High Energy 3450-4150 nm Fe:ZnS Laser

P.N. Lebedev Physical Institute, Russian Academy of Sciences
Moscow, Russia
podmarkov@sgi.lebedev.ru

Abstract—As high as 2.7 J of output energy at 3600 nm with 44% absorbed pump energy slope efficiency was demonstrated from Fe:ZnS laser operating at 85 K. With an intracavity prism, the Fe:ZnS laser was tuned from 3450 to 4150 nm.

Keywords—Fe:ZnS laser, tunable solid state lasers

I. INTRODUCTION

Tunable lasers operating in the spectral regions of mid-infrared atmospheric windows are of great interest for solving numerous scientific and applied problems. Divalent transition metal doped II-VI compounds are promising materials for tunable lasers of 2000-6000 nm spectral region [1]. In particular, the output spectrum of Fe:ZnSe laser has been tuned from 3770 to 4400 nm at liquid nitrogen temperature and from 3950 to 5050 nm at room temperature [2-3]. In our previous study Fe:ZnSe laser with the output energy as high as 2.1 J has been reported [4].

Iron doped ZnS is alternative material for this spectral region possessing higher thermal conductivity and lower dn/dT as compared with ZnSe. Tuning range of Fe:ZnS laser from 3490 to 4650 nm and output energy of 3.4 mJ have been demonstrated at room temperature [5]. In this paper we report the results of study of high energy Fe:ZnS laser operating at low temperature.

II. EXPERIMENTAL

In this study, 17 mm thick and 20 mm in diameter Fe:ZnS single crystal was grown from a vapor phase using seeded chemical vapor transport (SCVT) growth technique. The homogeneous doping by divalent iron ions was achieved straightforwardly during the crystal growing [1]. Working surfaces of the crystal were polished and parallel to within 30 sec of arc. The crystal was not antireflection coated for the pump or laser wavelengths.

A 2936 nm free-running flash lamp pumped Er:YAG laser was used as an excitation source. Pump beam was focused onto the crystal by the 75-cm-radius mirror into the spot size of 5 mm in diameter (FWHM). The Er:YAG laser produced 750-μs pulses consisting of ~0.5-μs irregular spikes with overall output energy up to 12 J. The Fe:ZnS crystal was pumped at a small angle to the cavity axis in a 45-cm-long cavity consisting of a spherical (R=100 cm) aluminum total reflector and a flat output coupler transmitting 71-75% in the 3.4-4.2 μm spectral range. The crystal absorbed 70% of pump radiation.

The Fe:ZnS crystal was placed inside a liquid nitrogen cryostat. For wavelength tuning experiments a Brewster cut CaF2 prism was inserted in the modified cavity with the 50-cm-radius-of-curvature aluminum total reflector.

III. RESULTS AND DISCUSSION

The Fe:ZnS laser characteristics were studied at temperature of 85K. The threshold absorbed pump energy was as low as 0.9 J. The output energy demonstrated linear growth with slope efficiency of 44% for all pump energy levels. The highest output energy value of Fe:ZnS laser was 2.7 J at 6.9 J of absorbed pump energy.

The free-running Fe:ZnS laser spectrum was located in the region from 3520 to 3650 nm. With the prism, continuous tuning was obtained in the spectral range from 3450 to 4000 nm. The longest wavelength (4150 nm) was achieved by using output coupler with transmission of 20% at this wavelength.

We achieved as much as 2.7 J out of Fe:ZnS laser with 24% real optical-to-optical efficiency (with respect to total pump energy). We believe the real efficiency of Fe:ZnS laser can be improved by using Fe:ZnS crystal with higher concentration of divalent iron and antireflection coating of the surfaces.

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REFERENCES


