学校编码：10384　　分类号_____密级_____
学　　号：23120101152938　　UDC _____

厦门大学

硕　士　学　位　论　文

基于薄膜滤光片的可调谐滤波器及其应用的研究

Research and Application of Tunable Optical Filters Based on Thin Film Filter

彭妍

指导教师姓名：董 小 鹏　教授

专 业 名 称 ：电磁场与微波技术

论文提交日期：2013　年　5 月

论文答辩时间：2013　年　　月

学位授予日期：2013　年　　月

答辩委员会主席：_____

评　　阅　　人：_____

厦门大学学位论文原创性声明

本人呈交的学位论文是本人在导师指导下,独立完成的研究成果。本人在论文写作中参考其他个人或集体已经发表的研究成果，均在文中以适当方式明确标明，并符合法律规范和《厦门大学研究生学术活动规范（试行）》。

另外，该学位论文为（　　）课题（组）的研究成果，获得（　　）课题（组）经费或实验室的资助，在（　　）实验室完成。（请在以上括号内填写课题或课题组负责人或实验室名称，未有此项声明内容的，可以不作特别声明。）

声明人（签名）：

年　　月　　日

厦门大学学位论文著作权使用声明

本人同意厦门大学根据《中华人民共和国学位条例暂行实施办法》等规定保留和使用此学位论文，并向主管部门或其指定机构送交学位论文（包括纸质版和电子版），允许学位论文进入厦门大学图书馆及其数据库被查阅、借阅。本人同意厦门大学将学位论文加入全国博士、硕士学位论文共建单位数据库进行检索，将学位论文的标题和摘要汇编出版，采用影印、缩印或者其它方式合理复制学位论文。

本学位论文属于：

（　　）1.经厦门大学保密委员会审查核定的保密学位论文，于　　年　　月　　日解密，解密后适用上述授权。

（　　）2.不保密，适用上述授权。

（请在以上相应括号内打“√”或填上相应内容。保密学位论文应是已经厦门大学保密委员会审定过的学位论文，未经厦门大学保密委员会审定的学位论文均为公开学位论文。此声明栏不填写的，默认为公开学位论文，均适用上述授权。）

声明人（签名）：

年　　月　　日

摘 要

可调谐滤波器是光通信系统和光纤传感应用领域的重要光器件。基于介质薄膜滤光片的可调谐滤波器因具有通带窄、插入损耗低、结构小、温度稳定性好和波长调谐范围大等优点而被广泛应用。

本论文主要基于薄膜光干涉滤波原理，分别对采用步进电机细分驱动技术和直流电机 PWM（Pulse Width Modulation）控制技术控制的设计两款可调谐滤波器的原理和结构作了详细的阐述。在测试和对比两种可调谐滤波器输出特性的基础上，对它们的各自应用方向进行分析和研究。本工作中通过步进电机细分驱动技术控制的可调谐滤波器能够在近 50nm（1525nm~1583nm）范围内实现波长可调，当以最小步进角运行时，滤波器的波长移动间隔小于 0.03nm。本文还基于步进电机控制的可调谐滤波器的光路结构基础上，对它的光路结构进行改进，并通过采用直流电机 PWM 控制技术设计出了另一款可周期性地输出系列连续窄带峰的可调谐滤波器，它能够有效解决普通步进电机控制的可调谐滤波器存在的多次转到相同角度时会出现角度不重合、改变波长时要重新归零、调节效率不高等问题。文章还提出了采用线偏振光来消除可调谐滤波器中的 P、S 偏振光分离对滤波器输出特性影响的方法，并通过在实验中采用偏振控器控制入射光的偏振态来改善滤波器的输出波形的方法来验证这种方法的可行性。

在分析和研究所设计的两款滤波器具体应用的基础上，研究了基于直流电机控制的可调谐滤波器的中心波长测量方法。文中详细分析了基于可调谐滤器的中心波长测量原理，并推导出了待测中心波长与测量时间的关系式。最后，本文还对直流电机控制的可调谐滤波器在光栅中心波长和可调谐激光器中心波长的具体应用做了详细的分析和实验测量，进一步验证了此种测量方法的可行性。

关键词：可调谐滤波器；电机控制技术；波长解调

Abstract

The tunable optical filter is an important optical device in optical communication systems and optical fiber sensing systems. Tunable filter based on thin film filter has been used in many fields for having the advantages of narrow passband, low insertion loss, small structure, good temperature stability and widely tunable wavelength range.

This thesis is based on thin film optical interference filter theory, by using of dielectric thin film filters and stepping motor drive technology and DC motor driven by PWM technology to design two kinds of tunable filters. By testing and comparison of the two output characteristics of two filters, the article researched and has an analysis on their respective application direction. The designed tunable filters controlled by stepper motor drive technology can have a wavelength adjustable range about 50nm (1525nm ~ 1583nm) when step motor moved in a minimum step angle, the shift of filter's wavelength is less than 0.03 nm. Based on the design structure of stepper motor controlled tunable filter, and to have an improvement on the filter optical structure, this paper firstly proposed a design structure by using two baffle in each vertical side of dielectric thin film filter. And to use of a DC motor controlled by PWM (Pulse Width Modulation) technology to design another kind of tunable filter, which could cycle output series of continuous narrow-band peak. This kind of tunable filter could help to overcome several shortcoming of ordinary stepper motor controlled filter, such as non-repeatability of same input angle during its operation, and need to re-zero as the filter adjust the wavelength, and the adjustment efficiency is not high, and so on. The article also firstly proposed a method of by using of linearly polarized light to reduce the impact to the filter output characteristics caused by the separation of P polarization light and S polarization light. And then did some experiment of using polarization controller to control the polarization state of the incident light to improve filter's output waveform. The experiment result indicated the feasibility of this proposition of by used of linearly polarized light to solve the

problem of separation of two polarized light.

In this article, a new center wavelength demodulation method based on the use of tunable filter controlled by DC motor driven by PWM technology, has been firstly proposed. Many efforts have been put on the analysis of this demodulation theory, and deduced the relationship of center wavelength and the measured time. Finally, larger amount of experiment about measuring fiber bragg grating's center wavelength and tunable laser's center wavelength by using of this demodulation method, and the testing result also validates the feasibility of this demodulation method.

Key words: Tunable optical filter; Motor control technology; Wavelength demodulation

目 录

Contents