博士論文（要約）

Novel Mode-Locking Techniques of Tm-doped Fiber Lasers

（ツリウムドープファイバレーザの新しいモード同期法に関する研究）

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指導教員：　山下　真司　教授

東京大学大学院工学系研究科

電気系工学専攻

37-137265

王　宇

2 μm wavelength lasers have properties of eye-safety, low loss in atmosphere, moderate absorption by water, carbon dioxide and plastic. At the same time, mode-locked Tm-doped fiber lasers can provide ultrashort pulse duration, extreme broad bandwidth with high efficiency and beam quality at the wavelength of 2 μm, which can be used for material processing, laser imaging detection and ranging (LIDAR) and supercontinuum generation in the mid-infrared region. Even though mode-locked Tm-doped fiber lasers have been realized with saturable absorbers such as nonlinear polarization rotation, nonlinear optical loop mirror and semiconductor saturable absorber mirrors, each of those saturable absorbers has its weakness such as sensitive to environmental distortion, low repetition rate, and high cost. Therefore, more robust and compact mode-locking methods with low cost are needed. In addition, the dispersion management of a laser cavity has been widely studied for high power performance in mode-locked Er- and Yb-doped fiber lasers. However, the dispersion management in mode-locked Tm-doped fiber lasers is rarely studied due to the lack of normal dispersion medium that are compatible to fiber. The purpose of this thesis is to study novel mode-locking methods and dispersion management in Tm-doped fiber lasers for solving the problems discussed above. For passive mode-locking, we demonstrate an all-fiber passively mode-locked Tm-doped fiber ring laser using evanescent field coupling in a tapered fiber with a single-layer graphene as a saturable absorber. The modulation depth limitation of a single-layer graphene is overcome by incorporating the graphene layer along the fiber longitudinal plane, effectively extending the interaction length between the single-layer graphene and the evanescent field. We also demonstrate a Tm-doped all-fiber mode-locked laser using a carbon nanotube saturable absorber, operating in the dissipative-soliton regime and the stretched-pulse-soliton regime. The net dispersion of the laser cavity is adjusted by inserting different lengths of normal dispersion fiber, resulting in different mode-locking regimes. These results could help the optimization of mode-locked fiber laser cavity design at the 2 μm wavelength region. For active mode-locking, we propose and demonstrate a mode-locked Tm-doped fiber laser using a new mode-locking technique termed “active mode-locking via pump modulation”. This method has advantages of simplicity, low cost and high power operation.