Design and Preparation of New Type Day and Night Filter

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Abstract. In order to image no color cast in daytime, and form black and white image at night, we use day and night filter to instead mechanical switching system in infrared night vision camera and monitoring system. Essential Macleod software is used to optimize the film spectra, the average transmittance exceeds 90% in 440~640nm. The spectra has a band pass in 850nm, the bandwidth is less than 40nm, and the peak transmittance is less than 20%. Physics vapour depositing method with the aid of ion beam assistant deposition systems is adopted. Through reducing film thickness error and optimizing technical parameter, we get the new type day and night filters on substrate of K9 glass.

Introduction

Modern digital video cameras, surveillance systems are usually composed of image sensor, image processing chip and other parts. Image sensor generally include charge-coupled device (CCD), the complementary metal oxide semiconductor (CMOS). The CCD and CMOS could induct both visible light and infrared light. The visible wavelength range is the 380~780nm, above 780nm belong to the infrared wavelength, When the CCD or CMOS inducts the infrared and visible light, the color of image is inconsistencies with the human eye seeing, that is so-called color cast, because the infrared light destroys the color reproduction. In order to get better color in natural light, people set the filter in front of the CCD or CMOS. The infrared camera can be used in both bright and dark environment, imaging without colour cast in the daytime, and also image in the case of the infrared light source at night, so people design the day and night filters[1].

The role of day and night filters and its design

Traditional infrared edge filter simply let visible light through, which makes the night imaging bad. To resolve this conflict, infrared cut filter could be used during the daytime, and remove the filter at night, but the life of small auto-slide device is limited. People design a special kind of infrared filters with visible and infrared transmission band, which can image color picture in the daytime and black and white picture at night. Generally using infrared light of the 850nm band, the filters' infrared pass band is too wide(>80nm), the average transmittance is 90%, so daytime imaging is still color cast[2, 3]. We developed new type day and night filter, the transmission light energy of two channel band is unbalanced. The infrared band-pass is less than 40nm, peak transmittance is lower than 20%, avoid imaging color cast in the daytime, and can be imaging good at night.

Table 1 Design specification of the day and night filters

Wavelength[nm]	transmittance [%]	
	forward	new type
440～600	> 90 %	> 90 %

645±5	～50 %	～50 %
665～790	< 3 %	< 3 %
820～870	> 90 %	< 20 %
900～1100	< 3 %	< 3 %

440 ~ 640nm is the monitor band used during the daytime, meanwhile 830 ~ 870nm is the monitor band used at night. This two bands have high transmission rate, resulting in daytime imaging is still cast. The transmittance of infrared band should be low, therefore we design the spectra with the transmission rate of 830 ~ 870nm band no more than 20%.

For designing the unbalanced two channel band-pass filter, the traditional method can not meet the requirement. The traditional interference edge filter, using two kinds of symmetric periodic structure (0.5HL0.5H) ^ n or (0.5LH0.5L) ^ n, can be modeled as a monolayer in the equivalent refractive index of membrane system[4]. But this method cant not reach the requirement of unbalanced two channel pass band day and night filters. Therefore we use the automatic optimization method. Automatic optimization method make full use of computer resources to optimize the membrane systems. the needle optical method with excellent spectral characteristics is developed in recent years, which can be tunneling from a local extreme value to another local extreme value, and solved some extent optical thin film design problems automatically[5]. Using the needle method, combined with genetic algorithm and simplex method, a variety of automatic optimization method combined with each other, and finally get to meet the requirements of the design spectrum.

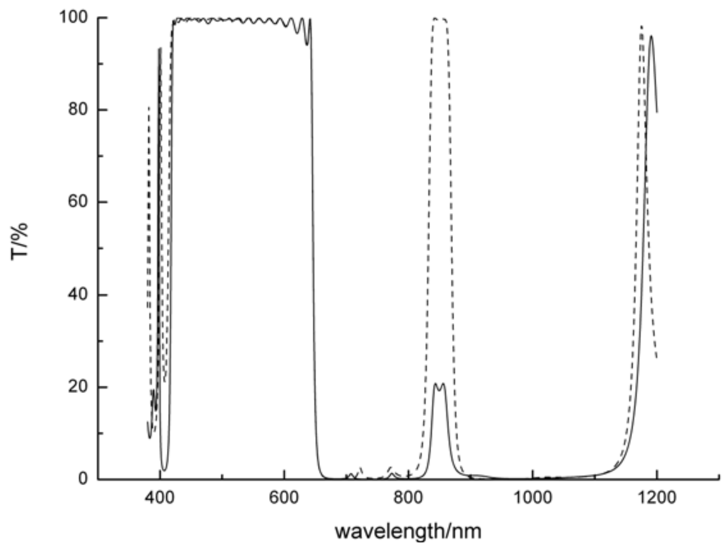

Fig.1 Spectra of day and night filters

The aforementioned design method is the dotted line spectra, the solid line is a new type dual-channel day and night filter design spectrum, 420~640 nm for color imaging, 820~870 nm band for black and white imaging in the night.

Day and night filters coated film system

In Figure 2 shows us DENTON automatic optical coating system. The system is equipped with CC-105 cold cathode ion source, IC/5 quartz crystal deposition rate controller, Lambda Pro automatic optical monitoring system and electron beam evaporation source. We use titanium oxide (Ti_2O_3) and oxide silica (SiO_2) as membrane material whose purity is 99.99%. CC-105 cold cathode ion source be used to clean the substrate before film deposition, the working gas is oxygen (O_2). The base pressure is better than 8.0×10^{-3}Pa. Substrate temperature is 473K The substrate is 25mm×1mm K9 glass.

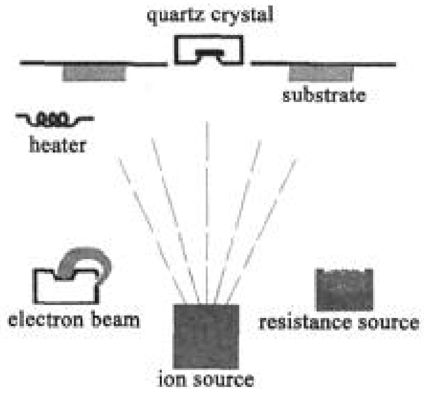

Fig.2 Sketch of optical evaporation system

Using low-energy cold cathode broad beam ion source, we can get high dense and stability optical film. The oxygen ion gas can provide the evaporation particles energy to improve the film quality, and react with the membrane material to supplement Ti_2O_3 missing oxygen atoms. Deposition rate of TiO_2 membrane should not be too large, otherwise they will be splashing, resulting in the film substrate deposition uneven.

Results and Discussion

Lambda 900 spectrophotometer is used to test the new type day and night filters. Figure 3 shows us the test spectral curve. The average transmittance of the curve between 440 ~ 640nm is more than 90%, 850nm band-pass is the infrared channal, the peak transmittance is below 20%, bandwidth is less than 40nm. The prepared optical dual-channel day and night filter meet the design requirements.

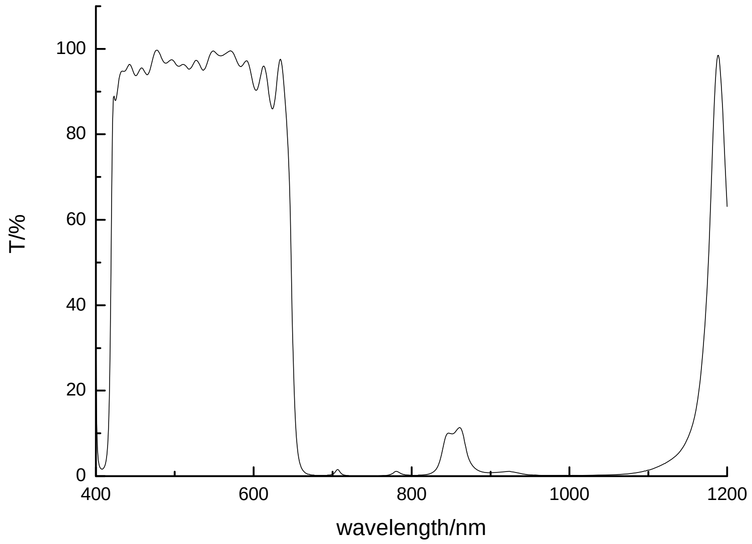

Figure 3 dual-channel day and night filter test spectrum

Dual-channel day and night filter deposited by ion beam assisted, the transmittance of the 850nm infrared light pass band is no more than 20%, making the daytime imaging does not appear obvious color cast, night imaging imaging good, satisfying the day and night imaging infrared cameras. The filter coated by ion beam assisted can withstand a variety of environmental testing. The process is reproducible, and production yield is high.

From the view of the coating system for the dual-channel day and night filter, the systematic errors is greater impact, resulting in a larger spectral difference of different batches products. Through analysing the sensitive layer of the film system, and adjusting the system errors, we get the filters which meet the design requirements.

Conclusion

On the basis of analysing the role played by the day and night filter, which in front of the CCD or CMOS sensor can reduce chromatic aberration, along with day and night can imaging. Through improving the special design of the coating system, we prepared unbalance dual-channel day and night filter. Multilayer dielectric films deposited on the K9 glass substrate using electron beam evaporation method by ion beam assisted. The coated test spectral curves meet the design requirements, realized no color cast and other factors that affect the image quality in the daytime, imaging black and white picture at night.

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