调 Q 光子晶体光纤激光器研究

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摘要：光子晶体的发现，预示着光和电磁波传播与控制技术方面的一次革命。利用光子晶体原理制作而成的光子晶体光纤（PCF）由于其本身所具有的特性，在短短的十年内研究取得了很大的进展。使用光子晶体光纤与调Q技术研制而成的调Q光子晶体光纤激光器与传统光纤激光器相比，由于有大模面积、高耐热能力等优势，将输出功率提高一个量级，形成高脉冲能量、峰值功率，优良光束质量的脉冲激光。而且，调Q光子晶体光纤激光器结构简单紧凑，与其它激光器相比具有有力的竞争优势。

本文将分两大部分对调 Q 光子晶体光纤激光器进行研究。第一部分将对本次实验所涉及的相关基本概念、理论基础、特性进行阐述，并概述它们的发展现状以及研究进展。这里面包括了光子晶体、光子晶体光纤、调 Q 技术、调 Q 光子晶体光纤激光器等。第二部分为实验部分的内容，本实验首先利用声光 Q 开关在 1.95 m 掺 Yb 大模面积双包层光子晶体光纤中实现了调 Q 输出，得到了脉冲能量 38.5 μJ，平均功率 2.5 W，脉冲宽度（FWHM）120 ns，峰值功率 320 W 的调 Q 光子晶体光纤激光器，并对实验结果与现象进行分析，讨论了实验中的多脉冲激光和激光脉冲重复频率变化的原因。其次，实验对调 Q 光子晶体光纤激光器结构和光纤进行优化选择，采用 1 m 长的棒状光子晶体光纤得到最大 14.5 W 平均功率、最窄 20 ns 脉宽、0.78 mJ 单脉冲能量的调 Q 激光，其峰值功率高达 20 kW，并分析了其脉宽、能量、功率光谱特性。

关键词：光子晶体光纤；调 Q 技术；大模面积 PCF；调 Q 光子晶体光纤激光器

The research on the Q-switched photonic crystal fiber laser

Abstract: The discovery of photonic crystal indicates a revolution of transmission and control of photonic and electromagnetic wave. Photonic crystal fiber(PCF) which is made by the principle of photonic crystal experience a rapid development in research field due to its special advantage. On the basis of PCF and Q-switched technology, the Q-switched photonic crystal fiber laser has advantages of large mode, high heat-resistant ability comparing with general fiber laser. The output of Q-switched photonic crystal fiber laser obtain pulse laser with high power, high energy and good quality beam. Besides, Q-switched photonic crystal fiber laser has a compacting configuration and competitive advantage to other pulse fiber laser.

In this thesis, there are two parts for the research of Q-switched photonic crystal fiber laser. In the first part, some conceptions, theory basis and characteristics of the related technologies will be described, and the author will also describe the development and research production of these technologies, which conclude photonic crystal, photonic crystal fiber, photonic crystal fiber laser and Q-switched photonic crystal fiber laser. The second part is about the experiment content. At first, a Q-switched photonic crystal fiber laser was demonstrated, using a 1.95 m-long large mode area ytterbium-doped double clad photonic crystal fiber and a AOM. Average power of 2.5 W, the 320 W peak power, pulse duration and energy of 120 ns and 38.5 μJ have been obtained with single-transverse

mode beam quality. Then, the experience data and phenomenon will be analyzed with the discussion of the phenomenon of multi-pulses in a period emerged in low repetition rates and short modulation width of Q switch. Secondly, the experiment will be optimized with the Q-switched PCFL configuration and the selection of fiber by using a 1 m rod-type photonic crystal fiber. Then, the experience obtain a maximum average power of 14.5 W, the minimum pulse duration of 20 ns and single pulse energy of 0.78 mJ for the Q-switched laser，with the 20 kW peak power. Finally, the thesis analyzes the pulse duration, energy, power spectrum characteristic.

Key Words: photonic crystal fiber; Q-switched technology; large mode area PCF; Q-switched photonic crystal fiber laser

教师点评：论文通过实验方法研究了调 Q 光子晶体光纤激光器，选题新颖，论文工作量适中，该论文材料详尽，论文撰写及时，符合本科毕业论文的规范。实验结果突出，通过对调 Q 光子晶体光纤激光器结构和光纤进行优化选择，采用 1 m 长的棒状光子晶体光纤得到最大 14.5 W 平均功率、最窄 20 ns 脉宽、0.78 mJ 单脉冲能量的调 Q 激光，其峰值功率高达 20 kW，并详细分析了其脉宽、能量、功率光谱特性。在毕业设计期间，熟练掌握了老师讲授的方法，并主动的去完成老师布置的作业，论文具有一定的创新性，从论文的质量来看，是一篇非常优秀的学士学位论文。