at the focus of a parabolic concentrator with a diameter of 1 m^2 is considered. The study was carried out by computer simulation of the laser system.

In principle, any laser material used in lasers with lump or diode pumping can be used for pumping by concentrated solar radiation. However, at the present time in solar pumped lasers, a few laser materials that meet a certain requirement are mainly used. These are, firstly, laser materials with sufficiently high thermal conductivities that can withstand the thermal load at pumping with a broadband solar spectrum, and, secondly, materials with a sufficiently low pumping threshold, to obtain laser generation under conditions of limited concentration of solar radiation used for pumping. So, while Nd: YAG laser materials are often used due to the relatively high thermal conductivity and low level of the pumping threshold, the Nd:Cr:GSGG laser material (which exceeds by some characteristics such as the best overlap of the absorption spectrum with the solar spectrum, the pumping threshold is lower than in Nd:YAG) is practically not considered for pumping by solar radiation. This is due to the fact that the thermal conductivity of the Nd:Cr:GSGG laser material is almost half of that for Nd:YAG [1]. In this connection, in the paper, the possibility of solving the problem of using Nd:Cr:GSGG was investigated, namely, providing a condition under which effective heat output is carried out, at the

same time, an effective transformation of solar energy into laser radiation energy is occurred.

It is known that in such cases, that is when it is necessary to determine the optimal variant among numerous, and especially when it is difficult to find an analytical solution in the theoretical study, one of the powerful methods is the method of simulating [2-3] the operation of the laser system (modeling of elementary processes that are repeated many times, the laws of which are fairly well known), which allows to significantly reduce the time spent on research and financial costs.

Thus, for solving the problem of Nd:Cr:GSGG associated with a low thermal conductivity, various schemes of the laser system were considered by conducting numerical experiments. One of the optimal design options that meet the above requirements is shown in Fig. 1.

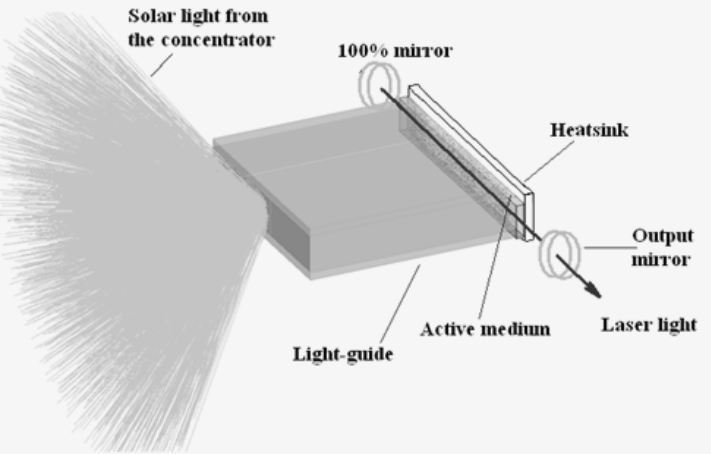


Fig. 1. Schematic picture of solar laser system.

As shown in Fig. 1, concentrated solar radiation in the focus of a solar concentrator with a diameter of 1 m is introduced through an input window 1×1 cm^2 in a metal light guide, a pump chamber, that provides uniform pumping by multiple reflections of the solar radiation inside the pumping chamber. The internal walls of the pump chamber were assumed to be coated with a silver coating, the reflection coefficient of which is about 97%. The working dimensions of the Nd:Cr:GSGG active element are 50×8×2 mm^3. The rear surface was assumed to have silver reflective coating through which heat exchange takes place by a water-cooled heat sink. For thermal contact, special heat-conducting pastes can be used.

For the configuration shown in Fig. 1, a computer simulation was carried out within the framework of the model proposed by us [2, 3] to determine the efficiency of absorption of solar radiation by the active element. The result obtained for the absorption efficiency was 31%. Next, the dynamics of temperature of the active element was calculated by solving the one-dimensional heat equation taking into account the absorption efficiency, the results of which are shown in Fig. 2. The results show that the average temperature of the active element can be maintained below 50°C, which provides a condition for the normal functioning of the laser based on active element Nd: Cr: GSGG.

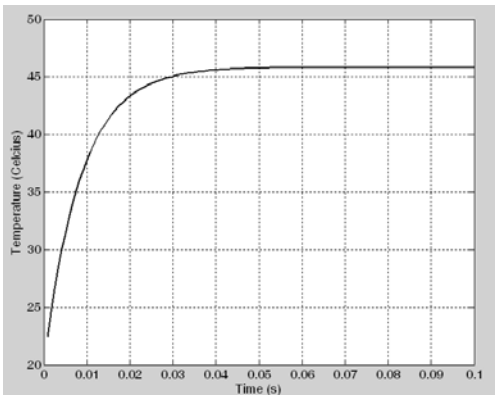


Fig. 2. Dynamics of temperature changes.

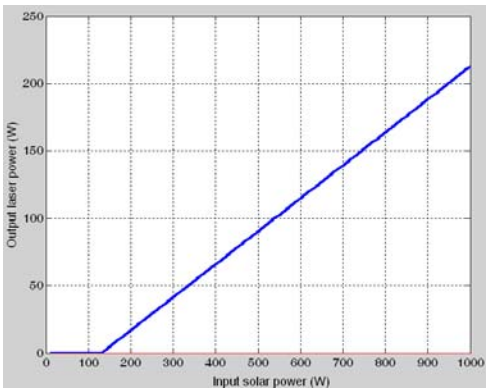


Fig. 3. Output laser power vs. input solar power.

At the next stage, the dependence of the output laser power on the solar power was calculated using the well-known expression for a four-level laser (Fig. 3). The calculations are based on the result for the absorption efficiency and considering the efficiency of energy transfer, which is considered close to 90%.

As the results show, the proposed configuration could significantly increase the laser power by 3-4 times compared to a record power of about 30 W/m^2 [4], obtained up to the present time. Moreover, the proposed configuration could also allow the use of other laser materials having relatively low thermal conductivities and which were considered unsuitable for pumping by concentrated solar radiation.

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