Design and Fabricate of 850nm Wide Angle Incidence Narrow Band Filter

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Abstract. Wide angle between -45° and +45° incidence 850nm narrow band filter is presented. In this research, an informal dielectric coating narrow band filter is designed. The relationship between the angle of incidence and the central wavelength shift quantificational are solved. The incident angle from -45° to +45° of 850nm narrowband filter is fabricated. The filter characteristics test results show that between 840nm and 930nm, the average transmittance is above 90%, and at the cut-off band, one is the wavelength from 380nm to 700nm, the other is from 1050nm to 1300nm, the average transmittance is below 1%, and the filter meets the application requirements of the laser fusing systems.

Introduction

Wide angle incidence narrow band filters are widely used in many acceptance systems and emission systems that are commonly used in laser fusing systems, Compared with metal film, metal-dielectric film filter, all-dielectric film narrowband filter, due to high transmittance, the deeper the cut-off level, the higher the rectangle and well space environmental applicability, has been widely used in laser systems[1]. At 850nm infrared semiconductor laser system, the laser has a wide divergence angle, and because of the influence of atmospheric refraction, absorption, scattering, turbulence, thermal blooming and stimulated Raman scattering, the laser's intensity, phase, and orientation will change during transmission[2]. The result is that laser and the face normal of detector form deviation. However, a key feature of a dielectric film is that with the incident angle increases, the central wavelength of the filter and passband will move to shorter wavelengths. It affects seriously performance of the laser system.

At present, domestic and foreign scholars through optimize the design of films; reduce the angle of the sensitivity of the filter to solve the problem that the wavelengths shift of filter caused by beam obliquely incident. For example, Kan Yu et al optimized narrowband filter in oblique incidence based on genetic arithmetic. And based on the principle of multi-beam interference, deduced the reflected light intensity and transmitted light intensity's expression of angle-tuned thin film filter when Gaussian beam obliquely incident. Junqiang zhang studied the effects of incidence light cone on transmission characteristics of narrowband filter, proposed the ideological that the accuracy of spectrum selection by quantitative compensation of the dielectric film filter center wavelength blue shift, and solved the problems of wavelength drift caused by incidence light cone.

In this paper, we analyze the theory of all dielectric films and the changes of spectrum when light incidents obliquely. And we design an informal dielectric film narrowband filter on substrate which is a long pass filter by Macleod. At last, we fabricate a wide angle 850nm narrow band filter by Leybold Optics.

Coating Design

When selecting the optical film materials, the transparency of the material, absorption and scattering properties, refractive index, machinable durability, chemical stability and laser induced damage threshold must be considered. For the film, the film design is on the base material which is given, with a minimum number of layers, to meet the requirements of the subject. The commonly

used high refractive index materials are TiO_2, Nb_2O_5, Ta_2O_5 and so on. The low refractive index material is SiO_2.

TiO_2's refractive index is high (about 2.2~2.5), good mechanical strength, and transparent in visible light to infrared light, so it is often used in all-dielectric film narrowband filter. But it is unstable during deposition, and it will release a lot of Ti_2O_3 and Ti_3O_5.

Nb_2O_5 is a high refractive index material whose refractive index falls between TiO_2 and Nb_2O_5[6]. It is transparent in the near ultraviolet to infrared. In ion-beam sputtering deposition, we can obtain the stacking density which is almost 1. But Pre-melting is very important before plating.

Ta_2O_5'srefractive index is high (about 2.1), and it is also transparent in visible light to infrared light, but it is more stable than TiO_2. Plating Ta_2O_5film is easier to get small absorption and scattering than TiO_2 film, the deposition rate of the film is also faster, and the stacking density is almost 1[7]. So it is often with SiO_2 plated all-dielectric film narrowband filter.

In comparison with these materials, we chose Ta_2O_5 as high refractive index material.

In this paper, interference filter select Ta_2O_5as high refractive index material and SiO_2 as low refractive index material, choose all-dielectric film narrow band filter film as basic structure. We choose high refractive index material as spacer-layer in order to reduce the influence of incident angle, use double cavity filter film to enhance its rectangularity. At last, we use Macleod to optimize film. The designs of interference filter film's theoretical spectral curves shown in Fig.1

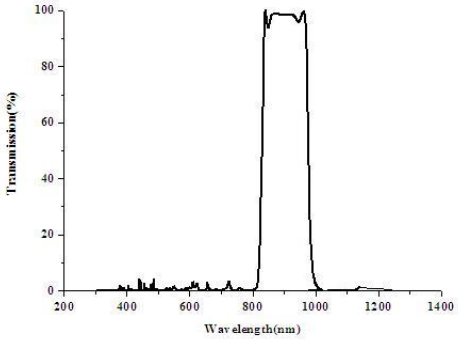

Fig. 1 The design of the 900nm narrow band filter's transmittance curve

In the picture, there are many sub-peaks in the short wavelength region. We can increase layer to take out sub-peaks. But this will bring about a problem. With the film increasing, the cumulative stress is intolerable. Such a large stress will inevitably lead to the substrate bending, eventually resulting in changes in the optical properties of the film (including the spectral shift and scattering increases, etc.), the mechanical properties reduced, and even lead to film rupture[8]. What's more, large stress produce great distortion in the wave front while incident light reflect in the film, and it will cause the entire optical system to be deviated from the design specifications, or even stop working[9]. So we consider adding shortwave absorption filter to absorb sub-peak in the shortwave region. In this paper, we use HWB830 colored glass as substrate to evaporation tests. We use spectrophotometer to test the spectral curve of three colored glass Fig.2.

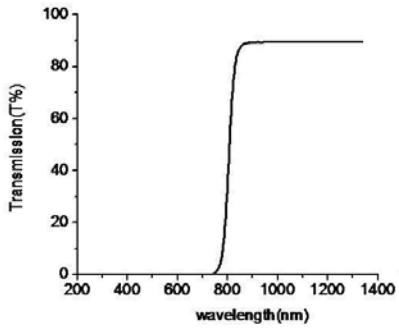

Fig. 2 The transmittance curve of HWB 830

Film Preparation

The result of film coating depends primarily on film thickness monitoring. If film thickness monitoring is more accurate, the film will be better. In this paper plasma-assisted thermal evaporation was used, the equipment is Leybold Optics. It uses quartz crystal oscillator control the rate of film deposition, and uses optical control method control optical film thickness. The design of combination film design relocated to the film preparation system. High refractive index material is Ta_2O_5, the vacuum is 1.9E-4 Pa, the deposition rate is 0.3nm/s. Low refractive index materials is SiO_2, the vacuum is 1.5E-4 Pa, and the deposition rate is 0.6nm/s[10].

Consequence

Filter is got by E-beam equipment of Leybold Optics on the substrate which is HWB830 colored glass. The plating products are test by spectrophotometer. Fig.3. Between 840nm and 930nm, the average transmittance is above 90%, and at the cut-off band the average transmittance is below 1%. And the rising and falling is steep. It is more narrow than the filter that we known. It has a very small offset. So it is better than the previous narrowband filter. We also fabricate the 850nm narrow band filter some times. The results are virtually identical.

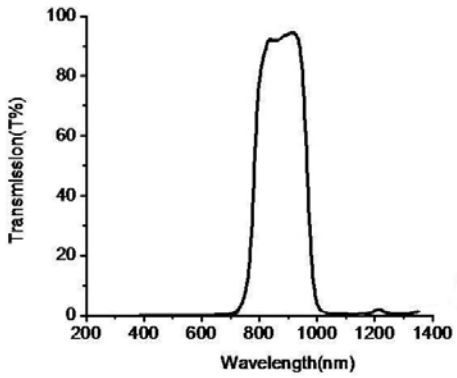

Fig. 3the transmittance curve of sample

Conclusions

Wide angle 850nm narrow band filter has achieved by using the film optics. Between 840nm and 930nm, the average transmittance is above 90%, and at the cut-off band the average transmittance is below 1%. And the rising and falling is steep. So the wide angle 850nm narrow band filter meets the actual requirements. There is no conflict of interests regarding the publication of this article.

Acknowledgment

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