

# Wide tunable BaGa<sub>4</sub>Se<sub>7</sub> optical parametric oscillator pumped by Nd:YLF laser

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**Abstract**—BaGa<sub>4</sub>Se<sub>7</sub> optical parametric oscillator (OPO) pumped by compact nanosecond Nd:YLF laser was demonstrated. Wide tuning range from 2.93 up to 9.3 μm is shown for the first time of our knowledge.

**Keywords**—Optical parametric oscillator, mid-infrared region

## I. INTRODUCTION

BaGa<sub>4</sub>Se<sub>7</sub> is perspective crystal as a nonlinear medium for MID-IR application. BaGa<sub>4</sub>Se<sub>7</sub> exhibits significantly larger NLO coefficients and wider middle IR transparent range than newly studied IR NLO material BaGa<sub>4</sub>S<sub>7</sub> [1-4]. Picoseconds BGSe optical parametric amplifier (OPA) was presented by F. Yang, J. Y. Yao and coworkers at [5]. Recently we demonstrated an OPO based on tandem of two HgGaS<sub>2</sub> (HGS) crystals with wide tuning range 4.2-10.8 μm [6]. At the present work, we demonstrate BaGa<sub>4</sub>Se<sub>7</sub> optical parametric oscillator (OPO) with a single element at the OPO cavity, pumped by the compact nanosecond Nd:YLF laser at 1053 nm. The OPO has spectral tuning range from 2.93 up to 9.30 μm.

## II. EXPERIMENT

Two BaGa<sub>4</sub>Se<sub>7</sub> (BGSe) elements were cut from the same boule with the next orientation:  $\theta=45^\circ$ ,  $\phi=0^\circ$  (ee-o) for the first sample and  $\theta=45^\circ$ ,  $\phi=90^\circ$  (oe-o) for the second one. The antireflection coating (single layer with  $T_{\max}@1.5 \mu\text{m}$ ) was performed to reduce the losses at the cavity of OPO. Special thin BGSe plates were prepared for investigation of optical damage threshold, more the less, the plates were oriented at the same way as the working samples ( $\theta=45^\circ$ ,  $\phi=90^\circ$ ). The damage threshold at the wavelength of Nd:YLF laser has occurred at  $2.1\text{-}2.4 \text{ J/cm}^2$  with the pulse duration of 10-15 ns for repetition rate 100-150 Hz. The optical parametric oscillator based on BGSe nonlinear crystal pumped by the compact nanosecond (10-15 ns) Nd:YLF laser at 1.053 μm is demonstrated for the first time of our knowledge. Extremely wide tuning range of BGSe-OPO (2.93 -9.30 μm) was reached by using of single element at the OPO cavity It becomes

possible by applying of original combination method of  $\theta$ -tuning with X- adjustment correction of nonlinear element at the cavity. The idler energy amounted to approximately 4-10 μJ at 4-5 μm, 2-4 μJ at 5-8 μm and 0.5-1 μJ at 9-10 μm at the pump level of 600 μJ. We have also demonstrated a BGSe optical parametric oscillator with the second element  $\theta=45^\circ$ ,  $\phi=90^\circ$  (oe-o). The tuning range was 5-5.4 μm, and the phase matched angles were  $\theta=33\text{-}36^\circ$ . It was no oscillation at normal incident ( $\theta=45^\circ$ ,  $\phi=90^\circ$ , oe-o) what is confirmed by [1-2]. Now the work in progress: change the pump laser to a Nd:YAG LQ215 (20Hz, 180 mJ, 5-10 ns) for demonstration of idler-pump energy dependence. This work was performed by financial support of “Special technology LTD” and the Program 5-100 of Russian ministry of science and education from NSU.

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