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Research Paper

Design of High Reflectivity Birefringent Multilayers Laser Mirrors

Science

KEYWORDS :

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ABSTRACT

In present research we used open filter software program with Matlap asa complete program to study influence of incident light angle with surface reflectivity and relationship withbriefringent.When the wavelength equal to 1500 nm and thirty reflective layers. Finally we can get the maximum reflectivity when the optical thickness of coating layers equal to quarter wave length.

1- Theory:-

There are two conventional ways to create a mirror: using the surface of a layer of metal, or using a tuned interference stack composed of multiple layers of transparent dielectric materials Metal mirrors are inexpensive and perform robustly across a broad range of angles, wavelengths, and polarizations, but they exhibit limited reflectivity. Multilayer interference mirrors are routinely used for optical applications requiring high reflectivity and wavelength selectivity. Although they can be designed to achieve a wide range of optical characteristics, each design typically performs across a limited range of incidence angles,wavelengths, and polarizations. A key limitation of multilayer mirrors stems from Brewster's law, a nearly200-year-old maxim of optics, which predicts the decrease of reflection for p-polarized light at material interfaces with increasing incidence angle. Specifically, Brewster's law states that there is an angle of incidence (Brewster's angle) for which the reflectivity for p-polarized light vanishes at a material interface. As a result, a multilayer interference mirror that is designed to have a 1% loss for reflection of p-polarized light (99% reflectivity) at normal incidence can have many times that loss at high incidence angles Using highly birefringent polymers, we have found that multilayer mirrors can be constructed that maintain or increase their reflectivity with increasing incidence angle. The reflective characteristics of these mirrors require a generalization of Brewster's law. This generalization has enabled the development of a new class of multilayer interference optics with design freedoms that can result in unprecedented means for transporting, filtering, andreflecting light. Optical birefringence describes the difference of a material's refractive index with direction. When birefringence is on the order of the change of the in-plane refractive index between adjacent material layers, surprising and useful optical effects occur.We refer to these effects as giant birefringent optics (GBO). A central feature of GBO is improved control of the reflectivity of p-polarized light. With the additional design freedom allowed by GBO, Brewster's angle can be controlled to any angle from0° (normal incidence) to 90° (grazing incidence), to imaginary values for light incident from media of any index of refraction. For imaginary values of Brewster's angle, the reflectivity at material interfaces (referred to as Fresnel or interfacial reflectivity) for p-polarized light increases with angle of incidence in a similar or identical form to that for s-polarized light. By comparison, isotropic materials have no substantial optical birefringence; that is, their refractive index values are equal for all directions. Interfaces of these conventional isotropic materials exhibit a limited range of Brewster's angles Because the optical effects presented are based on the fundamental physics of interfacial reflection and phase thickness and not on a particular multilayer interference stack design, new design freedoms are possible. For example, designs for wide-angle, broadband applications are simplified if optical elements with noBrewster's angle are used, particularlyif immersed in a high-index medium such as a glass prism. Color filters can be designed that provide high color saturation at all incidence angles and polarizations. Alternatively, a mirror or reflecting polarizer can be designed to have a Brewster's angle that is accessible in air. Conventional polymer film-making processes have been enhanced to fabricate a wide array of GBO films from commercially available polymers and monomers for use in a range of applications. These applications include high efficiency mirrors for piping visible light over long distances or uniformly lighting small optical displays. GBO multilayer films have been used to create reflective polarizers that make liquid crystal displays brighterand easier to view. Other applications include decorative products, cosmetics, security films, optoelectronic components, and infrared solar control reflectors for architectural and automotive glazing. After a review of birefringent optics, we discuss the relations describing GBO and show the implications of GBO on optical film performance and applications. Background. Multilayer interference optics can generally be described as the use of the amplitudes and phases of light reflected at planar material boundaries to produce constructive and destructive interference effects. Pairs or groupings of adjacent layers (termed unit cells) can produce constructive interference effects when their thicknesses are properly scaled to the wavelengths of interest. These interference effects in multilayered structures result in the development of wavelength regions of high reflectivity (reflection bands) withadjacent wavelength regions of high transmission (pass bands) (1). Much of the design effort in multilayer interference optics is devoted to controlling the angular dependence of reflection bands, which is complicated by polarization effects. These effects have long been known, with publications dating to before the turn of the century [see, e.g., Drudge (2, 3). Sir David Brewster empirically deduced the law named for him by observing that light reflected from an air-glass interface is highly polarized at a specific angle (4). The same phenomenon occurs for all interfaces between isotropic materials. Aside from the well-knownMcNeill polarizing beam splitters (5) and magneto-optic materials (6), such polarization effects are typically undesirable, as they limit the angular performance of multilayer interference stacks. Various researchers (7–10) have developed a variety of limited solutions to the problem. In addition, modern computer optimization codes have dealt admirably with the problem. However, the basic phenomenon associated with Brewster's angle still continues to constrain the angular and wavelength performance of multilayer interference stacks fabricated from materials having isotropic indices ofrefraction. Multilayer polymeric interference mirrors were pioneered in the late 1960s (11), and even though the large birefringence of oriented polyethylene terephthalate (PET) was known at the time (12), the use of materials with large optical birefringence in a multilayer mirror (polymeric or otherwise) has not been reported. Numerous other works have been published

on birefringent optical materials (13), but none of these discuss the use of birefringence to control(or eliminate) Brewster's angle effects and phase thickness relations among interface multilayer interference stacks.Using Eq. (8.10.6) and the TM and TE Snell's laws, Eqs. (1,2), we may rewrite the reflection coefficients in terms of the angle θ only:

$$\rho TM = \frac{nH1nH3\sqrt{n_{Ls}^2 N_a^2 \ Sin^2\theta_a} - nL1nL3\sqrt{n_{Hs-N_a^2 SIN^2\theta_a}^2}}{nH1nH3\sqrt{n_{Ls-N_a^2 SIN^2\theta_a}^2} + nL1nL3\sqrt{n_{Hs-N_a^2 \sin^2\theta_a}^2}} \quad \ldots\ldots(1)$$

$$\rho TE = \frac{\sqrt{n_{H2-N_a^2 \sin^2\theta_a}^2} - \sqrt{n_{Lz-N_a^2 sin^2\theta_a}^2}}{\sqrt{n_{H2-N_a^2 sin^2\theta_a}^2} + \sqrt{n_{Lz-N_a^2 sin^2\theta_a}^2}} \quad \ldots\ldots(2)$$

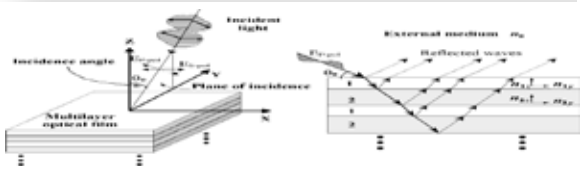
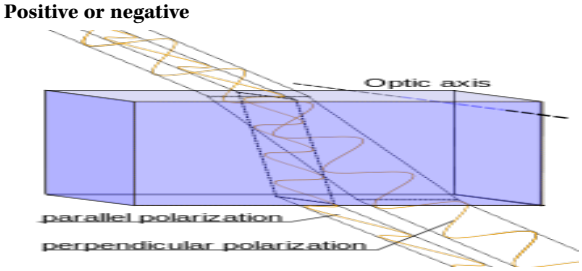


Figure (1) Oblique incidence on multilayer dielectric structural.

Positive or negative



Rays passing through a positively birefringent material. The incident light has parallel and perpendicular polarization components (linear polarization at 45º the optic axis). The optical axis is perpendicular to the direction of the perpendicular component of incident ray, so the ray polarized parallel to the optic axis has a greater refractive index than the ray polarized perpendicular to it. Uniaxial birefringent materials are classified as positively (or negatively) birefringent when, for light (having parallel and perpendicular components) directed to the optic axis, the refractive of light polarized parallel to the optic axis is greater (or smaller, respectively) than light polarized perpendicularly to the optic axis. In other words, the polarization of the slow (or fast) wave is parallel to the optical axis when the birefringence of the crystal is positiveor negative, respectively.

Applications:-

A calcite crystal laid upon a paper with some letters showing the double refraction Birefringence is widely used in optical devices, such as liquid crystal displays, light modulators, color filters, wave plates, optical axis gratings, etc. It also plays an important role in second harmonic generation and many other nonlinear processes. Birefringent filters are also used as spatial low-pass filters in electronic cameras, where the thickness of the crystal is controlled to spread the image in one direction, thus increasing the spot-size. This is essential to the proper working of all television and electronic film cameras, to avoid spatial aliasing, the folding back of frequencies higher than can be sustained by the pixel matrix of the camera. Calcite is frequently used to produce twin beams of perpendicularly polarized light for use in quantum mechanical experiments.

2- The results and discussion:-

We consider a giant birefringent optics mirror of (30)bilayers of high and low index quarter-wave layers with refractive indices n_H=[4.1] and nL=[3.7].The surrounding media are air ,na=nb=1.4 .The layers are quarter wavelength at the normalization wavelength λ0=1500nm at oblique incidence, so that for both polarizations we take LH=LL=0.25.Because the high/low index layers are matched along the z-direction, nH3 = nL3, the TMreflection coefficient at the high/low interface will be constant, independent of the incident angle θ.In this research to study the change in reflectivity values to change the angle and using the program open filter .The reflectivity values (60%)at an angle of $30^0$and while increased the reflectivity become (74%) at an angle ofup to 60^0as show in figure 1. Andusingmat lap program,We found that reflectivity values also increase with the change angles as shown in the figure (2) and(3) ,Because of the change in giant birefringent depending on the above equations. The typical open filter code used to generate the graph :

N:-number of layers ,nH:-higher refractive index, nL:-low refractive index

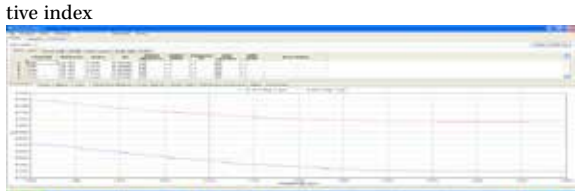
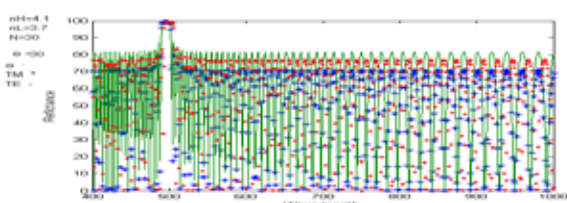
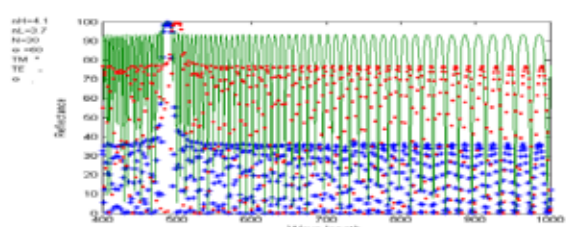


Figure (2) shows the reflectivity characteristics of the multilayer stack with wave length.The typical MATLAP code used to generate the graph :-



Figure(3) Birefringent mirror with identical TM and TE reflection bands.



Figure(4) Birefringent mirror with identical TM and TE reflection bands.

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