Abstract of Doctoral Thesis

Title：Ultrashort Optical Pulse Generation Using Actively Mode-Locked and FM Fiber Ring Lasers

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Fiber lasers with ultrashort pulse generation and high beam quality have been becoming significant in various fields of applications, such as optical communication, high-precision material processing, and bio-medicine. This thesis works on developing new technologies for generation of ultrashort optical pulses using fiber lasers. A picosecond frequency modulation (FM) fiber laser and an actively mode-locked femtosecond fiber laser have been investigated and developed.

Picosecond optical pulse generation using the FM fiber laser was analyzed in detail. FM Fiber laser operation was realized by using a fiber ring with an internal phase modulator and an erbium-doped fiber amplifier. To generate picosecond pulses from the FM fiber laser, an external dispersive single-mode fiber was employed. By external intensity modulation, the background of the output optical pulse chain was removed. The background ratio of the generated ultrashort pulses was calculated and compared with the experimental results. The experimental results showed an output optical pulse width of 1.77 ps and a flat spectral bandwidth of 0.5 THz. The pulse train had the repetition rate of about 10 GHz. With short pulse width, wide and flat bandwidth, and high repetition rate, this laser can be used for many applications such as optical communication.

In addition, an actively mode-locked erbium-doped fiber laser was developed to generate femtosecond pulses. Instead of using conventional sinusoidal modulation, impulse modulation was utilized to modulate the fiber ring cavity losses. The impulse modulation was realized by a dual-electrode Mach-Zehnder intensity modulator, which was driven by a fabricated electrical impulse generator. The principles of femtosecond optical pulse generation by the proposed laser was analyzed in detail. The active mode-locking directly generated optical pulses with duration of 300 fs and a repetition rate of 9.188 MHz, the same as the fundamental frequency of the cavity. With such short pulse width and fundamental repetition rate, the generated pulses contain very high peak power, which is promising for applications in biology such as cell fusion and cell killing.