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Sb_2Te_3 topological insulator for 52 nm wideband tunable Yb-doped passively Q-switched fiber laser

Key words: Topological insulator; Sb_2Te_3; Fiber laser; Passive Q-switching laser; Wavelength-tunable laser

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Motivation

1. Owing to their excellent nonlinear optical characteristics, tunable energy bandgap, and easy processing, various two-dimensional (2D) and quasi-2D materials have become popular choices as modulators in optical devices and pulse fiber laser generation in the past few years.
2. As a typical topological insulator that possesses saturable absorption and giant third-order nonlinearity characteristics, Sb_2Te_3 has also been widely investigated for pulsed laser.
3. Wavelength-tunable laser sources have attracted a lot of attention due to the pressing need in spectroscopy, optical communication, biomedical science, and other fields. Wavelength-tunable Q-switched fiber lasers based on various 2D saturable absorber (SAs) have been widely investigated, but most of them operate at the 1.5 μm region.

Main idea

1. Synthesize high-quality Sb_2Te_3 crystal.

2. Prepare Sb_2Te_3 SA for generating pulse laser.

3. The Sb_2Te_3 SA was introduced into the laser ring cavity. A wideband tunable Yb-doped passively Q-switched fiber laser could be realized with the help of a wavelength-tunable filter.

Method

1. High-quality Sb_2Te_3 crystals were synthesized via the flux zone method.

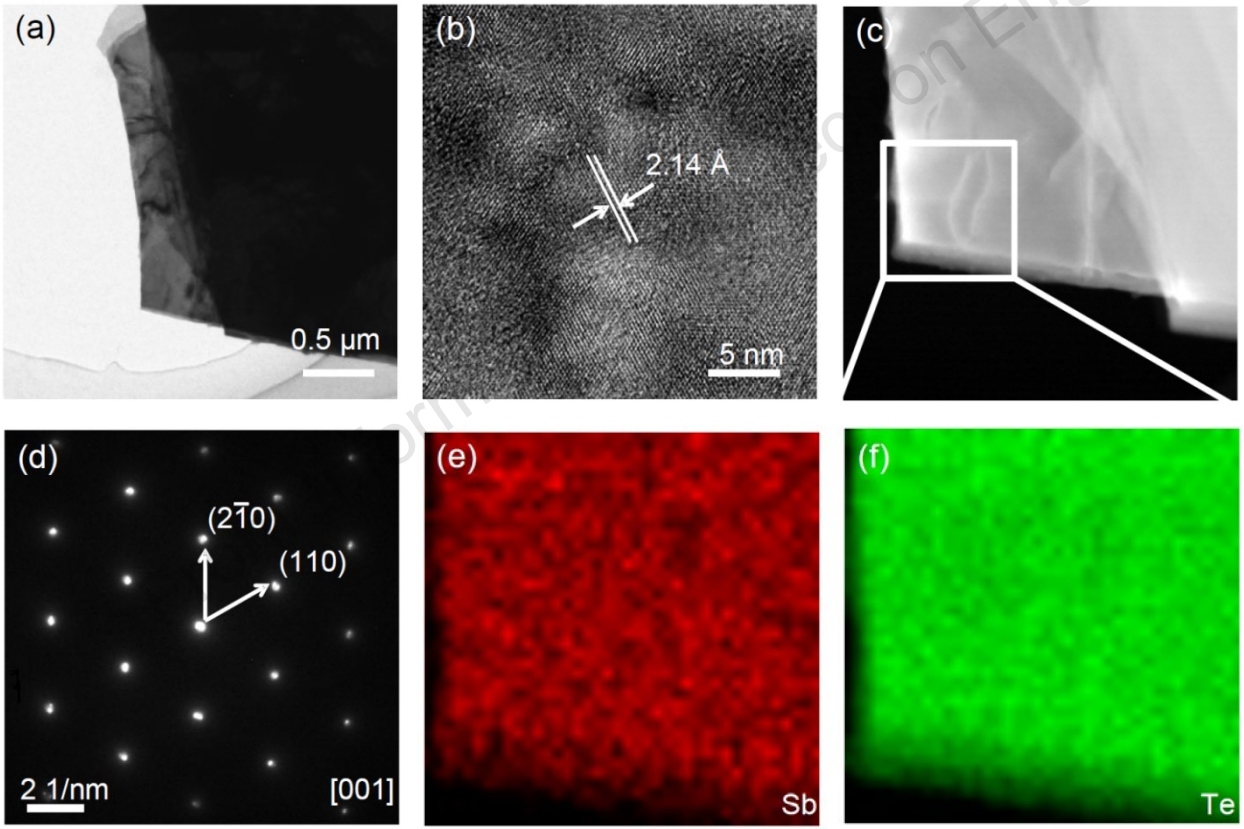

Fig. 1 Transmission electron microscopy (TEM) characterization of the Sb_2Te_3 sample: (a) TEM image of the Sb_2Te_3 sample on a copper grid; (b) high-resolution TEM image of the Sb_2Te_3 sample; (c) HAADF-STEM image; (d) corresponding SAED pattern showing its single crystal nature; (e) elemental mapping of Sb; (f) elemental mapping of Te

Method (Cont'd)

1. High-quality Sb_2Te_3 crystals were synthesized via the flux zone method.

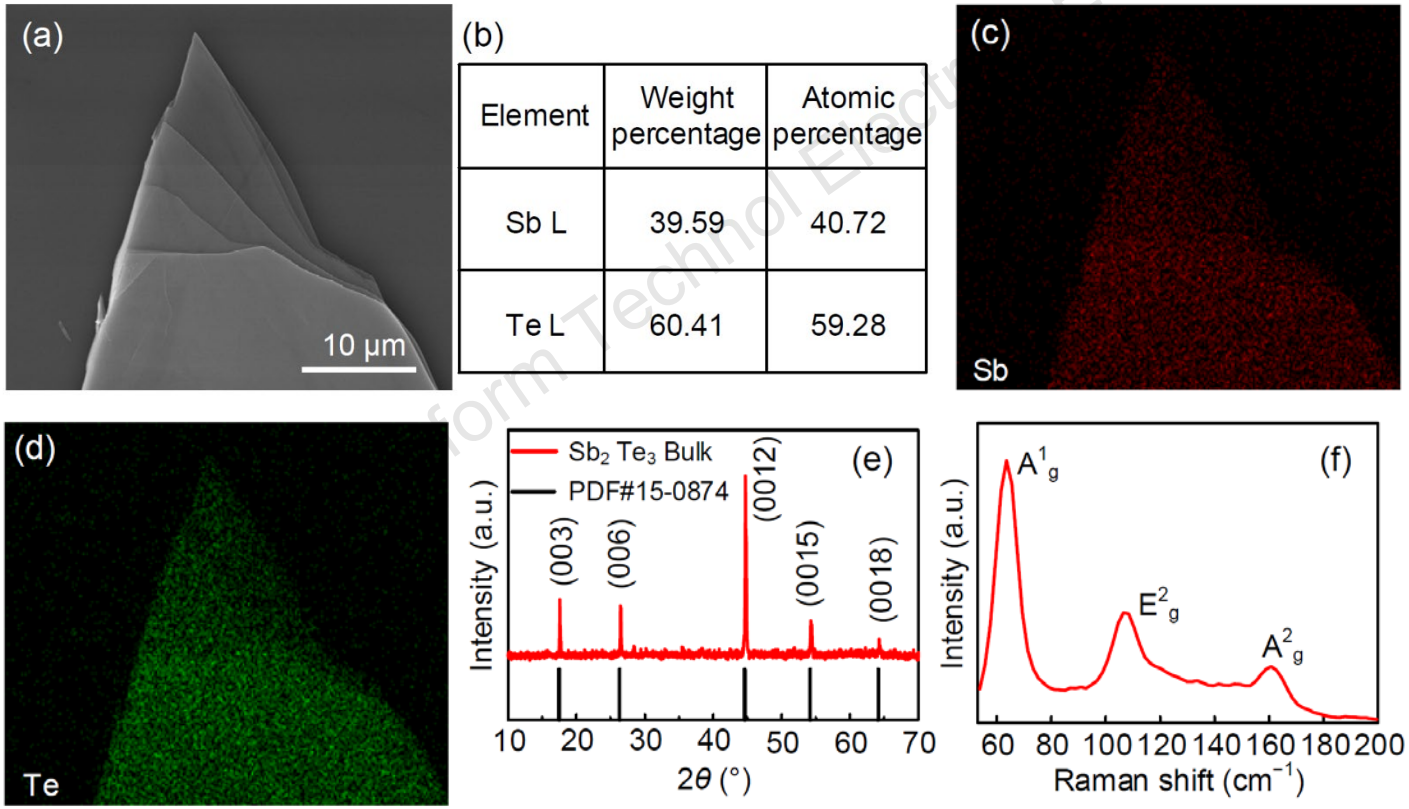

Fig. 2 Characterization of as-grown samples: (a) SEM image of a randomly selected Sb_2Te_3 nanosheet; (b) corresponding elemental analysis of this Sb_2Te_3 nanosheet; (c) EDX element mappings for Sb; (d) EDX element mappings for Te; (e) XRD pattern; (f) Raman spectrum of the Sb_2Te_3 nanosheet

Method (Cont'd)

2. The nonlinear saturation absorption properties of Sb_2Te_3 SA were also characterized by a power-dependent transmission technique.

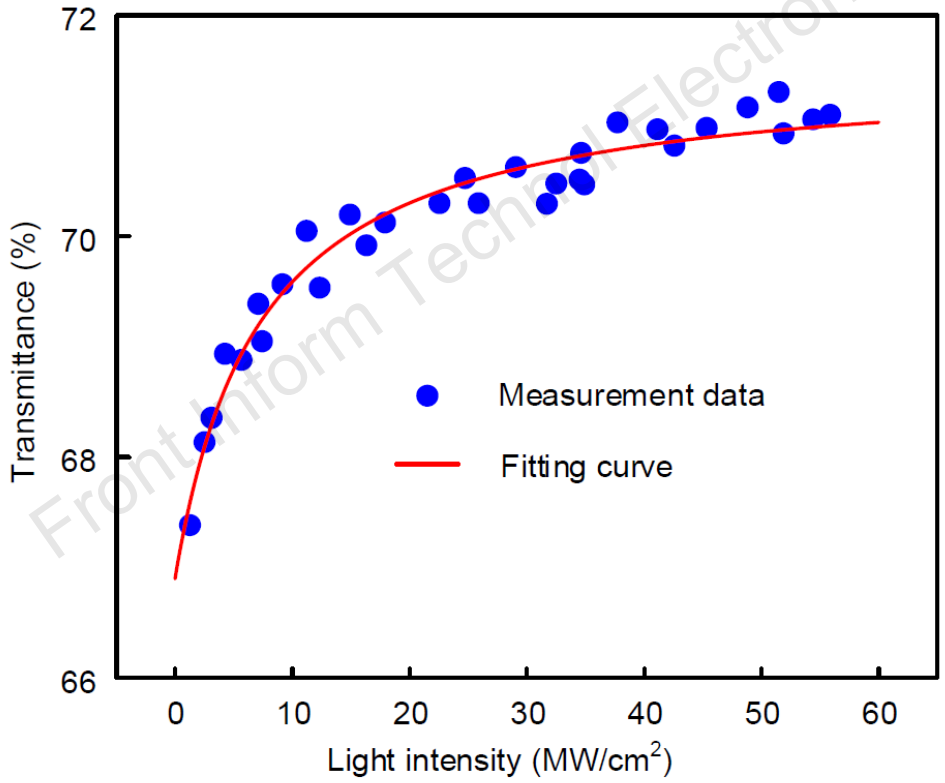

Fig. 3 Nonlinear transmittance of the Sb_2Te_3 saturable absorber at different light intensities

Method (Cont'd)

3. The Sb_2Te_3 SA was introduced into the laser ring cavity.

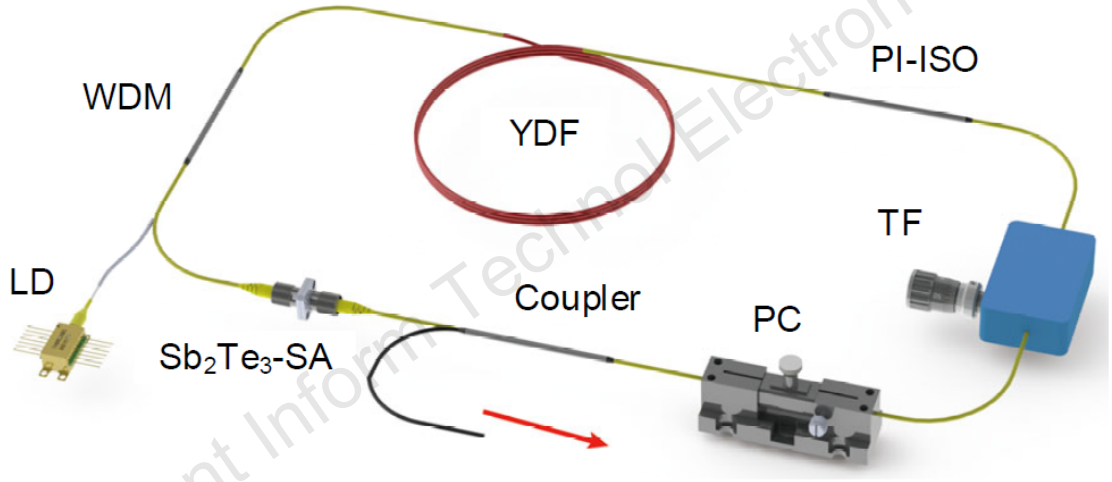

Fig. 4 Experimental setup for the Sb_2Te_3 SA based wavelength-tunable passive Q-switching YDF laser

SA: saturable absorber; YDF: Yb-doped fiber; LD: laser diode; WDM: wavelength division multiplexing; PI-ISO: polarization-insensitive isolator; TF: tunable filter; PC: polarization controller

Major results

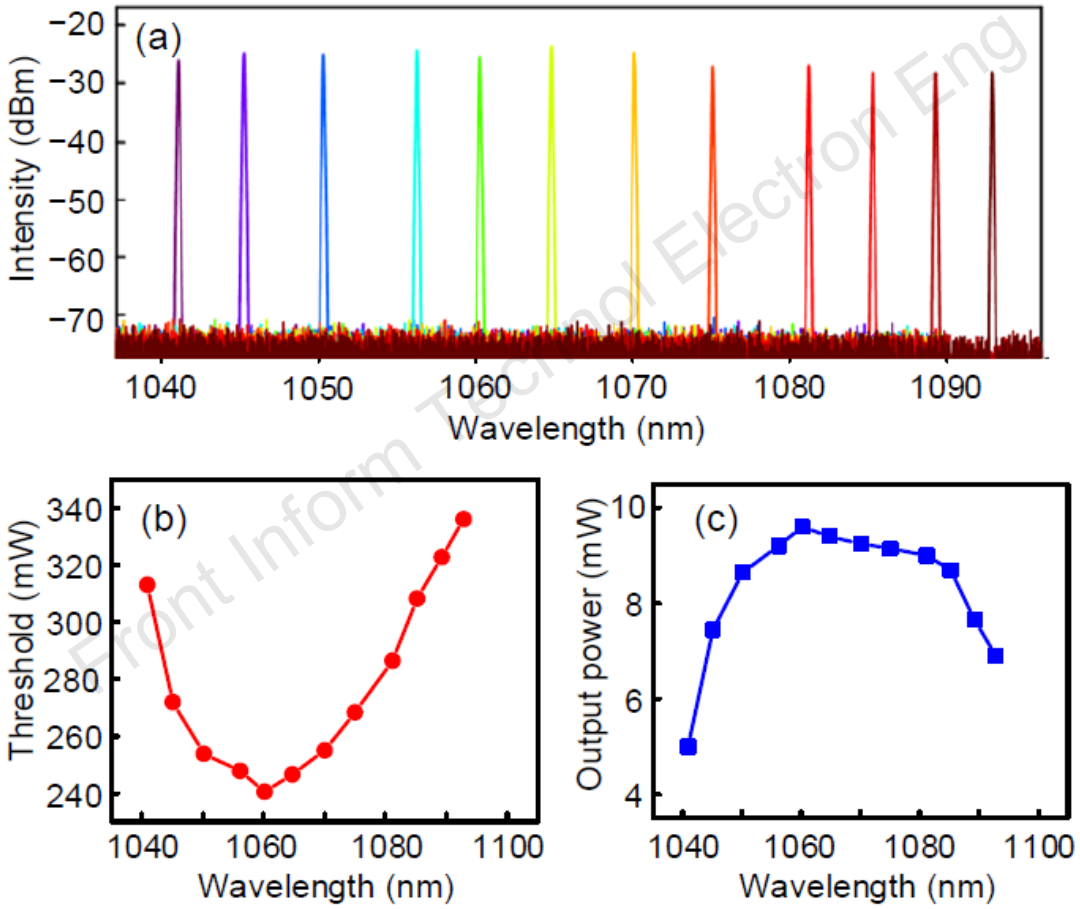

Fig. 5 Pulse characteristics at different wavelengths: (a) spectra; (b) pulse threshold; (c) output power

Major results (Cont'd)

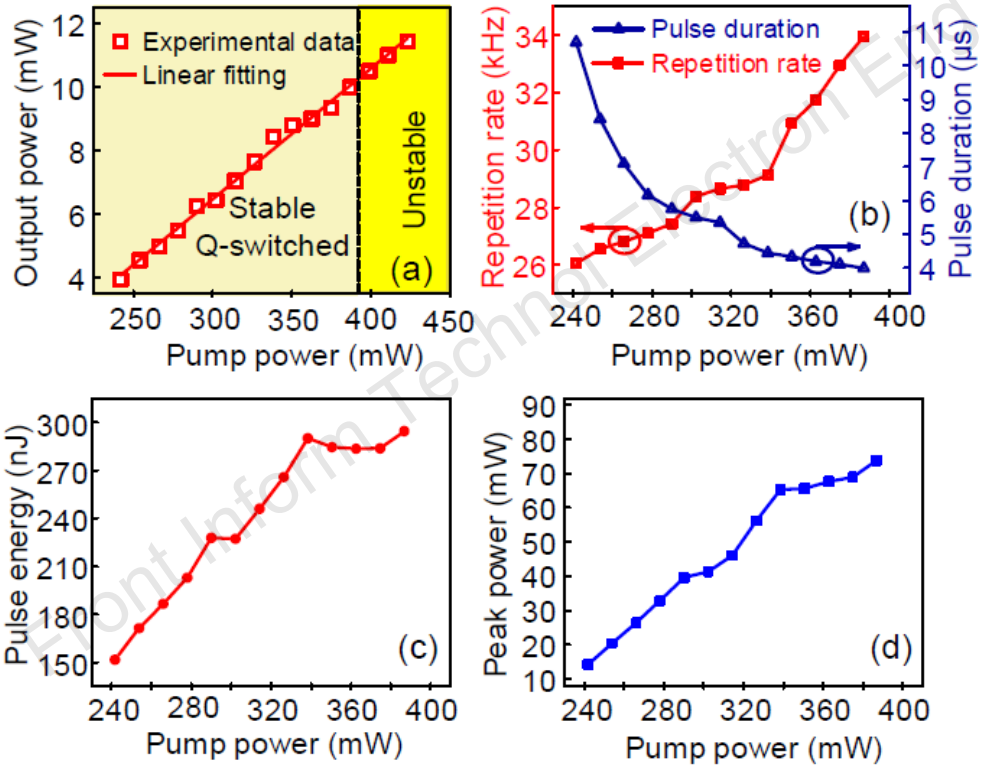

Fig. 6 Q-switched laser properties at 1060.8 nm output wavelength: (a) output power recorded by a power meter; (b) pulse width and repetition rate of pulse train at different values of pump power; (c) pulse energy; (d) peak power

Major results (Cont'd)

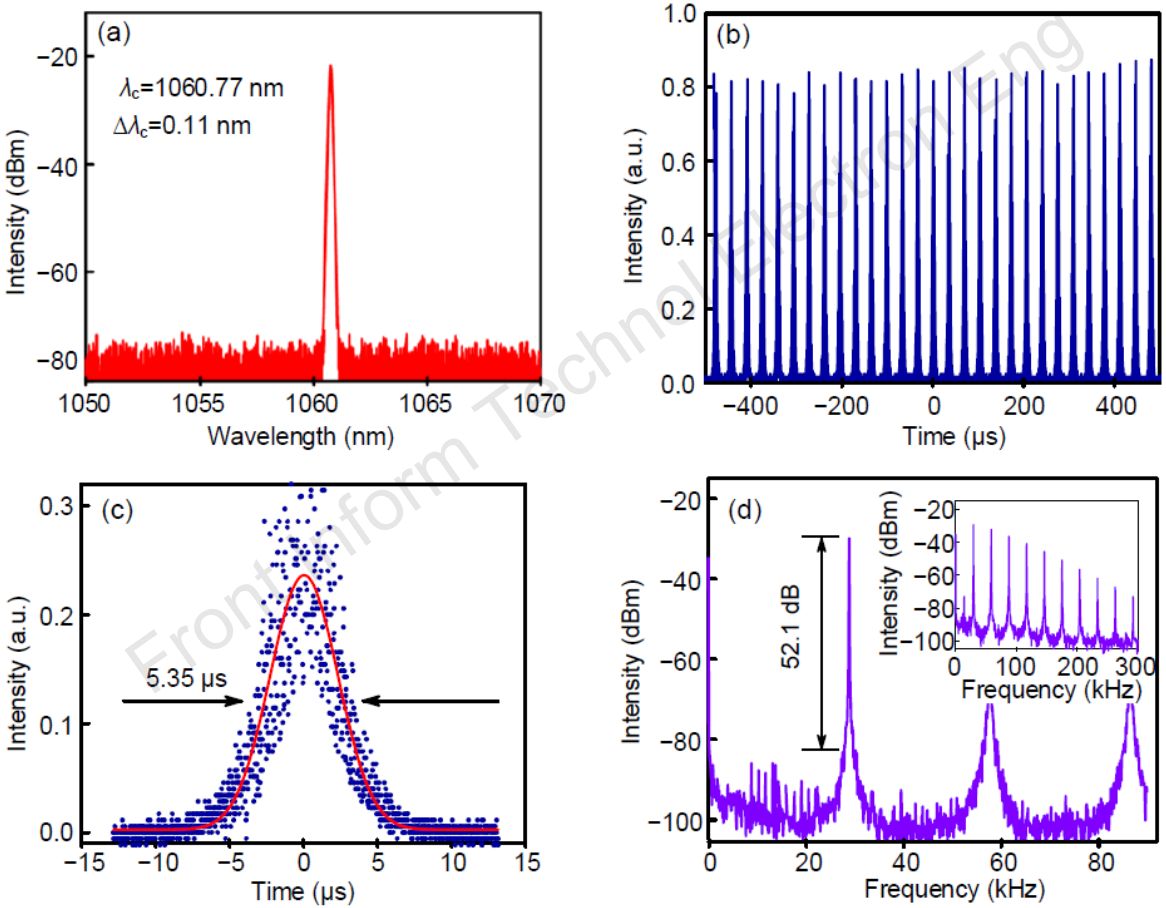

Fig. 7 Pulse properties at fixed pump power: (a) output spectrum centered at 1060.77 nm; (b) pulse train; (c) pulse duration; (d) RF spectra where the inset RF trace ranges from 0 to 300 kHz

Conclusions

1. A broadband tunable passive Q-switching Yb-doped laser based on Sb_2Te_3 was experimentally demonstrated for the first time.

2. The wideband saturable absorption properties of Sb_2Te_3 enable a Q-switched pulse operation range of 1040.89 to 1092.85 nm.

3. With a simple and convenient configuration, this broadband tunable passive Q-switching fiber laser can be highly attractive for applications in optical communication, biomedical diagnostics, environmental sensing, and other fields.

王涛，2017年获北京理工大学光电信息科学与工程专业学士学位，2019年获国防科技大学光学工程硕士学位，目前在国防科技大学攻读博士学位，研究兴趣集中在脉冲光纤激光器。

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