

Q-switched Pulse Laser Generation based on Polyaniline Boron Nitride Saturable Absorber

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Abstract

This study demonstrates the use of Polyaniline Boron Nitride (PANI-BN) as a saturable absorber for generating Q-switched pulses in a 1.5 μ s erbium-doped fiber laser (EDFL). Stable Q-switching was achieved, the maximum pump powers from 212.1 mW, producing repetition rate 93.9 kHz and pulse width of 5.1 μ s. The laser operated at 1532.2 nm. The results highlight PANI-BN's potential as an effective saturable absorber for enhancing EDFL performance across various applications. This innovation opens the door for the development of more efficient, reliable fiber laser systems with wideranging applications.

1. Introduction

Fiber lasers are used in various applications, including materials processing, medical treatments, telecommunications, and research. Q-switching is a technique used to generate short, intense pulses of light by temporarily "switching off" the laser's output to store energy in the fiber, and then releasing this energy rapidly to produce high-intensity pulses [1]. A saturable absorber is a material that absorbs light at lower intensities but becomes transparent when exposed to higher-intensity light, allowing for the rapid release of stored energy in the form of short pulses [2]. In a fiber laser based on Polyaniline Boron Nitride (PANI-BN) as a saturable absorber, the PANI-BN composite is used to modulate the laser's output in a passive Q-switching configuration. BN helps dissipate the heat generated during pulse generation, preventing material degradation and ensuring the longevity of the device [3].

In conclusion, fiber lasers that utilize Polyaniline Boron Nitride as a saturable absorber represent a significant advancement in laser technology. By leveraging the unique properties of PANI and BN, these lasers offer high-performance pulsed output, improved thermal stability, and greater efficiency.

2. Fabrication and characterization of the Polyaniline Boron Nitride (PANI-BN) as a SA

The thin-film saturable absorber (SA) was prepared using the casting method by dispersing commercially available PANI-BN powder into a Poly (methyl methacrylate) (PMMA) solution. PMMA was selected for its optical clarity, chemical and thermal stability, and mechanical strength, making it ideal for uniform PANI-BN dispersion. Precisely 2 mg of PANI-BN was added to 5 ml of PMMA solution in a glass bottle and stirred for 72 hours to achieve uniform mixing Figure 1.

3. Laser Setup

The nonlinear absorption measurement confirms that the PANI-BN SA exhibits sufficient modulation depth to induce self-amplitude modulation within the EDFL cavity at the 1558.7 nm wavelength, as illustrated in Figure 2 .

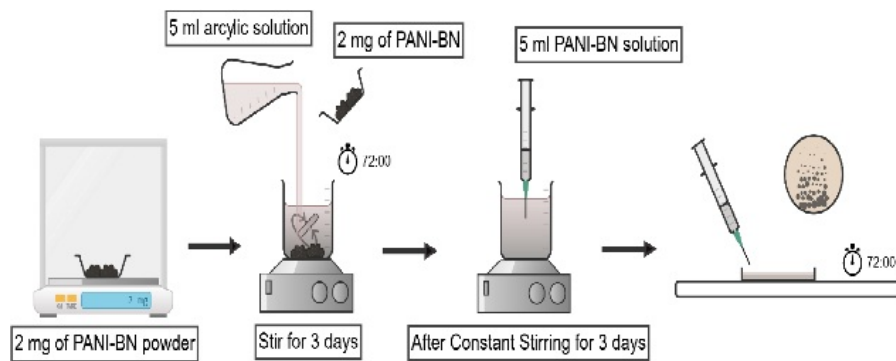


Figure 1. Step by step fabrication process of PANI-BN-acrylic film.

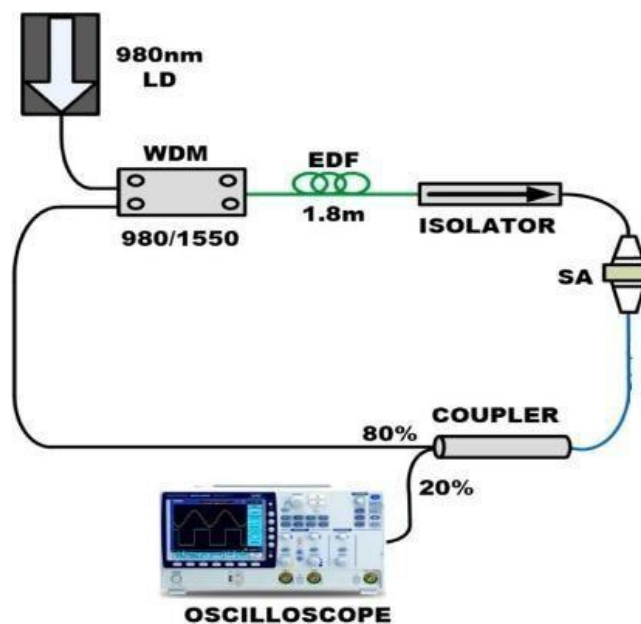


Figure 2. Schematic representation of the EDFL employing a PANI-BN Q-switcher.

The gain medium in this system is provided by a fiber amplifier containing a 1.8 m of (EDF), which is pumped by a 980 nm laser diode. The lasing injecting by 980 nm into the EDF through a wavelength division multiplexer (WDM). To enforce unidirectional light propagation, an optical isolator is integrated within the cavity. For efficient extraction of the oscillating laser signal, an 80:20 3 dB coupler.

4. Results and Discussion

Figure 3 shows the gain and spectral broadening behavior when increasing the power to 212.1 mW, showing the center wavelength for the CW at 1533.8 nm, and for the SA 1532.2 nm. The CW laser and the SA enhanced laser have the same peak wavelength because they share the same gain medium and/or seed wavelength, and the saturable absorber modifies temporal characteristics (like pulsing), not the central wavelength of the laser.

Beyond this point, the system shifted into a steady Q-switched state. As the pump power was 212.1 mW, the Q-switched behavior remained stable in Figure 4.

5. Conclusion

The integration of the PANI-BN-based saturable absorber into an erbium-doped fiber laser successfully enabled stable Q-switched pulse generation at 1532.2 nm. Operating at a pump power of 212.1 mW, the system achieved a maximum repetition rate of 93.9 kHz, a pulse width of 5.1 μ s. These results confirm the effectiveness and reliability of PANI-BN as a promising SA material for Q-switching in fiber lasers.

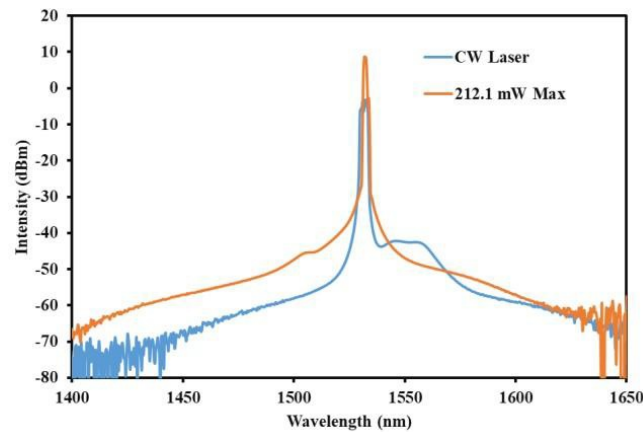


Figure 3. Shown the spectrum for CW, and the max SA wavelength.

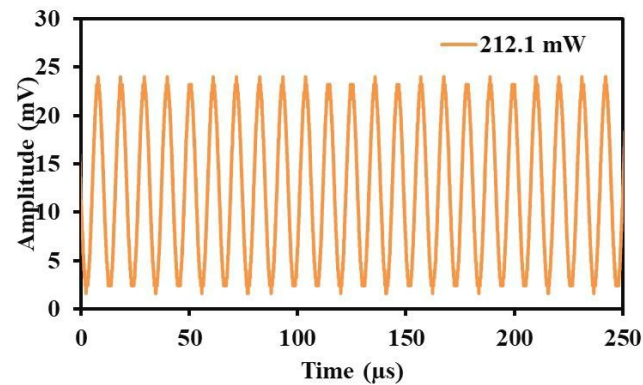


Figure 4. Oscilloscope pulse train at pump power max level 212.1 mW shows the full Q-switched pulse.

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