Pinghua TANG, Mulin LUO, Ting ZHAO, Yuliang MAO, 2021. Generation of noise-like pulses and soliton rains in a graphene mode-locked erbium-doped fiber ring laser. *Frontiers of Information Technology & Electronic Engineering*, 22(3):303-311. https://doi.org/10.1631/FITEE.2000372

Generation of noise-like pulses and soliton rains in a graphene mode-locked erbium-doped fiber ring laser

Key words: Erbium-doped fiber lasers; Graphene; Saturable

absorption; Passive mode-locking

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Motivation

- 1. The recent reports of the mode-locked fiber laser focus mainly on a single operation state, that is, noise-like pulse regime or soliton rain regime.
- 2. Compared to the single operation state, lasers that can switch between noise-like pulses and soliton rains have more advantages.
- 3. Systematically investigating the switching process between noise-like pulses and soliton rains in the same laser is beneficial for understanding nonlinear pulse dynamics in ultrafast optics.

Main idea

- 1. A graphene saturable absorber with excellent nonlinear optical properties is fabricated.
- 2. An erbium-doped ring fiber laser is designed and the fabricated graphene saturable absorber is used to modulate the fiber laser to generate the mode-locked pulse.
- 3. Dynamic generation processes of the noise-like pulses and soliton rains in the graphene mode-locked erbium-doped fiber ring laser are observed and investigated.

Method

- 1. A graphene saturable absorber is fabricated and its polarization-dependent saturable absorption is characterized via a balanced twin-detector measurement technique.
- 2. A graphene-based erbium-doped mode-locked ring fiber laser is designed to generate noise-like pulses and soliton rains.

Major results

Graphene mode-locked erbium-doped fiber laser

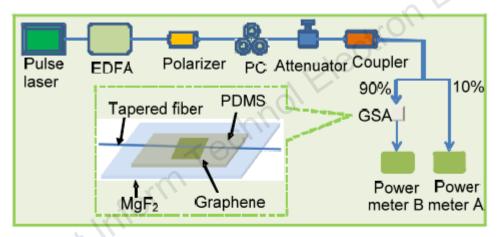


Fig. 1 Measurement of polarization-dependent absorption of the graphene saturable absorber (GSA)

Insert is the structure of the tapered fiber based GSA. EDFA: erbium-doped fiber amplifier; PC: polarization controller; PDMS: polydimethylsiloxane

Major results (Cont'd)

1. Test results of the noise-like pulse state

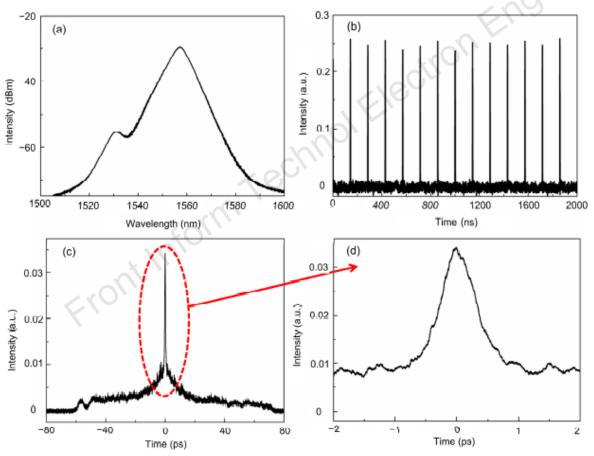
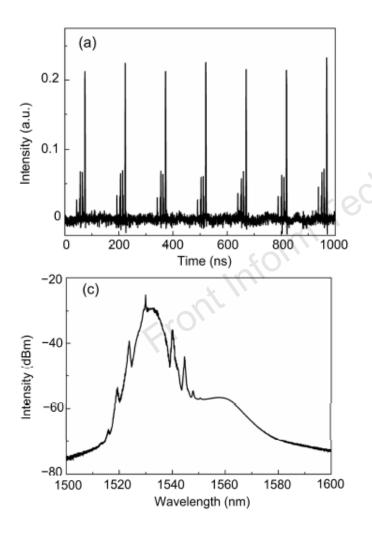


Fig. 5 Characteristics of the graphene saturable absorber mode-locked erbium-doped fiber laser operating in a noise-like pulse state: (a) optical spectrum; (b) output pulse train; (c) autocorrelation trace; (d) magnified autocorrelation trace in (c)

Major results (Cont'd)

3. Test results of soliton rains



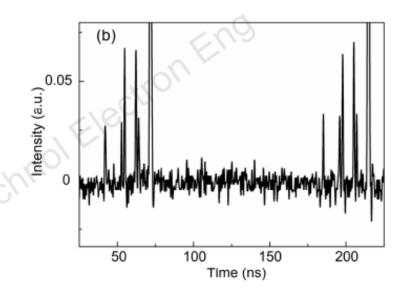


Fig. 3 Output characteristics of the soliton rains: (a) output pulse train; (b) magnification of the pulse train; (c) optical spectrum

Conclusions

- 1. Various mode-locked pulse states, including noise-like pulses, soliton rains, and the particular mode-locking at different wavelengths, have been observed and studied in a mode-locked fiber laser based on the graphene saturable absorber.
- 2. Based on the experimental results on different soliton operations, the soliton interaction induced by the large cavity loss, total dispersion, and soliton-soliton attraction induced by the graphene saturable absorber has been illustrated.