$Er,Yb:GdAl_3(BO_3)_4$ Laser Passively Q-switched by MBE-grown Cr:ZnS Thin Films

K.N. Gorbachenya[1], V.E. Kisel[1], A.S. Yasukevich[1], N. Tolstik[2], E. Karhu[2], V. Furtula[2], E. Sorokin[3], V.V. Maltsev[4], N.I. Leonyuk[4], A. Galinis[5], T. Lipinskas[5], U. Gibson[2], I.T. Sorokina[2], and N.V. Kuleshov[1]

1. Center for Optical Materials and Technologies, Belarusian National Technical University, 65/17Nezavisimosti Ave., Minsk, Belarus

2. *Department of Physics, Norwegian University of Science and Technology, Høgskoleringen 5, N-7491 Trondheim, Norway*

3. *Photonics Institute, Vienna University of Technology, Gusshausstrasse 27/387, A-1040 Vienna, Austria*

4. *Department of Crystallography and Crystal Chemistry, Moscow State University, 119992 GSP-2 Moscow*

5. *UAB «Optogama», Mokslininku str. 2A, 08412, Vilnius, Lithuania*

Q-switched erbium lasers emitting in the 1.5-1.6 µm spectral region are widely used in laser rangefinders and LIBS systems.These applications require compact and low-cost sources of laser pulses with high average output power. Passive Q-switching is one of the most simple and reliable method to achieve the abovementioned requirements. $Er,Yb:GdAl_3(BO_3)_4$ (Er,Yb:GdAB) crystal was shown to be an efficient laser material for the 1.5-1.6 µm spectral range [1]. Recently a passively Q-switched Er,Yb:GdAB laser was demonstrated with $Co^{2+}:MgAl_2O_4$, graphene and SWCNT saturable absorbers [2-4]. Here we report Er,Yb:GdAB laser passively Q-switched by using of MBE-grown Cr:ZnS thin films.

Thin films of Cr-doped ZnS were deposited using the high purity materials (99.999% purity) in the UHV MBE deposition system at base pressure of ~$4x10^{-9}$ Torr and thermal evaporation. As a result high-quality polycrystalline films transparent through the visible and infrared regions were obtained. Film thickness was kept in the range of 2 to 10 µm with Cr content varied from 0.01 to 3 at.%.The Er(1 at.%),Yb(11 at.%):GdAB crystal was obtained by dipping seeded high-temperature solution growth. The laser cavity consisted of pump mirror (PM) (R>99.5% at 1522 nm and T>95% at 976 nm) deposited onto external side of the 1.0-mm-thick active element (AE) and a flat output coupler (OC) with transmission of 9% at 1522 nm. As a saturable absorber (SA) – 8.8-µm-thick Cr(0.11 at.%):ZnS film with initial transmission of 98.4% at 1522 nm deposited on a 1-mm-thick sapphire substrate was used. The minimal geometrical cavity length was 4 mm, that was limited by the design of the active element cooling system. The setup for laser experiments is schematically shown in Fig. 1. Stable passively Q-switched mode of laser operation was obtained with maximum average output power of 0.39 W at 1522 nm and TEM_{00} mode (M^2<1.5) spatial profile of the output beam. Laser pulses with energy of 9.2 µJ and duration of 8 ns were obtained at a repetition rate of 42 kHz when the incident pump power was 5 W. The oscilloscope traces of single Q-switched pulse and corresponding pulse train are shown in Fig. 2.

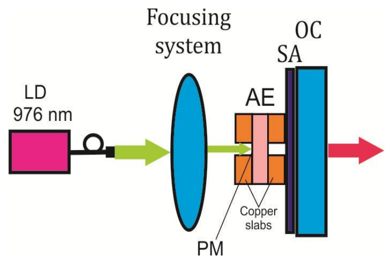

Fig. 1 Setup for laser experiments

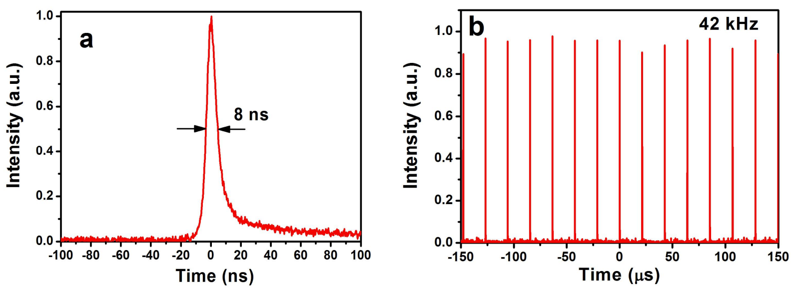

Fig. 2 Output pulses of the Er,Yb:GdAB passively Q-switched laser. (a) Single pulse with width of 8 ns; (b) pulse train with repetition rate of 42 kHz

In conclusion, passively Q-switched Er,Yb:GdAB laser with MBE-grown Cr:ZnS thin film saturable absorber was demonstrated for the first time to our knowledge. Optimization of the Cr^{2+} concentration and film thickness will result in better laser performance. Moreover, important technological aspect is that MBE growth technique allows deposition of the Cr:ZnS saturable absorber film directly onto the active crystal, thus demonstrating approach to fully integrated microchip laser emitting in the 1.5-1.6 µm spectral region.

References

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