VERY LONGWAVELENGTH LOWPASS INTERFERENCE FILTERS

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The extension of metallic mesh interference filter techniques to wavelengths longer than 2000 μm is discussed. The problems associated with design considerations and removal of leaks is considered in some detail. Successful filters were produced with edges at 6.3 cm⁻¹ and 4.3 cm⁻¹. When used in series and with a specific optical system, good rejection of unwanted radiation was achieved.

Key words: filters, millimeter waves.

Introduction

It has been possible for some time to produce low-frequency-pass filters for the wavelength region 50 μm - 1000 μm using interference techniques (1). At these wavelengths the reflecting elements of the interference filter are composed of metallic mesh since the dielectric multilayer filters are restricted to wavelengths below 50 μm due to the large lattice and/or free-carrier absorption in the multilayers. In addition there are many difficulties in evaporating the necessarily thick films and producing good adhesion (2).

The filters described in this paper show how interference filters using metallic mesh may be made which work efficiently at very long wavelengths, namely
greater than 2000 µm. The filters described here were required to define the optical bandwidth of the emission from a Tokamak plasma. The edges of the filters had to be defined with high precision, at 6.3 cm<sup>-1</sup> and 4.3 cm<sup>-1</sup>. Only interference filters can produce well controlled cut-ons.

**Theory**

The use of interference techniques in filter design is well-known and can be found in more detail elsewhere (3). Only the important conclusions and the specific applications of metallic mesh will be considered here.

The basic equation of interference filter design can be written in terms of the multiple reflection between two effective interfaces

$$T = \frac{T_1(\omega)T_2(\omega)}{1-R(\omega)} \cdot \frac{1}{1 + \frac{4R(\omega)}{(1-R(\omega))^2} \sin^2 \beta}$$

$$R(\omega) = \sqrt{R_1(\omega)R_2(\omega)}$$

$T$ is the overall transmission of the filter. $T_1(\omega)$, $T_2(\omega)$, $R_1(\omega)$, and $R_2(\omega)$ are the frequency-dependent transmission and reflection coefficients of the two surfaces, $\beta$ is a phase factor, generally due to the optical path difference between successive interfering beams.

$$\beta = \frac{2\pi}{\lambda} \cdot n \cdot d \cdot \cos \theta$$

$\lambda$ is the wavelength, $n$ the refractive index of the medium between the surfaces, $d$ the physical separation of the surfaces and $\theta$ is the angle of incidence of the radiation. Usually $\theta \approx 0^\circ$ and $n = 1$ for air spaced mesh filters.

Hence $\beta = \frac{2\pi d}{\lambda}$.

Although only two surfaces are needed for the discussion, the values of $T_1(\omega)$, $T_2(\omega)$, $R_1(\omega)$, and $R_2(\omega)$ will in general be determined by many surfaces. In dielectric multilayer filters it may require as many as 35 layers or more to achieve the desired performance.