University of Technology
Laser and Optoelectronics Engineering Department
Laser Eng. Branch

Design and implementation of Pulsed Fiber Laser Based on Nano-Diamonds Saturable Absorber for Tera hertz Communication Systems

A Thesis

Submitted to the Department of Laser and Optoelectronics Engineering of the University of Technology in Partial Fulfillments for the Requirements for the degree of Doctor of Philosophy in Laser Engineering

By

Aseel Abdul-Ameer Shakaty

MSc. (2006)

Supervised by

Prof. Dr.Jassim Kadim Hmood ***Dr. Bushra Rozokhy Mahdi***

2022 ***1444***

Abstract

Pulse fiber laser have attracted great attention due to their superior beam quality and straightforward optical alignment. Enormous researchers have been devoted to the evolution of passively short and ultrashort pulse fiber laser by finding new material to act as saturable absorber. This research focuses on the implementation and design of pulsed erbium doped fiber laser (EDFL) fiber laser for terahertz communication systems. A (ND) particles were investigated as a saturable absorber (SA) to produce both Q-switched and mode locked pulses in (EDFL). The solid nanocomposite film is prepared with two ND concentrations (10% and 20%) by the drop-casting method. Both physical and optical properties of the prepared films are experimentally demonstrated. The SA, which possesses 20% ND concentration, has 5.46 % modulation depth with 2000 MW/cm^2 saturation intensity. While, the measured modulation depth of the 10% ND-SA is 15%. The ND-SA is positioned in the ring cavity of the EDFL to explore their abilities for generating Q-switched pulses and mode locked pulses.

The Q-switched EDFL with 10% ND-SA at a maximum available pump power of 187 mW generates pulses with a center wavelength of 1558 nm, a repetition rate of 127.2 kHz, pulse duration of 1.565 µs, and an output power of 0.447 mW. While the Q-switched EDFL with 20% ND-SA at a pump power of 187 mW produces a center wavelength of 1558.7 nm, a repetition rate of 127.9 kHz, pulse duration of 1.5 µs, and an output power of 0.557 mW.

Sequentially, the performance of the mode locked EDFL is investigated after integrating ND-SA within the laser ring. The 10% ND-SA EDFL begins

a mode locking operation at 100 mW pumped power. The acquired ultra-short pulses have a pulse width of 910 fs, 1.4 MHz repetition rate and 0.3 mW output power, at 187 mW pumped power. While, the 20% ND-SA starts a mode locking operation at pumped power of 116 mW with a pulse duration of 0.84 ps, repetition rate of 1.93 MHz, and output power of 0.517 mW, at pumped power of 187 mW.

Finally, a new terahertz generation system based on a ND-SA mode locked EDFL in a different THz frequency band was produced, at which a pure and stable THz carriers were generated by heterodyning mode locked laser frequency lines by a software VPI photonics simulator. The result show that the transmission performance of both 4-QAM and 16-QAM modulated signal is required and the bit error rate BER could be lower than 10^{-3} the threshold of free error correction FEC.