UNIVERSITI TEKNOLOGI MARA

Q-SWITCHED AND MODE-LOCKED ERBIUM DOPED FIBER LASER USING CADMIUM SELENIDE BASED PASSIVE SATURABLE ABSROBER

AHMAD HAZIQ AIMAN BIN ROSOL

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ABSTRACT

To date, various Q-switched and mode-locked Erbium doped fiber lasers (EDFL) have been demonstrated using various types of nanomaterials based saturable absorber (SA) such as graphene, topological insulators and transition metal dichalcogenides. In this dissertation, cadmium selenide (CdSe) quantum dots (QD) is proposed and demonstrated for Q-switching and mode-locking pulse generation in Erbium doped fiber laser (EDFL) cavity. A Q-switched EDFL is demonstrated using a CdSe doped PMMA microfiber, which was obtained using direct drawing technique. The CdSe microfiber is placed between two cutting microfiber tips which are connected to an EDFL cavity to produce a Q-switching pulse train operating at 1533 nm. The repetition rate of the pulse train is tunable within 37 kHz to 64 kHz while the corresponding pulse width reduces from 7 μs to 4 μs as the pump power is varied from 34 mW to 74 mW. The maximum pulse energy of 1.16 nJ is obtained at the pump power of 74 mW. The RF spectrum of the pulse train shows signal to noise ratio of about 47dB, which indicates the stability of the laser. The mode-locked EDFL is demonstrated by using Manganese-doped CdSe QD based SA in a 202m long laser cavity with anomalous fiber dispersion of -4.265 ps^2. The laser produces a soliton pulse train operating at 1561.1 nm with a repetition rate of 1 MHz and pulse duration of 480 ns as the pump power is increased above the threshold of 113 mW. At the maximum pump power of 250 mW, the maximum pulse energy of 6.2 nJ is obtained. Better mode-locking performance is expected by optimizing the dispersion parameter of the laser cavity and reducing the cavity loss.

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CHAPTER ONE
INTRODUCTION

1.1 Background

Optical fiber was conventionally used as a transmission medium to transmit signal from one place to another with high speed data transfer. It can be also used for other applications involving optical devices such as amplifiers, lasers and sensors. Since the introduction of the concept of light amplification via the stimulated emission of radiation (LASER) by (Gould, 1959), this topic has grown tremendously. The light emission and amplification are possible due to the stimulated emission process in the active gain medium. Over the last 10 years, the field of fiber laser has started to gain tremendous interest by numerous researchers around the world.

The research on fiber laser has grown rapidly since Planck discovered that the energy could be emitted or absorbed only in discrete forms which are called quanta. This laser has shown more advantages compared to the other types of lasers such as dye, chemical and solid state lasers. This is attributed to the ability of this laser to provide better efficiency and also its more compact size. Light is tightly confined to a small cross sectional area of an optical fiber and this allows high intensity of light to be generated in the core. The high surface area to volume ratio in an optical fiber allows excellent heat dissipation, facilitating unprecedented power scaling capacity.

To date, various applications have been demonstrated and reported for the fiber lasers in micro cutting or micro machining, bio-sensing, range finding and material processing (Fermann & Hartl, 2013; Nishizawa, 2014; Scholle, Fuhrberg, Koopmann, & Lamrini, 2010). Conventionally, micro-machining uses carbon dioxide lasers, but recently fiber lasers have emerged as a superior alternative due to its easy beam delivery, less bulky size and more promising use compared to Carbon Dioxide (CO_2) lasers that use Helium gas in the system (Powell, 1993). Fiber lasers have also been widely used for industrial applications such as cutting, welding and engraving. This is attributed to the usage of pulse trains which can minimize the melting effects, surface damages and shock waves (Lucas & Zhang, 2012). These effects are easily developed when using commercial continuous wave lasers.