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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

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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波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

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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

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