SIMULATION AND EXPERIMENTAL INVESTIGATION OF OPTICAL PROPERTIES OF ZNS AND MGF_2 THIN FILM COATED ON GLASS

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ABSTRACT

Optical properties of thin films and nanomaterials, including absorption, transmittance and reflection in the visible and infrared regions of the radiation are of great importance. Materials such as ZnS and MgF_2 are common optical materials that can be used as coatings and thin films. In this paper, some samples of coatings and thin films such as ZnS, MgF_2, and Au / MgF_2 on a glass substrate were spectrally simulated in the range of 200 to 1100 nm. The transmission, reflection, and absorption spectra were studied for the simulated samples using Filmetrics and Macleod softwares. The samples were simulated for thicknesses of 10 up to 100 nm. After that, some of the corresponding real samples were made and examined with the absorption and reflection devices; the results of which have been compared with the simulated ones. The spectral analysis, reflective spectroscopy and colorimetry were also included. Furthermore, characterization of each sample were performed by Raman spectroscopy. In summary, ZnS showed 60% transmission in the visible and near-infrared regions for thicknesses of 10 to 100 nm in the simulation, and for the two real samples made at 28 and 40 nm thicknesses. The MgF_2 coating showed a reflectance of 4 to 8% for thicknesses of 10 to 150 nm in the simulations, respectively. In practice, MgF_2 coating showed a transparency of between 95 and 99%. Coating of 135 nm of MgF_2 on 7 nm of gold is found to be able to increase the transparency from 35% to 45% in the infrared region.

INTRODUCTION

Solar radiation, absorption and reflection in the optical regions, such as visible and near infrared, cause the surfaces to heat up. To prevent the absorption of heat radiation, some properties such as anti-reflectance, reflection of infrared and visible radiation with the aim of cooling the environment is important; which has been also applied for high reflection in the mirror surface of large telescopes such as the James Webb Telescope or for tens or hundreds of other applications. We know the optical properties, transmission, absorption and reflection of some materials. In this regard, ZnS, MgF_2, and many other materials can be used as suitable coatings for common optical applications. For example, they have been used for controlling the transmission, absorption or reflection of the sunlight and in some cases, for cooling the buildings. The samples were characterized by Raman spectroscopy, FTIR infrared conversion spectroscopy, UV_Vis_NIR ultraviolet-visible-infrared spectroscopy in addition to calculating reflection, absorption and transmittance values. Therefore, here the focus of our work is on the ZnS and MgF_2. The transmission, absorption, and reflection process of the samples have been simulated and studied, and then some of those have been fabricated, analyzed and compared. ZnS is widely used for systems with an infrared wavelength of 8 to 11 μm for windows and infrared lenses. It is inherently transparent from 0.4 to 12.5 μm (1). The MgF_2 spectrum shows good conductivity and near-zero reflectance at longer wavelengths (2). First of all, some coatings such as ZnS and MgF_2 coatings have been coated on glass (in the ultraviolet-visible region). The ceramic pigments of titanium oxide or silicon has been the other materials to be studied. With visible-infrared spectroscopy methods, the amount of absorption, reflection and transmission of these materials can be investigated. Application of these studies in visible and infrared regions can be used in the cooling of buildings, apartments and industrial centers for military applications in infrared optical equipment with high transmission and reflection. They are characterized by Raman spectroscopy, Fourier transform infrared spectroscopy, and ultraviolet-visible spectroscopy, which can help to our better understanding of their optical and spectral properties of the samples. The lens of the glasses protect the eye from the sun's harmful rays, although they create reflections that sometimes obstruct clear vision. After the incidence of the light rays on the surface of the lens, they are reflected from the surface and therefore the light that passes through it is reduced. Sometimes, this reduces the resolution of the image for the person wearing the glasses. An anti-reflective coating, including MgF_2, is applied to spectacle lenses to minimize or eliminate glare and acts as an anti-reflective or anti-reflective coating (3). MgF_2 is the most widely used dielectric material for monolayer coatings. It is well known for its outstanding optical properties. It is not absorbed in the wide wavelength ranging from 120 nm to 8 mm and has a high transparency. Its refractive index is 1.38 in the wavelength of 550 nm. Additionally, it has a crystalline structure with a structure of P42 / mnm and a density of 3.171 g / cubic centimeter. Its monocrystalline form is used for ultraviolet to visible and infrared applications. Thus, MgF_2 is an important optical and coating material. Its polycrystalline structure is widely used for visible and infrared applications (1). MgF_2 is a well-known and common anti-reflective material that can be used to reduce the reflection in glasses, using various coating methods on the glass surface. ZnS is widely used for optical devices with long wavelengths from 8 to 11 micrometers for windows and lenses. It is inherently transparent from 0.4 to 12.5 μm. The absorption of this film coating is relatively constant in the visible region. When the photon energy reaches the energy gap, the absorption begins to increase. This material has two common crystal structures. One is α-ZnS phase, which has a hexagonal crystal structure of mineral vertzite with a spatial structure of P63mc and a density of 4.088 g / cm3. The other is the ZnS _β phase, which has a long zinc cubic crystal structure with a spatial structure of F43m and a density of 4.090 g / cm3. It can be produced by the chemical vapor deposition process, in which zinc vapor reacts with hydrogen sulfide to form solid sulfide. Suitable optical thin films can be produced from this material. Two types and grades of ZnS are commonly available. The standard type of FLIR, which is yellow and has small crystalline grains and has a very large visible dispersion, contains both crystalline structures and impurities, especially hydrogen. The second type is produced by isostaticbeing pressed on a standard material, along with the production of larger grains and the reduction of impurities. ZnS has a good heat shock resistance. In air, it can withstand temperatures up to about 600 ° C without any degradation. In the visible optical to infrared regions, it is trasnparent from about 0.4 to 12.5 μm, although it has a relatively high absorption near 6 μm and a refractive index of 2.002 (1).

2. Experimental experiments for producing thin layers of MgF2, ZnS and Au by thermal deposition vacuum evaporation method in vacuum

MgF_2, ZnS and Au samples are coated in vacuum and on a glass substrate. The position of glass substrates in the deposition process were the same, and depending on the type of materials, the thickness of the considered samples and the different density of materials, different amounts of each sample were used. For example, for the case of Au, depending on the thickness of about 7 up to a few tens of nm, the amount of the applied substance has been chosen from 0.010 to 0.018 grams (for ZnS MgF_2 0.1 grams). As mentioned, in the first step, an amount of the considered samples; MgF_2 or ZnS, in each separate experiment, is placed on a suitable and clean boat, and then the substrate glasses are also installed on the holder. Then the chamber is closed and the deposition process is initiated. It is worth noting that different time deposition and applied voltages have been considered for different thicknesses of the samples.

3. Optical studies of the samples

For measuring the absorption, transmittance, reflection and colorimetry of the samples, UV_Vis_NIR analysis (Ocean Optics HR4000 spectrophotometer) with an operating range of 200 to 1100 nm has been used in this research. This spectrometer has been equipped with the halogen-deuterium and tungsten lamps Lamps, which emit in the ranges of 200 to 500 and 500 to 1100 nm, respectively. This specified spectrum is emitted through the lamp, which are incident on the sample through the fiber. Then the required data would be collected in different modes of absorption, transmission, reflection and colorimetry by separate fibers. After the spectrum is collected by the fibers in each of the relevant modes, it enters the spectrometer and is recorded by the detector of the device. After that, the data have been analyzed by the Ocean View software; the results of which have been provided in the next section of this paper.

4. Results and discussion

High transmission is one of the important characteristics of glass. In addition, deposition of materials on the optical glasses such as BK7 or on other transparent substrates, for studying the values of transmittance, absorption, and reflection in different spectrum regions such as visible and near infrared has always been considered by researchers. Here, a review of the real laboratory glass substrate and its corresponding simulation has been provided. Then, the transmission, absorption and reflection spectra of ZnS coatings, which are widely used in visible and infrared regions, are simulated on the glass surface (quartz) from 10 to 100 nm. In the next step, some samples of these materials are actually layered on the surface of the glass substrate, according to the method described above, and then their transmission, absorption, and reflection spectra are investigated. Another sample was the MgF2 anti-reflective coating, which was deposited on the surface of the Au coating to study their anti-reflective properties in the visible and near infrared regions, which is also simulated. Similarly, the study of spectra and their values in different conditions of absorption, transmission, and reflection in the range of 200 to 1100 nm has been investigated. The simulations were performed by Filmetrics and MacLeod softwares was used. In addition, Raman spectroscopic studies of some of these coatings compared to their raw materials have been investigated.

1-4. The absorption, transmission, and reflection of the UV and near Infrared spectra of the ZnS thin film deposited on glass substrate

In this case, the absorption, transmission and reflectance spectra of the ZnS sample for different thickness of 10 to 100 nm were investigated and simulated. After that, the real samples at two thicknesses of 28 and 40 nm were randomly tested; the figures of which and their absorption and transmission spectra are shown in the following:

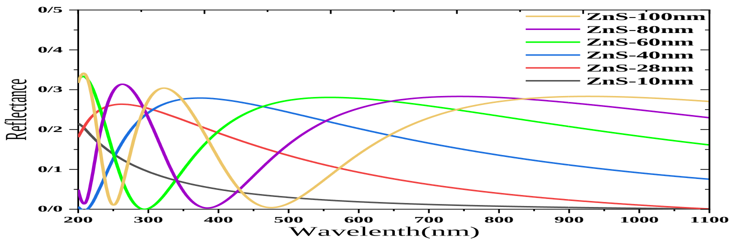


Figure 1-1 Simulation of reflectance spectra for samples with the thicknesses ranging from 10 to 100 nm for ZnS_10-100nm.

After that, the experimental fabricated samples of ZnS coatings with two thicknesses of 28 and 40 nm, which can have the appropriate transparency to measure the transmission spectrum, is studied. The samples and the results of their transmission spectrum are provided in the following.

Figure 1-2. The experimental fabricated coatings on the substrate in two thicknesses of ZnS-28nm, ZnS-40nm.

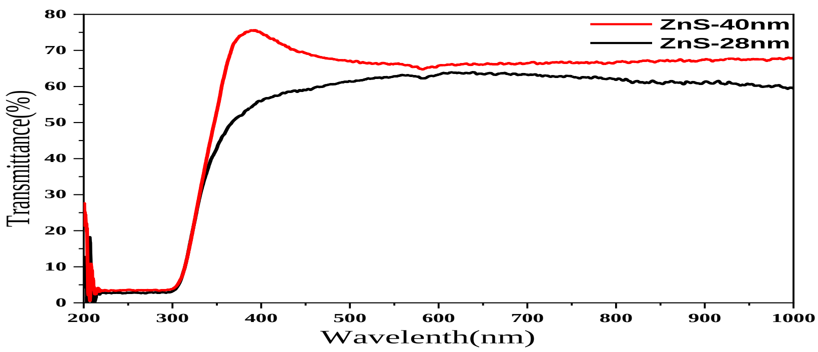


Figure 1-3. Comparison of the UV_Visible_ near Infrared transmittance spectra of the two samples of ZnS thin films with thicknesses of 28 and 40 nm coated on the glass substrate.

The above figure, which compares the ultraviolet-visible-infrared spectra of two samples with thicknesses of 28 and 40 nm being coated on the glass substrate, shows that ZnS has 60% transparency in the spectrum range of 400 to 1000 nm; although in the visible region the difference in thickness is very small, but in the infrared, about 12 nm increase in thickness has caused an increase of about 8% in the spectrum. Then, the absorption spectra of the samples made in the laboratory were measured, the results of which can be seen in the figure below.

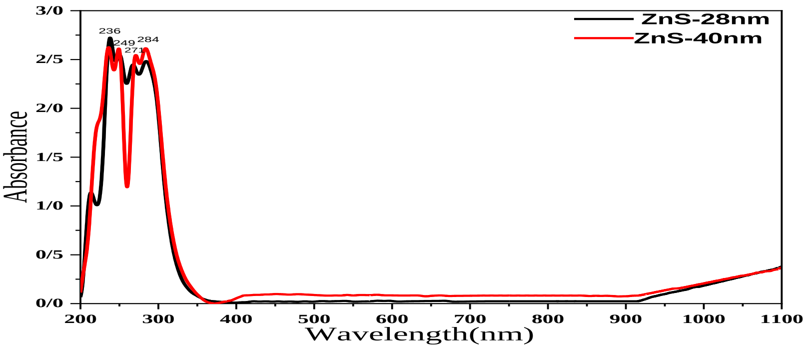


Figure 1-4. Ultraviolet Visible_ near-infrared absorption spectrum in the range of 200 to 1100 nm for ZnS samples coated on glass glass substrates at 28 and 40 nm thicknesses.

The absorption spectrum of the ZnS sample is seen in which there are multiple peaks such as 249, 236, 271 and 284 nm. However, according to reported studies, ZnS has a high potential for absorbtion of the incident light at wavelength range of 220 and 350 nm. However, a portion of this absorption may be due to ultraviolet glass substrates that clearly blocks the transmission of the spectrum. For example, the absorption in the range of 250 nm has also been reported in the Noor Azie Azura Mohd Arif paper for ZnS (4). McLeod software was used to compare the simulation results with those of the experimental samples simultaneously. As can be seen in the following figures, the transmission of ZnS coating, with a thickness of less than 40 nm on the hypothetical surface of a quartz substrate, is between 50 and 90% in the range of 300 to 1100 nm, which is approximately between 60 and 90 percentage in simulations with filmetrics.

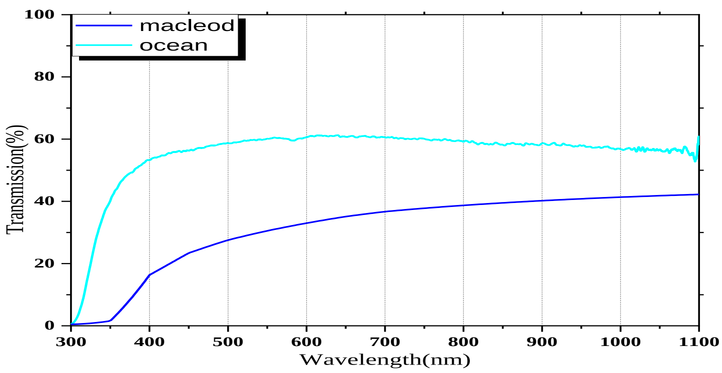


Figure 1-5. The visible-infrared spectrum of the ZnS samples with a thickness of 28 nm on a glass substrate by McLeod software compared to an experimental sample.

2-4. Ultraviolet-visible-infrared absorption, transmission and reflection of MgF_2 anti-reflective thin film on the substrate surface Glass

In the following figures, the magnesium fluoride coating on the glass surface is simulated. The simulation thickness values are from 10 nm to 150 nm. In the case of magnesium fluoride, it can be clearly seen that the reflectance was very small, ranging from 4 to 8%. Therefore, it is a very transparent coating with a transparency of more than 95%, even at thicknesses higher than 100 nm. Transparency is found to be varied between 95% and 99%. Therefore, it can be used as an anti-reflective coating on other coatings, including reflective coatings such as gold, because its adsorption is almost negligible, and in the absorption spectrum of the real sample, mainly the adsorption of the substrate glass is seen. However, this coating may also be applied directly to the glass, causing an increase of about 10% in near-infrared transmission. Therefore, it can be easily used for ultraviolet and infrared applications.

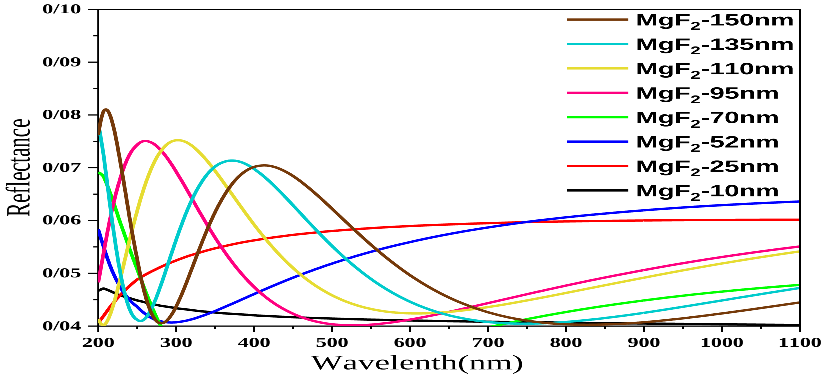


Figure 1-6 MgF_2 thin film reflectance spectrum simulated for thicknesses ranging from 10 to 150 nm.

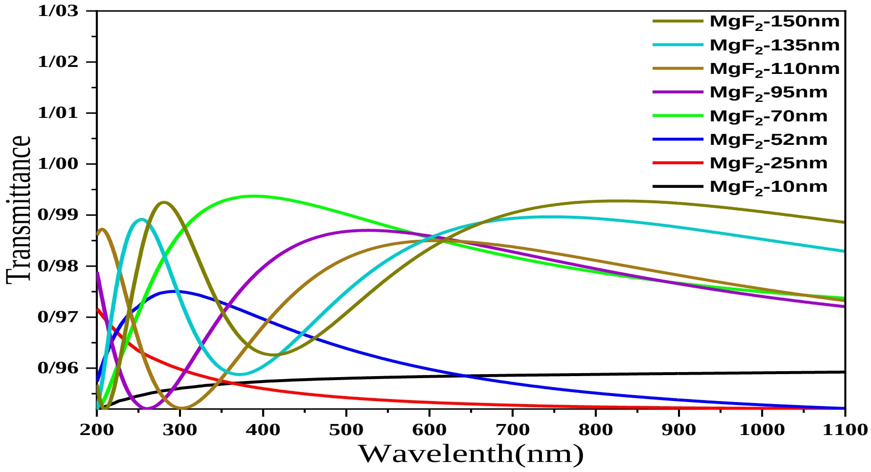


Figure 1-7 The simulated transmission spectrum of the MgF_2 thin film for thicknesses ranging from 10 to 150 nm.

3-4. Absorption, transmission, and reflection of ultraviolet_visible_infrared of the Au / MgF_2 anti-reflective / reflective thin films on the surface of glass substrate.

The following figure shows the simulation of a 7 nm gold coating and then a 135 nm coating of MgF_2, which have been investigated as an anti-reflective coating with the aim of increasing the transparency. The optical properties of AR coatings depend on the thickness of the coatings, the wavelength and the refractive index. The transmission spectrum of MgF_2 thin films produced is compared with the spectrum of samples of gold thin film coated with MgF_2.

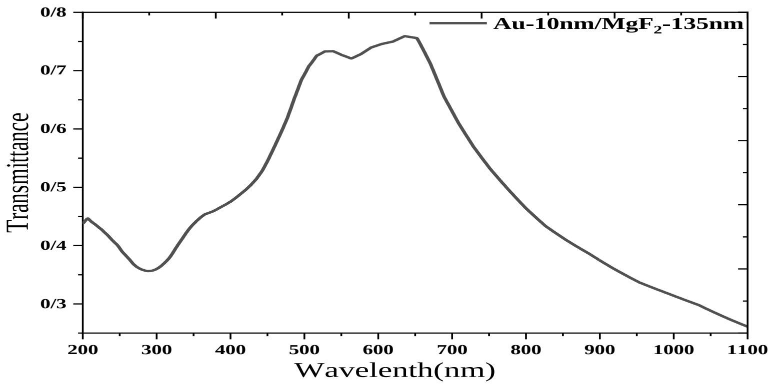


figure1-8. The simulation result of the transmission of the Au-10 nm / MgF_2-135nm sample.

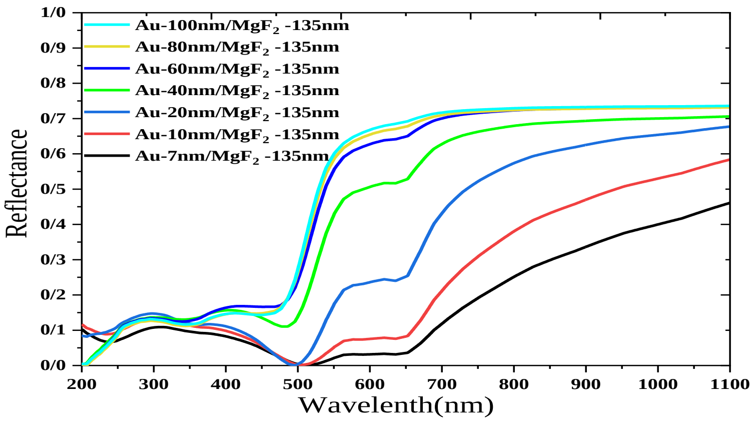


Figure 1-9 The simulation reflection of Au / MgF_2-135nm sample with thicknesses of 7 to 100 nm.

In the above simulation figures, various simulations of magnesium fluoride coating were deposited on the gold coating and then real samples were made of them, which can be seen in the following spectroscopic results of several samples.

Figure 1-10. The fabricated sample coated on the glass with dual coatings Au-7nm / MgF_2-135nm.

As shown, thin films of gold less than 8 nm thick are almost transparent, and this is true of most metals. The absorption edge at 300 nm for all materials is due to the adsorption under the glass layer. In the case of 7-nanometer and 10-nanometer-thick gold samples that have been analyzed, it can be clearly seen that they have a maximum throughput of about 500 nanometers and a drop in the UV and infrared edges. The black spectrum also shows the transmission of about 62%. From 700 nm onwards, the transmission shows a descending state that is close to infrared. All thin layers of gold precipitated by thermal evaporation method have a maximum transparency for $\lambda = 500$ nm. However, they behave differently at longer wavelengths. The following are examples of other layers of this type that are simulated in pairs, which can be seen in the following images:

5. Magnesium fluoride micro Raman spectrum of MgF_2

The micro Raman spectrum of MgF_2 samples can be seen below, which is quite similar to the samples reported by other researchers, including Barker (6).

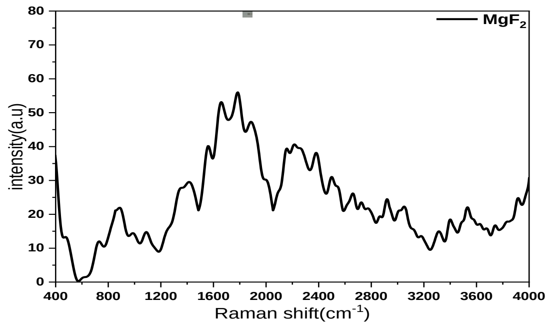


Figure 1-11 Raman spectra of MgF_2 magnesium fluoride sample.

Recently, it has been tried to make a new material for hole-passing layer by combining diamine with mineral. This effort improves the structural and chemical stability of the hole-transmitting layer, as minerals have much higher melting temperatures. In this study, magnesium fluoride ~ MgF_2! Selected for minerals. MgF_2 has a wide transparent region from 200 to 5000 nm, which indicates that the band gap of MgF_2 is more than 6 eV. It is found that the MgF_2 film prepared by the conventional vapor deposition method has an almost stoichiometric composition and is smooth and uniform. TPD-doped MgF_2 thin films were prepared by vapor deposition. The source materials were simultaneously evaporated from two separate graphite crucibles and placed on a substrate maintained at room temperature with a vacuum pressure of 131027 Torr. MgF_2 and TPD deposition rates were maintained during deposition using ~INFICON XTC thickness monitors! 40 Å/min and 5-20 Å/min, respectively, TPD concentration is expressed in terms of volume percentage estimated from sedimentation rate. X-ray diffraction studies showed that TPD-doped MgF2 thin films are amorphous and have excellent stability at room temperature. Even after heat treatment at 82°C for 2 hours, no crystallization was observed (7).

A typical XRD pattern of MgF_2-MWCNTs is shown in Figure 1-25. The diffraction peaks of MgF_2 corresponded to (111), (210), (211) and (112) planes, respectively. In addition, there was a MWCNT peak. The diameter of MgF_2 nanoparticles made from autoclaved sulfate was larger than MgF_2 made from aged processed salts, because the MgF_2 nanoparticles grew during the autoclaving process. The size of MgF_2 nanoparticles synthesized in situ on the surfaces of MWCNTs can be adjusted by sol-gel processing of MgF_2 in different ways (8).

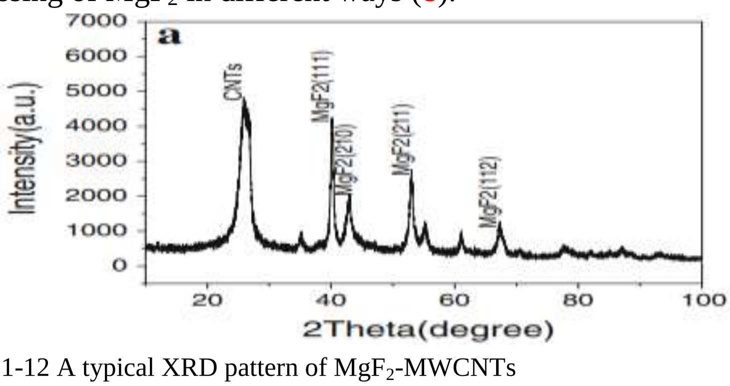
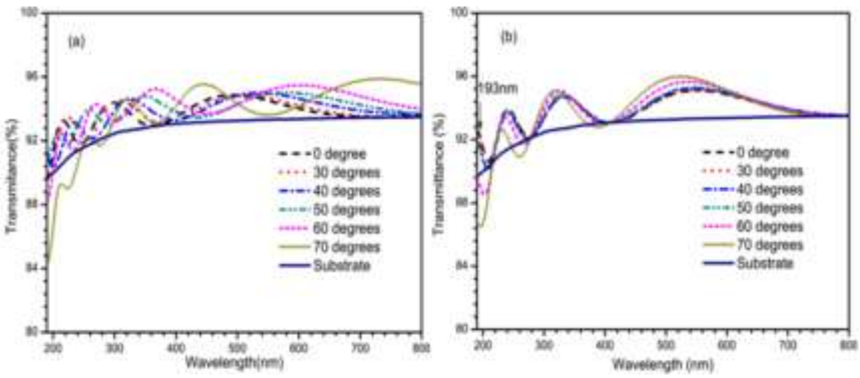


Figure 1-12 A typical XRD pattern of MgF_2-MWCNTs

The MgF_2/ZnS bilayer can also be used as an encapsulation layer for flexible OLEDs (organic light-emitting diodes) because the flexible substrate cannot withstand high process temperatures. In addition, we can fabricate the

MgF_2/ZnS bilayer and OLEDs in one chamber, which ensures that the entire process is carried out in a high vacuum environment. Transferring devices from an evaporation system to an encapsulation system (such as sputtering or a plasma-enhanced chemical vapor deposition system) is believed to cause dark spots due to unwanted exposure of the OLED to particles, oxygen, and water vapor immediately prior to encapsulation. It becomes primary. The MgF_2/ZnS bilayer has a good water vapor and oxygen barrier capability, which has been proven by the calcium degradation test. Devices encapsulated with several pairs of MgF_2/ZnS films showed a significant improvement in lifetime compared to devices with a single pair of MgF_2/ZnS thin films. Transparent and smooth MgF_2/ZnS thin films are potentially applied to high-emissivity OLEDs and flexible OLEDs due to their good light transmission properties and easy fabrication (9). The atom-to-atom density feature of 1 vapor-deposited thin film growth can be used to produce mixed layers of one or more soluble or insoluble materials with variable composition-dependent refractive index. Although several z-7 workers have studied the refractive index changes of blend films with composition, only scanty data are available on the dispersion behavior of the optical constants of blend films. It is clear that the knowledge of dispersion of optical coefficients of mixed film materials is of great importance in designing and manufacturing optical devices. Therefore, it is desirable to study the detailed optical behavior of composite films with the aim of ensuring their usefulness for optical devices. This paper reports the results of our investigation of the dispersion behavior of the optical constants and the shape of the fundamental absorption edge of homogeneous mixed films of ZnS and MgF_2. The



wavelength dependences of the refractive index of ZnS-MgF_2 layers with different compositions as well as pure ZnS and pure MgF_2 layers are shown in Figure 1. The refractive index values of pure ZnS and pure MgF_2 layers are completely matched. well with those obtained by previous workers. From Figure 1, it is evident that the dispersion is higher for films with a high concentration of ZnS than for films with a higher concentration of MgF_2 (10). Figure 1-26 shows the measured spectrum of magnesium fluoride monolayer films produced at different deposition angles in angled deposition devices. Obviously, the minimum transmittance of magnesium fluoride films is slightly higher than that of the uncoated substrate in the wavelength range of 300 to 800 nm (11).

Figure 1-13 transmission spectra of MgF2 films prepared with different deposition angles and comparison with uncoated substrate.

In another study, Nielson et al used sulfide doping on low density polyethylene fibers to improve solar reflectance for radiative cooling. Sometimes polyethylene fibers are injected with different structures or nanostructures such as titanium dioxide, zinc sulfide and zinc selenide (composites). For example, a polyethylene layer with a thickness of 400 micrometers containing 15% sulphide with a solar reflectance of 84.9% and an absorption of 13.8% has been used as a cover for a radiator in daytime cooling (12). Sulfide is a direct bandgap semiconductor with an energy bandgap of about 3.65 eV. This value of the energy bandwidth may be related to the state of preparation and the amount of doping between 3.65 and 3.7 electron volts, and this threshold of zinc sulfide absorption is placed in the ultraviolet (13). In a research, the optical properties of the films were calculated in the visible light to near and mid-infrared regions, and the simulation results showed a low reflection of infrared radiation up to less than 0.02% and infrared transmission up to more than 0.80% at a wavelength of 8 to It was 13 micrometers. Then, their cooling performance has been checked. Similarly, for zinc selenide and zinc telluride, the cooling power during the day is more than 90 W/m_2, and therefore these types of coatings support radiant cooling during the day and night (14). We report a design and fabrication strategy to create synthetic multilayer optical filters using a thermal evaporation technique. We selectively chose a zinc sulfide (ZnS) lattice for the high refractive index layer (n = 2.35) and a magnesium fluoride (MgF_2) lattice as the low refractive index layer (n = 1.38). In addition, the microstructures of ZnS/MgF_2 multilayer films are also investigated through TEM and HRTEM imaging. The filters are made of 7 and 13 alternating layers with high refraction and low refraction, which show 89.60 and 99% reflection, respectively. The optical micro cavity achieved an average transmission of 85.13% in the visible range. The obtained results show that these filters can be an exceptional choice for next-generation anti-reflection coatings, high-reflection mirrors, and polarized interference filters. ZnS has a wide direct band gap of 3.5–3.8 eV, a high refractive index of 2.35 at 550 nm 15 with low optical absorption in the visible and infrared spectral regions, and transmission of high energy photons, 16–19 while MgF_2 has The refractive index is low. Refractive index 1.38 at 550 nm 15 and wide pass range. Extensive studies on the optical properties of ZnS films and MgF_2 report that they are quite useful for optical coatings. A high value of refractive index contrast between two types of materials (nH/nL) is more desirable in design. Multilayer structure because it minimizes the number of layers and their physical thickness for a given spectral function. The refractive index of MgF_2 is close to the root of the refractive index of ZnS. For these reasons, ZnS and MgF_2 are suitable options for producing interference optical filters. Hence, by using only a few layers, it is possible to obtain surfaces with a reflectivity equal to that of a silver mirror (96.6%) and surfaces that reflect more than 99%.

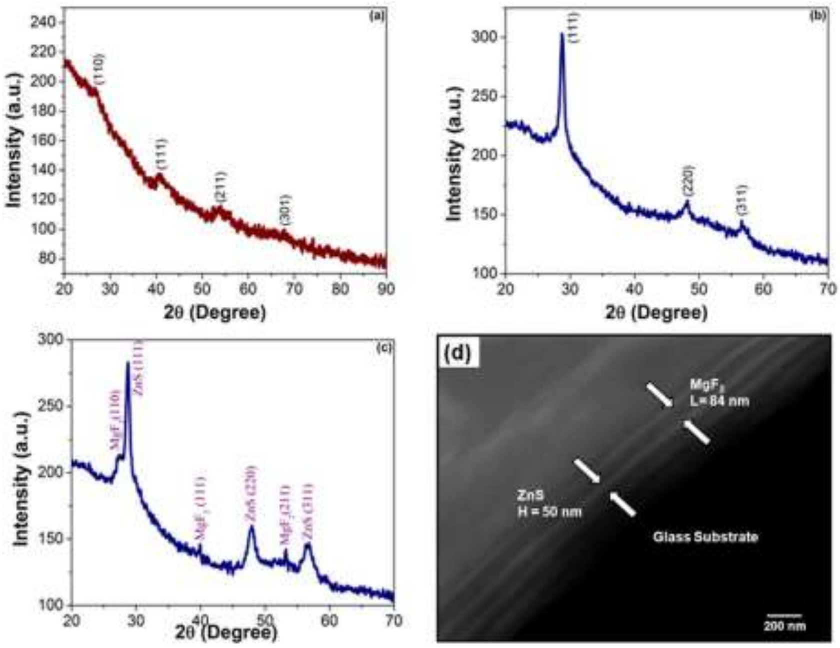


Figure 1-14. XRD patterns of (a) monolayer MgF_2, (b) monolayer ZnS and (c) 13 multilayer ZnS/MgF_2 (d) cross-sectional SEM image of 7 multilayer ZnS/MgF_2 (15).

In this study, multi-layer anti-reflective coatings of magnesium fluoride (MgF_2) and zinc sulfide (ZnS) were prepared using the angle of view deposition (GLAD) method. MgF_2 and ZnS materials are coated on glass substrates in a Hind-Hivac model F 15 coating unit. Anti-reflective coatings were prepared at different angles of the diagonal radiant flux (α = 40°, 65°, 70°, 80°) by thermal evaporation method. X-ray diffraction (GIXRD) analysis showed that the coated thin films at different dip angles were crystallized in a single phase with a crystalline structure. The XRD results showed the improvement of film crystallinity with increasing grain size. Optical properties were investigated throughout the measurement of transmission and refractive index spectra and extinction in the visible region. As the flux angle increased from 40° to 80°, the refractive index of the films decreased from 2.8 to 1.66. As the flux angle increased from 40° to 80°, the extinction coefficient of the films increased from 0.03849 to 0.05997. The extraordinary transparency of MgF_2 has led to its use in optical systems. MgF_2, when used as a coating on optical window lenses, has an ideal anti-reflective property. ZnS is a remarkable wide bandgap semiconductor that is widely used in optical systems. It has a reflection loss of 24.7% and a refractive index of 2.2. ZnS is a practical and suitable material for use in anti-reflective films, due to its special features such as high versatility, wide bandgap, high transmittance and low cost. One of the suitable methods for making ZnS films is the physical vapor deposition (PVD) method. This technique has unique advantages including; Low operation cost, low material consumption, high sedimentation rate. MgF_2 and ZnS thin films are easily prepared with high optical quality using thermal evaporation systems, making the materials suitable for use in optical devices. (16). Zinc sulfide (ZnS), a remarkable infrared (IR) optical material, is used in many optoelectronic systems that require an anti-reflection (AR) and suitable protective coating to increase transmission, on windows, lenses, and domes. Figure 4 shows the IR transmission spectra of coated and uncoated ZnS samples. The coating meets the specifications with an average transmission of 96% in the desired spectral region and a peak beyond 98% at a wavelength of 4.2 µm. Compared to the theoretical value presented in Figure 1-28, the measured throughput is lower.

First, the used ZnS substrate is subjected to hot pressure and its transmission rate does not exceed 71%, so its absorption drop is the reason for the transmission difference. Second, instrument-agent calibration errors and monitoring errors during layer deposition contribute greatly to this.

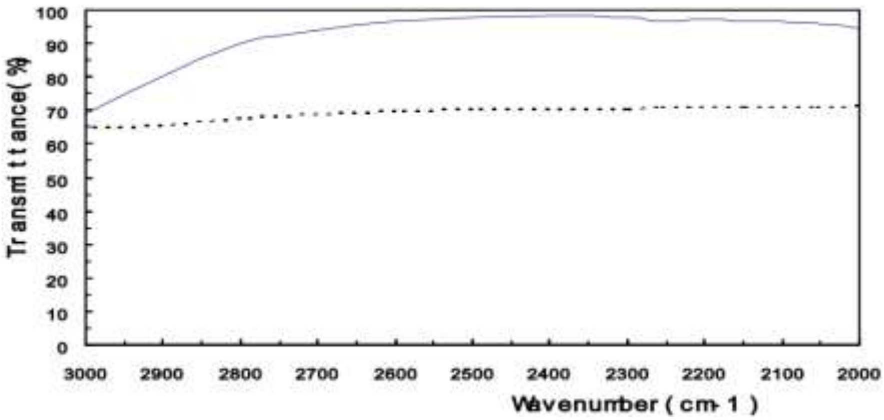


Figure 1-15 Spectra of coated (solid curve) and uncoated (dotted line) ZnS sample (17).

From FTIR spectroscopy, it was found that in the wavelength range of 8 to 12 micrometers, the average transmittance of the two-sided coated sample increases by 26% and reaches a maximum of 98%. FESEM figures show that all samples were uniform, compact with good adhesion on the ZnS substrate. XRD pattern of ZnS/MgF_2 multilayers which shows the presence of both MgF_2 and ZnS virgin phases respectively. The design was done by the Essential Macleod program (Thin Film Center Inc.), which is a comprehensive software package for the design and analysis of optical coatings. In this software, the desired characteristic (transmission/reflection/absorption) is determined by optimizing the thickness of the upper and lower refractive index layers. The design of multi-layer coating using MgF_2 and ZnS was done on ZnS substrate. Optimization was done with the simplex method at a reference wavelength of 10 micrometers (18). Magnesium fluoride (MgF_2) in particular has attracted much attention in research and has become a standard material for optical coatings. MgF_2 is known as a material with high transparency, high refractive index (1.3), good mechanical properties, hardness: 415 (Mohs), low absorption coefficient, good stability in hostile environments and good chemical stability. The high transparency of this material has made it widely used in optical windows. MgF2 is a very good anti-reflective material used as a coating on lenses. One of the reasons for using this material as a resonance in lasers is its high anti-reflection property. A number of researchers have produced MgF_2 thin films using the GLAD method, for example: Chun et al deposited MgF_2 thin films at different angles and investigated the effect of increasing the deposition angle on their optical and structural properties. The results showed that with the increase of deposition angle, the refractive index decreased and the extinction coefficient increased. Barinogueh et al prepared MgF_2 thin films using GLAD technique and investigated their optical properties. The results showed that the effective refractive index decreases with the increase of the deposition angle. Therefore, our main goal is to design and manufacture. A monolayer MgF2 antireflective coating and to investigate the effect of the deposition angle on its optical and structural properties, we also aim to achieve an optical transmittance of more than 98% in the large wavelength range (19). In this study, we investigated the simultaneous response characteristics of MIM nanostructures on a disk composed of magnesium fluoride (MgF_2) as an insulating layer and gold (Au) as metal layers. The MIM nanostructures on the disk are expected to have two LSP modes, which generate electric fields outside the MIM nanostructures and inside the insulating layer, and are expected to respond independently to changes in two phases: the surrounding environment and inside the insulating layer. Furthermore, by introducing MgF_2, which is known to absorb hydroxyl groups of water molecules as an insulating layer, MIM nanostructures with LSP mode are expected to respond to the hydroxyl group, which generates electric fields inside the insulator. Layer. By combining the individual mode distribution and MgF_2 absorption characteristics, MIM nanostructures are expected to investigate the information related to RI change in solution and changes within the MgF_2 layer related to the interaction of molecules in solution with MgF_2 (20).

RESULTS

In a nutshell, it can be seen that the types of optical coatings used in optical equipment or devices, require accurate knowledge of the values of transmission, absorption, reflection in different spectral regions such as ultraviolet, visible and infrared. The results obtained from the simulations in several cases, including ZnS, magnesium fluoride, and others, are a relatively good criterion for detecting the same properties in real and operational samples. However, each of these coatings has its own characteristics and these results are summarized below: ZnS has good transparency in the range of 200 to 1100 nm. The simulation was performed by Filmetrics and McLeod in thicknesses of 10 and 100. Thickness of about 10 nm has a transparency of more than 90%, while at thicknesses of about 100 nm this parameter has decreased to less than 60%. However, with an increase in thickness from 10 nm to 100 nm, the transparency has varied depending on the wavelength of the visible to near infrared regions. McLeod's simulation for crossing for ZnS coating, with a thickness of less than 40 nm on the hypothetical surface of a quartz substrate, is between 50 and 90% in the range of 300 to 1100 nm, which in the simulation with Filmetrics was approximately between 60 and 90%.

In the simulations, in general, the transparency in the infrared region with a thickness of less than 100 nm has been more than 60%, and therefore this material seems to be suitable for applications in near infrared areas. For any thickness and application, simulations must be performed. Comparison of the visible-infrared spectrum near two real-made samples with thicknesses of 28 and 40 nm on the glass substrate, shows that ZnS in the range from 400 nm to 1000 nm to 40 nm thickness, about 60% transparency. Although in the visible region the difference in thickness is very small, but in the infrared, about 12 nm, the increase in thickness has caused an increase of about 8% in the spectrum. Therefore, both simulations and experimental samples show at least 60% transparency, mainly for thicknesses less than 100 nm.

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