Thulium-doped fiber lasers operating with wavelengths in the vicinity of 2 µm are useful for several emerging applications including generating mid-IR light via nonlinear frequency conversion. In this study we describe the design and construction of a thulium fiber laser system comprising a master oscillator and a power amplifier. The first stage is a Q-switched, thulium-doped photonic crystal fiber oscillator utilizing an acousto-optic modulator to produce 65-80 nanosecond pulses. A diffraction grating in the cavity provides wavelength tunability from 1.8 - 2.05 µm. The oscillator produced up to 3 W of average power and 150 µJ pulse energies, corresponding to 2.3 kW peak powers. The amplifier stage consists of a large mode area, thulium-doped, step-index fiber seeded with powers up to 2.09 W from the oscillator. An output energy of 700 µJ with 81-260 ns pulse width, and 22W at CW operation were achieved at a wavelength of 1.9 µm. The effect of the fiber holder temperature on the amplifier performance relative to output pulse energy and seed wavelength was also studied.

As a part of this thesis, a methodology has been developed to thoroughly characterize Tm:fiber amplifier performance. This has been the subject of prior work by several research groups, however, this work explicitly focuses on the precise characterization of absorbed pump power, pump bleaching, and extracted amplified energy for a range of input seeds power, pulse energy, and wavelength in order to better understand amplifier performance.

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The public is welcome to attend.