Pulsed laser Q-switched by graphene on silicon waveguide and ultra-low self-start threshold power realization

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Abstract

Statement of the Problem: Ultra-low self-start threshold power for Q-switch or mode-locking is of great importance in achieving compact pulsed laser sources with ultra-low power consumption for sensing and ranging. Saturable absorbers (SAs) with low saturable threshold is the critical factor. It's natural to reduce the mode area to obtain high power density and decrease self-start threshold power which makes the silicon waveguide with transferred SAs the perfect choice. However the two-photon absorption (TPA) along with free carrier absorption existing in silicon waveguides would compete with the saturable absorption. Moreover, the traditional SAs transfer method, full-cover transfer, results in high intracavity loss and fixed modulation depth. Methodology & Theoretical Orientation: To weaken competitions between TPA and saturable absorption, a patterned transfer technique is used that the length of SAs on chip is precisely controlled by PMMA layer spin-coating and O_2 plasma reactive ion etching which following the common wet-transfer method. Thus, intracavity loss and modulation depth is controlled so that the power needed to trigger saturable absorption is decreased and the TPA effect is reduced. In our experiments, the graphene as a kind of maturely studied SAs with a precise controlled length 87.4μm is transferred on a TE mode silicon waveguide. Then we build a fiber laser circuit. Findings: At wavelength 1.55μm, Q-switch operation by SAs on silicon waveguide is firstly realized. Furthermore, the power triggering saturable absorption is calculated to be as low as 0.1mW which is two order of magnitude lower than reports before. Conclusion & Significance: Patterned transfer techniques is found critical and firstly utilized for pulse generating. Pulsed laser Q-switched by SAs on chip is firstly demonstrated. In addition, self-start threshold power as low as 0.1mW is reported which is potential in realizing compact pulsed laser sources with ultra-low power consumption for sensing and ranging.

Image

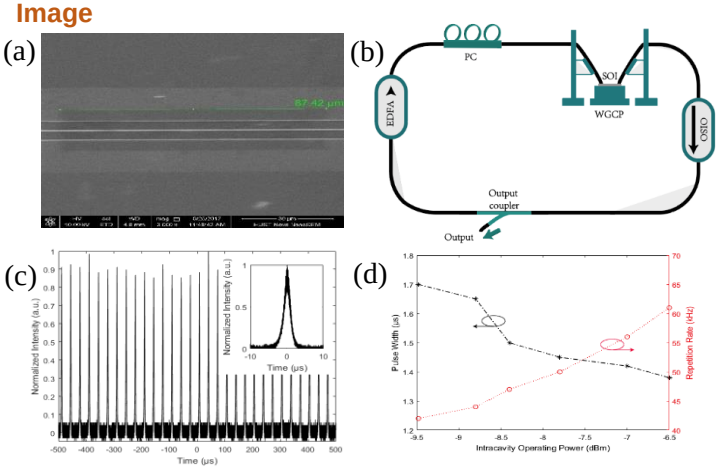
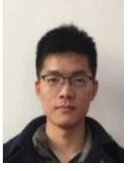


Figure 1: (a) SEM image of the prepared SA on silicon waveguide. (b) Q-switch experiment setup. OISO denotes optical isolator and WGPC represents waveguide-coupling platform. (c) Q-switch pulse train. Insert: single pulse in 20 μs span. (d) Repetition rate and pulse duration of pulse train versus calculated power running through silicon waveguide.

Recent Publications

1. Chen H, Corboliou V, Solntsev AS, Choi DY, Vincenti MA, Ceglia DD, et al. (2017) Enhanced second-harmonic generation from two-dimensional mose2 on a silicon waveguide. Light Science & Applications 6:e17060.
2. Martinez A, Sun Z (2013) Nanotube and graphene saturable absorbers for fibre lasers. Nature Photonics 7:842-845.
3. Cheng Z, Tsang HK, Wang X, Xu K, Xu JB (2013) In-plane optical absorption and free carrier absorption in graphene-on-silicon waveguides. IEEE Journal of Selected Topics in Quantum Electronics 20:43-48.
4. Tien EK, Yuksek NS, Qian F, Boyraz O (2007) Pulse compression and mode-locking by using TPA in silicon waveguides. Optics Express 15:6500.
5. Yin L, Agrawal GP (2007) Impact of two-photon absorption on self-phase modulation in silicon waveguides. Optics Letters 32:2031.



Biography

Shaodong Hou has his expertise in ultra-fast pulse lasers and nonlinear optics. He is now working for his doctorate in Huazhong University of Science and Technology. For years, he has been focusing on novel photonic device for pulsed laser to achieve better performance and find new applications.

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Notes/Comments: