Femtosecond Alexandrite Laser with InP/InGaP Quantum-Dot Saturable Absorber

S. Ghanbari [1], K.A. Fedorova [2], A.B. Krysa [3], E.U. Rafailov [2], A. Major [1]

[1] Department of Electrical and Computer Engineering, University of Manitoba, Winnipeg, R3T 5V6, Canada

[2] School of Engineering & Applied Science, Aston University, Birmingham, B4 7ET, UK

[3] EPSRC National Centre for III-V Technologies, University of Sheffield, Sheffield S1 3JD, UK

***Abstract* - A semiconductor saturable absorber mirror (SESAM) passively mode-locked Alexandrite laser was demonstrated. Using an InP/InGaP quantum-dot saturable absorber mirror, pulse duration of 380 fs at 775 nm was obtained. The laser was pumped at 532 nm and generated 295 mW of average output power in mode-locked regime with a pump power of 7.3 W. To the best of our knowledge, this is the first report of a passively mode-locked Alexandrite laser using SESAM in general and quantum-dot SESAM in particular.**

Keywords - solid-state laser; Alexandrite; saturable absorber; mode locking.

I. Introduction

Ti:sapphire is the most commonly used tunable vibronic laser crystal that directly generated a few cycle optical pulses. Unfortunately, Ti:sapphire lasers suffer from low efficiency and high cost. On the other hand, Alexandrite is another vibronic laser crystal that has wide (~100 nm) wavelength tuning range, high thermal conductivity, large στ product, highly polarized output radiation and broad absorption bands that can be used for direct pumping with visible laser diodes [1,2]. Despite these advantages, no femtosecond mode locking of Alexandrite was demonstrated to date with a semiconductor saturable absorber mirror (SESAM). It is the most popular method to produce ultrashort pulses because it does not require critical cavity alignment that is needed in KLM lasers [3-6]. Therefore, the extension of SESAM mode locking to Alexandrite is a promising alternative that can pave the way to development of multi-Watt femtosecond sources. In this respect, quantum-dot SESAMs (QD-SESAMs) are particularly attractive for generation of ultrashort pulses [7-9]. In this work we report on the first passively mode-locked Alexandrite laser using an InP/InGaP QD-SESAM. This results open the way for the development of efficient ultrashort pulse Alexandrite lasers that can rival the currently used Ti:sapphire lasers.

II. Experimental setup and results

The experimental setup used a standard 5-mirror cavity [6]. The Brewster-cut Alexandrite crystal was 7 mm in length and doped with 0.155% of Cr. The crystal was pumped at 532 nm with a maximum power of 7.3 W. The pump was focused into a ~45 μm spot size diameter inside the crystal by a 150 mm focal length lens. About 85% of the pump power was absorbed in the crystal. The cavity contained the InP/InGaP QD-SESAM which was used as one of the plane end mirrors. Previously, the QD-SESAM used in this work was tested with Ti:sapphire lasers [7]. The beam diameter on the QD-SESAM was ~171 μm. Two SF10 prisms separated by 345 mm were used to compensate for the positive intracavity dispersion. The output coupler had 3% transmission.

The used QD-SESAM shifted the Alexandrite emission wavelength from the typical 755 nm to longer wavelengths. Reliable mode locking with an average output power of 295 mW at the incident pump power of 7.3W was achieved. Pulses as short as 380 fs in duration were produced with 1.8 nm wide (FWHM, full width at half maximum) spectrum centered at 775 nm that indicated a time-bandwidth product of 0.341. The fluence on the saturable absorber was about 535 μJ/cm^2. The autocorrelation trace of the pulses and the corresponding spectrum are displayed in Fig. 1. Considering the repetition rate of ~79.9 MHz, pulses had energy of ~3.7 nJ and peak power of >9.5 kW. The laser operated in the fundamental transverse mode.

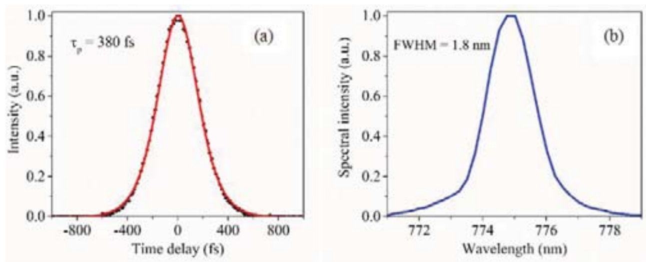

Fig. 1. Measured (a) autocorrelation and (b) spectrum of the generated pulses.

In conclusion, a passively mode-locked Alexandrite laser using an InP/InGaP QD-SESAM with pulse duration of 380 fs was demonstrated. Extension to diode pumping and careful dispersion management should lead to the generation of even shorter pulses with multi-Watt average powers that will be attractive for various applications including ultrafast spectroscopy and nonlinear microscopy [10].

III. References

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