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Spectral and Thermal Effects on the Transmission Modulation Depth and Attenuation Level Estimation of High Density Optical Filters

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ABSTRACT

There are many operating parameters describing optical filter properties such as the amount absorbed electromagnetic radiation which depends on the operating signal wavelength; the amount of the absorbing material in the radiation path (filter thickness); and the absorption coefficient of the material at that wavelength. This paper has presented fused silica (SiO_2) glass, polystyrene (PS) plastic and arsenide trisulfide (AS_2 S_3) glass band pass optical filters for visible and near infrared spectrum regions over wide range of the affecting parameters. Filter transmittance, filter optical density, attenuation level or blocking level, filter correlation factor, and transmission modulation depth are the major interesting design parameters under room temperature and high temperature effects.

1. INTRODUCTION

Optical filters are devices which selectively transmit light of certain properties while blocking (absorbing) the reminder [1]. In general they're sensitive to light of particular wavelengths (and in consequence color) or range of wavelengths. This property makes optical filters often used in many industrial applications. In many branches of industry source emitting intense non-visible radiation (for example white hot metal or glass) has to be monitored. Optical filters are often used for such applications. In such cases infrared (IR) or heat absorbing filters are used in order to block mid infrared wavelengths (thermal radiation) but allow visible light to be transmitted. Additionally, neutral density filters are often used in order to reduce the intensity of light by reflecting or absorbing a portion of it [2]. As a light beam passes through a transparent or translucent material (filter), part of its electromagnetic radiation is absorbed. The amount absorbed electromagnetic radiation depends on [3]: the wavelength; the amount of the absorbing material in the radiation path (filter thickness); the absorption coefficient of the material at that wavelength [4]. Systems with greatly improved optical filters, i.e., filters that provide sub-angstrom spectral resolution, rapid wavelength tuning, low wavefront distortion (for imaging), and high throughput, will be needed. The challenge in remote sensing is to provide rugged, easily used [5], relatively inexpensive devices that can project an image of contaminant concentrations on a screen and record measurements for long-term research. The challenge in optical communications is to integrate extremely inexpensive and rapidly tunable devices into existing systems [6]. A number of different types of filters exist that meet many of the required specifications. These filters include interference filters produced from multilayer structures and Fabry-Perot étalon filters such as the Lyot filter, which serve as fixed interferometers. The Lyot filter is currently the preferred approach for applications requiring very high spectral resolution [7]. In the present study, SiO2 glass based optical band pass filters have been investigated over wide range of the operating parameters. This theoretical study has presented the main optical filter characteristics in visible and near infrared regions compared to arsenide trisulfide (AS2 S3) glass and polystyrene (PS) plastic based optical filters under the same design and operating considerations.

2. FILTER MODEL ANALYSIS

All materials will absorb radiation in some parts of the electromagnetic spectrum. The amount of absorption depends on the wavelength, the amount of absorbing material in the radiation path, and the absorption of that material at that wavelength. Materials that absorb some visible wavelengths appear colored. As a beam of light passes through an absorbing medium, the amount of light absorbed is proportional to the intensity of incident light times the absorption coefficient. Consequently, the intensity of an incident beam drops exponentially as it passes through the absorber.

3. SIMULATION RESULTS AND PERFORMANCE EVALUATION

Advanced glass and plastic wavelength selective optical filters have been deeply investigated in the visible and near infrared spectrum regions to enhance it performance operation characteristics such as signal filtration quality, filter optical density, filter free spectral range, filter correction factor, and filter transmission modulation depth over wide range of the affecting operating parameters as shown in Table 2.

have indicated that filter correction factor decreases with increasing ambient temperatures for different glass and plastic optical filters in both visible and near infrared regions. It is observed that SiO2 glass optical filter has presented higher filter correction factor compare to other glass and plastic materials based optical filters under the same operating conditions. It is theoretically found that filter correction factor operation in NIR region is better than its operation in visible region for different glass and plastic optical filters.

As shown in the series of Figs. (3-14) have indicated that filter transmittance of different glass and plastic optical filters is dramatically affected by high temperature effects. Filter transmission decreases with increasing ambient temperature in both visible and NIR spectral regions. Filter transmittance has its peak value in 550 nm (visible region) and in 1000 nm (NIR region).

Assured that filter attenuation level or filter blocking level of different glass and plastic optical filters is dramatically affected by high temperature effects. Filter attenuation level increases with increasing ambient temperature in both visible and NIR spectral regions. Filter attenuation level has its minimum value in 550 nm (visible region) and in 1000 nm (NIR region).

Proved that filter transmission modulation depth decreases with increasing ambient temperatures for different glass and plastic optical filters in both visible and near infrared regions. It is observed that SiO2 glass optical filter has presented higher filter transmission modulation depth compare to other glass and plastic materials based optical filters under the same operating conditions. It is observed that filter transmission modulation depth in NIR region is better than its transmission modulation depth in visible region for different glass and plastic optical filters.

4. CONCLUSIONS

In a summary, different glass and plastic optical wavelength selective filters are deeply investigated in both visible and near infrared spectrum regions over wide range of the affecting parameters. The tradeoffs between glass and plastic optical filters in its design parameters such as filter correction factor, filter transmission, filter attenuation levels, and filter transmission modulation depth. Table 3 has presented the summary for design parameters of glass and plastic optical filters under room temperature and high temperature effects in both visible and near infrared spectral transmission regions.

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