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Letter to the Editor

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Dependence of beam divergence of $Nd^{+3}:POCl_3:ZrCl_4$ inorganic liquid laser on optical pumping and resonator configuration

The laser beam quality is the important factor influencing the practical application of pulsed neodymium lasers to material processing, and to high power amplifier systems. It has been shown, that the thermal effects in the active medium caused by optical pumping result in serious deterioration of laser beam quality, especially in the high energy pumping level [1].

Thermal effects create serious problems also inorganic liquid lasers based on neodymium dissolved in $POCl_3$:$ZrCl_4$. Although these lasers are of great interest in application when high power light sources are desirable, their practical use, however, limited by the poor output beam quality jointly with highly toxic and corrosive properties of solvent.

The inorganic liquid lasers have been studied extensively [2–3], but the properties of output beam obtained from these lasers have never been properly examined.

In this letter we present the experimentally observed dependence of beam divergence of inorganic liquid laser on resonator configuration and optical pumping.

The laser head consisted of glass cell (165 mm long, 10 mm internal diameter) filled with active medium, and two linear xenon flashlamps enclosed in double elliptical chromium plated reflector. Heating of the active liquid by UV radiation from flashlamps was reduced by means of two yellow glass filters. The laser head was air cooled. Further details concerning laser design and properties of laser liquid may be found in our previous works [4, 5].

Resonator was formed by two external plane-parallel or spherical dielectric mirrors. The far field patterns were recorded on ORWO type I 1050 infrared sensitive plates using Exacta VX 1000 camera equipped with long focal length telephoto lens (C. Zeiss Orestegor, 500 mm focal length). The reduction of laser beam energy was accomplished by appropriate number of calibrated neutral density filters. The full width of beam divergence was obtained from densitometer traces of far field patterns recorded on photographic plates.

Plane parallel mirrors being most frequently used in the design of inorganic liquid lasers, almost all published data on performance of these lasers refer to such a resonator configuration.

In our experiments, the plane parallel resonator was formed by two dielectric plane mirrors having reflectivities of 99.9% and 66%, spaced by 500 mm. Very irregular far field patterns observed were independent of length of pumping pulse and varied between 100 μs — 600 μs. Associated beam divergence estimated to be about 2 mrad at threshold increased to about 25 mrad with pumping level increasing to quadrupled threshold pumping energy. Such behaviour indicates that the measure of beam divergence is determined exclusively by thermal effects n the active medium. During the pumping pulse, the surface becomes hotter than the centre of rod-like column of liquidt which acts as a weakly diverging lens having the time dependen, focal length.

In such conditions, beam spot shape varies strongly from shot to shot, depending on thermal gradients present in active liquid.

Most experiments were run with spherical mirrors with equal radius of curvature R ($R_1 = R_2 = 2$ meters). In this case, the strong dependence of beam quality and resulting beam divergence on length of pumping pulse was observed.

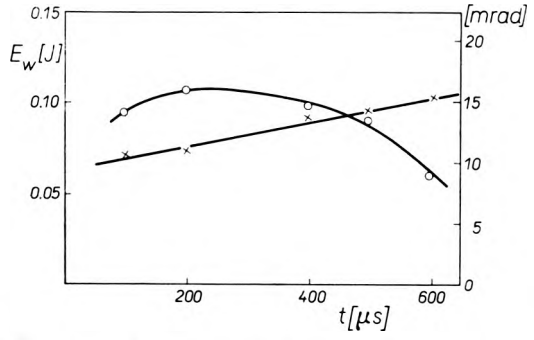

Fig. 1. Dependence of output energy (o) and beam divergence (x) on length of pumping pulse. Spherical resonator

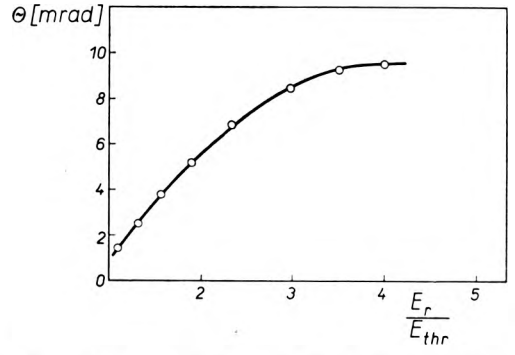

Fig. 2. Dependence of beam divergence on normalized pumping energy

In fig. 1 we present the dependence of output energy and beam divergence on length of pumping pulse of constant energy equal to quadrupled threshold pumping energy. Resonator length was equal to 0.65 m. As it can seen, shortening of pum-

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ping pulse results in a marked increase of energy density in output laser beam.

The dependence of laser beam divergence on pumping energy for 100 μs pumping pulse (full width at half maximum) is presented in fig. 2.

Reduction of pumping pulse length and pumping energy enables the observation of pure transverse modes structure in the far field patterns.

Results presented indicate that the poor beam quality of inorganic liquid lasers with plane parallel mirrors results exclusively from thermal effects in active medium. These effects can be reduced by the use of spherical resonator, the configuration of which should be matched to energy and length of pumping pulse.

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