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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

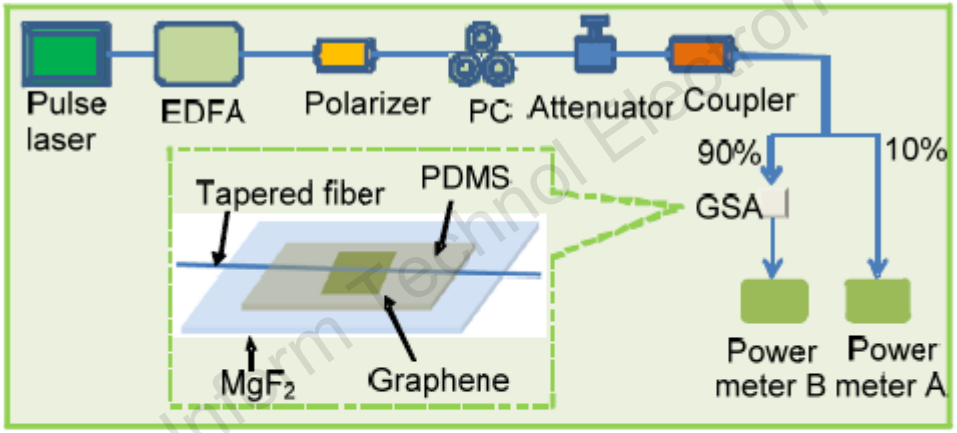

Fig. 1 Measurement of polarization-dependent absorption of the graphene saturable absorber (GSA)
Insert is the structure of the tapered fiber based GSA. EDFA: erbium-doped fiber amplifier; PC: polarization controller; PDMS: polydimethylsiloxane

Major results (Cont'd)

1. Test results of the noise-like pulse state

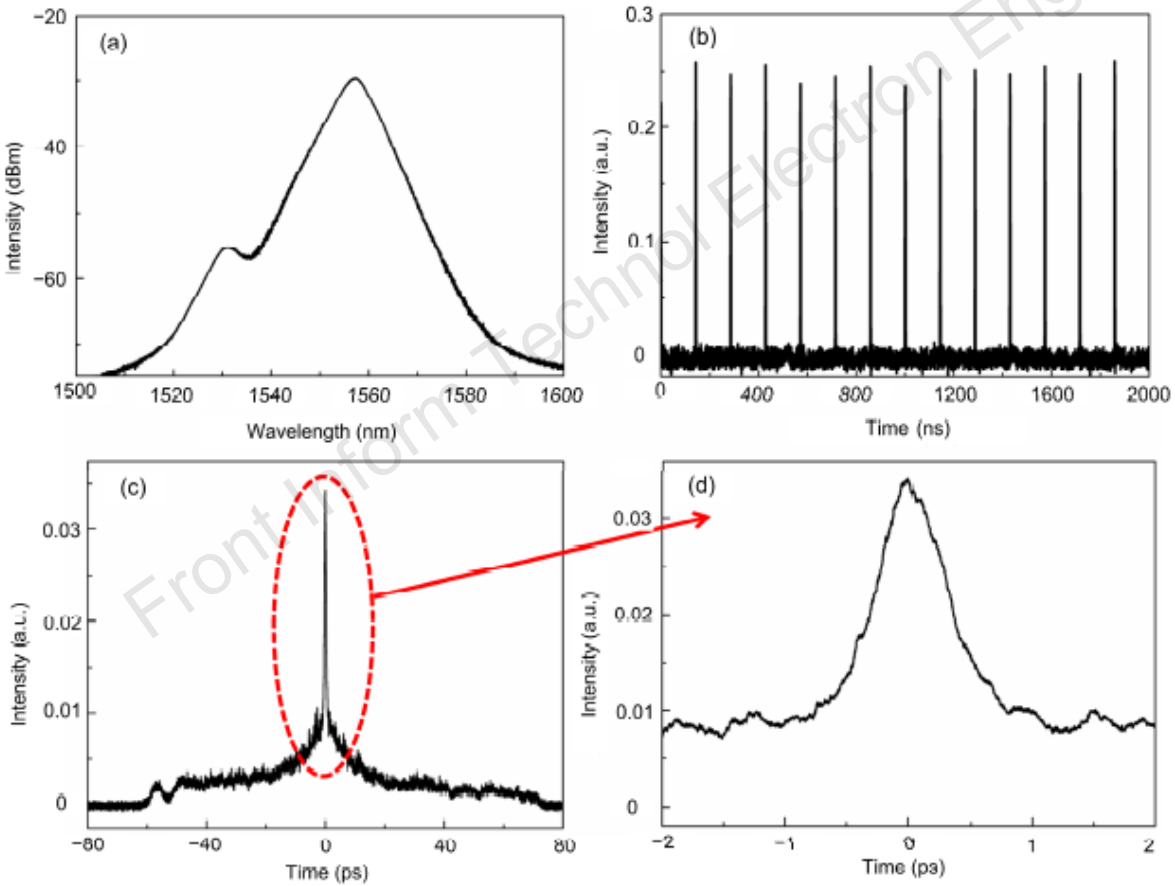

Fig. 5 Characteristics of the graphene saturable absorber mode-locked erbium-doped fiber laser operating in a noise-like pulse state: (a) optical spectrum; (b) output pulse train; (c) autocorrelation trace; (d) magnified autocorrelation trace in (c)

Major results (Cont'd)

3. Test results of soliton rains

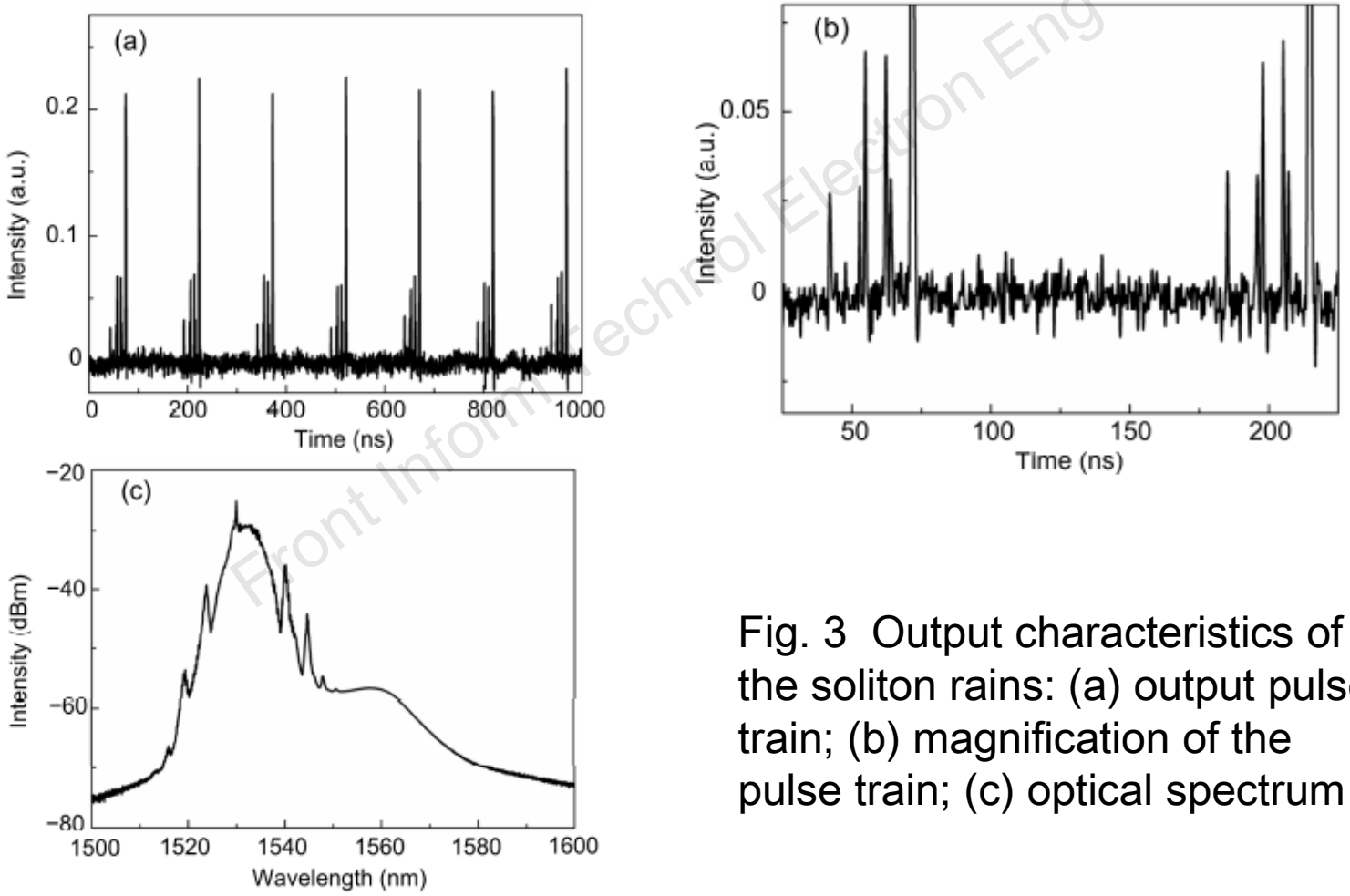

Fig. 3 Output characteristics of the soliton rains: (a) output pulse train; (b) magnification of the pulse train; (c) optical spectrum

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.