Gigahertz repetition rate dual-wavelength mode-locking of waveguide lasers with graphene

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Over the last few years much attention is paid to the development of high repetition rate (over 1 GHz) ultrafast lasers. These lasers are important for applications in telecommunications, frequency metrology and in fundamental physics. There are different approaches to achieve generation of ultrashort pulses with GHz repetition rates such as passive and active mode-locking of bulk or fiber solid-state lasers, semiconductor waveguide lasers and VCSELs. However, one of the simplest and compact design of mode-locked lasers with GHz repetition rate is based on a short plane parallel mirrors cavity, completely or almost completely filled with gain medium, containing saturable absorber, which provides passive mode-locking[1], [2]. An important condition for achievement of a stable mode-locking regime is operation in a fundamental transversal mode (TEM 00).

Here we report an approach to build-up compact ultrafast lasers with gigahertz repetition rate based on the use of single-layer graphene saturable absorber mirror (GSAM) as the output coupler in waveguide solid-state laser. The stability of self-starting mode-locking can be efficiently controlled by applying the appropriate waveguide geometry[3], while the output lasing parameters and the repetition rate of ultrashort pulses can be precisely controlled by adjustment the gap between the active medium and the GSAM. In particular, due to very efficient coupling of pump light in the waveguide cavity and wavelength insensitive properties of graphene we demonstrate the possibility to achieve synchronous mode-locking at two or more central wavelengths using the same GSAM. We also demonstrate the applicability of the developed laser as a tunable master-oscillator for fiber-based amplified laser systems and achieved 530 mW output power using Yb-doped fiber amplifier.

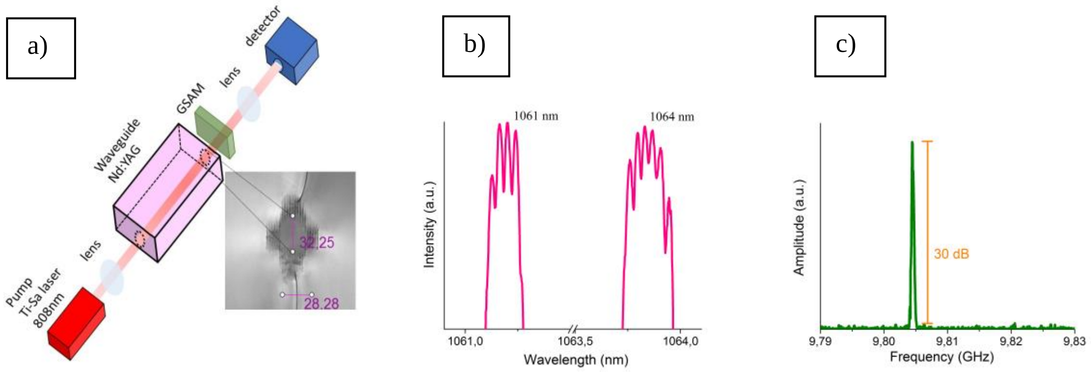

Fig.1. (a) The scheme of the waveguide Nd:YAG laser and obtained optical (b) and RF spectra (c)

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