Abstract

Pulsed fiber lasers have attracted a considerable amount of interest as a result of their straightforward optical alignment, superior beam quality and effortless cooling. Tremendous research work has been devoted to the development of passively Q-switched and mode-locked lasers through finding novel materials to be used as saturable absorber. The main objective of this thesis is to investigate short and ultrashort pulse generation with erbium doped fiber laser (EDFL). Three novel nanomaterial saturable absorbers have been investigated and the performance of pulsed laser was characterized.

The three different nanomaterials were used in the current work: Tellurium Oxide (TeO_2), Lead Sulfide (PbS), and Tellurium nanorods (Te nanorods). The film or suspension approaches to prepare the SA have been employed. Finding the optimum concentration of the suggested SA materials was a challenge too. The linear and nonlinear absorption besides other properties were taken in order to characterize the fabricated SAs.

By integrating the proposed SAs in the all-fiber ring cavity, Q-switched pulse operation generated directly using an EDF as an active medium. For TeO_2-SA film, a dual wavelength of 1568.02 and 1569.09 nm was observed with a frequency difference of 0.13 THz. Meantime, a stable Q-switched regime with the maximal pulse repetition rate of 45.7 kHz, the shortest pulse width of 2.69 μs, and maximum pulse energy up to 39.4 nJ were attained at a maximum available pump power of 275 mW. While for PbS-SA suspension, stable short pulses of 8.55 – 3.43 μs were generated as the corresponding pump power increased from 73-300 mW while the repetition rate tuned from 14.86 – 38.71 kHz accordingly. The maximum pulse energy obtained by the present setup was 10.6 nJ at maximum input pump power. After synthesizing Te nanorods, SA was prepared by the two

methods. The first one, Te nanorods suspension induced four-wave-mixing (FWM) to construct all-fiber multi-wavelength passively Q-switched. seven wavelengths were generated within a span of 1592.4-1599.6 nm waveband and mode spacing of 1.2 nm. In the meantime, the Q-switched operation has been attained with the minimum pulse width of 2.85 μs, maximum repetition rate of 44 kHz, and the maximum pulse energy of 50 nJ at 275 mW pump power. For the second method, A Triple-wavelength Q-switched pulse operation were generated by utilizing Te nanorods-SA film. These wavelengths are centered at 1572.5, 1573.6 and 1574.7 nm when the input pump power was 112.5 mW. As the input pump power increases from 87.5 mW to 220 mW, pulse duration was decreased from 5.53 μs to 4.64 μs, while the pulse repetition rate increased 6.5-23.85 kHz. The output powers and the corresponding pulse energies are ranged from 0.23 mW to 1.2 mW, according 35 nJ to 50.3 nJ, respectively.

Stable ultrashort pulsed operations were also attained by using those nanomaterials SA. Initially, TeO_2-SA was employed to manifest a mode-locked fiber laser with pulse width and pulse repetition rate of 5.3 ps and 1.56 MHz, respectively. Similarly, PbS suspension was also successfully operated as a mode-locker. It was utilized to produce a laser with a pulse width of 4.01 ps and a repetition rate of 1.82 MHz. Finally, a pulse width of 3.56 ps and a repetition rate of 1.87 MHz was achieved by using Te nanorods suspension.

In conclusion, this work has successfully drawn attention to the potentials that proposed nanomaterials in fiber laser technology especially for Q-switching and mode-locking applications.