

TABLE OF CONTENTS

Title	Page
Table of contents	i
List of Figures	iv
List of Tables	vi
الاية	vii
Dedication	viii
Acknowledgement	ix
Abstract	x
المستخلص	xi
CHAPTER ONE	
BASIC CONCEPTS	
1-1 Introduction	1
1-2 Study objectives	3
1-3 Thesis structure	3
1-4 Laser and its properties	4
1-5 Transparent and opaque materials	5
1-6 Homogeneity and heterogeneity	5
1-6-1 Homogeneity	6
1-6-2 Heterogeneity	6
1-7 Isotropy and Anisotropy	7
1-8 Refractive index and extinction coefficient	8
1-9 Interaction of light with matter	9
1-9-1 Absorption	10
1-9-1-1 Beers-Lambert Law	11
1-9-2 Reflection	12
1-9-3 Emittance	13
1-9-4 Dispersion	14
1-9-5 Scattering	15
1-9-6 Kirchhoff's Law	16
1-10 Relationship between Transmittance, Reflectance, and Absorptance	16
1-11 Intensity Measurement	17
1-11-1 Transmission measurement	18

1-12 Single and Multi-Layer Thin films	18
1-13 Production methods of thin-films	21
1-13-1 Chemical Deposition	21
1-13-1-1 Plating	22
1-13-1-2 Chemical Solution Deposition (CSD)	22
1-13-1-3 Chemical Vapor Deposition (CVD)	22
1-13-2 Physical Deposition	23
1-13-2-1 Thermal evaporation	23
1-13-2-2 Sputtering	23
1-13-2-3 Pulsed Laser Deposition	23
1-13-2-4 Cathodic Arc Deposition (Arc-PV)	23
1-13-3 Deposition from Liquid	24
1-14 Interference by thin films	24
1-14-1 Thin film interference due to reflected light (Parallel Thin Film)	25
1-14-2 Thin film interference due to transmitted light	27
1-15 Reflectivity of a Single Thin Film on a Substrate	29
1-16 Typical Applications of thin Films	30
1-16-1 Antireflection coatings	31
1-16-2 Achromatic beam splitters	31
1-16-3 Color filters and band-pass filters	31
1-16-4 Color-selective beam splitter	33
1-16-5 Narrow pass-band (interference) filters	33
1-16-6 Semi-transparent mirrors	34
1-16-7 Heat control filters	34
1-16-8 High reflectivity mirrors	35
1-16-9 Polarizers	35
1-16-10 Reflection filters	35
1-17 Literature Review	35
CHAPTER TWO	
EXPERIMENTAL PART	
2-1 Introduction	39

2-2 Experimental setup	39
2-2-1 Vacuum chamber	40
2-2-2 The vacuum pump	40
2-2-3 The vacuum gauge	41
2-2-4 The samples	41
2-3 Lasers and light sources	44
2-3-1 Helium –Neon (He-Ne) laser	44
2-3-2 Omega laser XP	46
2-3-3 Diode Laser (532 nm)	47
2-3-4 Aiming beam (LED) of Q- switched Nd: YAG laser	48
2-3-5 Sodium vapor lamp	48
2-4 Photo-detector	49
2-5 Digital Oscilloscope (CRO)	50
2-6 Digital Multimeter DT-700D	50
2-7 Setup arrangement	51
2-8 Experimental procedure	51
CHAPTER THREE	
RESULTS AND DISCUSSION	
3-1 Introduction	54
3-2 Samples Results and Analysis	54
3-2-1 Results of Diode laser (532 nm) assisted deposition	55
3-2-2 Results of He-Ne laser assisted deposition	61
3-3 Conclusions	65
3-4: Recommendations	66
References	67

LIST OF FIGURES

Figure	Page
Fig.1.1: The interaction of radiation with matter	10
Fig.1. 2: The interaction of light with a transparent material	11
Fig.1.3: The variation of refractive index with wavelength	14
Fig.1.4: Energy balance of incident light upon interaction with a sample	17
Fig.1.5: the spectral reflectivity of single layer at normal incident a) $n_s=1.51$	19
Fig.1.5: the spectral reflectivity of single layer at normal incident b) $n_s=1.58$	19
Fig.1.5: the spectral reflectivity of single layer at normal incident c) $n_s=1.61$	19
Fig.1.6: A stack of thin films, each of optical thickness $\lambda/4$	20
Fig.1.7: Optical path difference in parallel thin films for reflected beams	25
Fig.1.8: Optical path difference in parallel thin films for transmitted beams	27
Fig.1.9: Measured spectral transmittance multilayer which reflects the blue and near infrared	31
Fig.1.10: Measured spectral transmittance at various ϕ of a color selective beam splitter.	31
Fig.1.11: Measured spectral transmittance at $\phi=45^\circ$ of a color selective beam splitter which reflects the green	32
Fig.1.12: A color selective beam splitter which reflects the red and green, but transmits the blue.	32
Fig.2.1: Schematic diagram of the experimental setup	38
Fig.2.2: Vacuum pump photograph	40
Fig.2.3: CuSO_4 structure	41
Fig.2.4: Absorption spectrum of CuSO_4	42
Fig.2.5: Outline of the energy levels involved in the He-Ne laser.	44
Fig.2.6: All components and the experimental setup for He-Ne assisted deposition	50
Fig.2.7: All components and the experimental setup for laser diode assisted deposition	51

Fig.3.1: Part of measurement of the transmitted intensity through the thin film using sodium light source	54
Fig.3.2: The detected Diode laser 532 nm signal before deposition	55
Figure 3.3: Interference fringe indicates deposition of $\lambda/2$ of laser diode thickness of the thin film of CuSO_4	55
Fig.3.4: transmission percentages versus wavelengths for 266 nm thickness of CuSO_4 thin film	57
Fig.3.5: The refractive indices of 266 nm CuSO_4 thin film versus wavelengths	58
Fig.3.6: Absorption coefficients versus wavelengths for 266 nm thickness of CuSO_4 thin film	59
Figure 3.7: Interference fringe indicates deposition of $\lambda/2$ of He-Ne laser thickness of the thin film of CuSO_4 .	60
Fig.3.8: transmission % versus wavelengths for He-Ne laser assisted deposition of CuSO_4 thin film	62
Fig.3.9: The refractive indices of 316.4 nm CuSO_4 thin film versus wavelengths	63
Fig.3.10: Absorption coefficients of 316.4 nm CuSO_4 thin film versus wavelengths	64

LIST OF TABLES

Table	Page
Table 1.1: Measured and illicit contributions of light	17
Table 2.1: Specifications of the vacuum pump	39
Table 2.2: Copper Sulphate properties	39
Table 2.3: Technical specifications of He-Ne laser	45
Table 2.5: Technical specifications of Omega XP	45
Table 2.6: Specifications of diode laser 532 nm	47
Table 2.7: Specifications of sodium lamp 93122	48
Table 2.8: The specifications of C.R.O.	49
Table 2.9: DT-700 Multimeter basic specifications	49
Table 3.1: intensities with and without the deposited thin films with thickness = 266 nm	56
Table 3.2: wavelengths and their Transmission percentage, Reflectance calculated values	56
Table 3.3: wavelengths, Reflectivity's, and the calculated refractive indices	58
Table 3.4: wavelengths and the calculated values for the absorption coefficients	59
Table 3.5: intensities with and without deposition of thin film with 316.4 nm thickness	61
Table 3.6: wavelengths and their Transmission , and Reflectance	61
Table 3.7: wavelengths and the calculated refractive indices for 316.4 nm thickness	63
Table 3.8: wavelengths and the absorption coefficients for 316.4 nm thickness	64

الله

قال تعالى:

(.. وَقُلْ رَبِّ زِدْنِي عِلْمًا ..)

صدق الله العظيم

طه (آية ١١٤)

Dedication

This work is dedicated to the soul of my youngest sister (Nibras), may Allah forgive her and grant her his highest paradise.

Also is dedicated to my family, especially to my father who I will never be able to repay him for his absolute backing and support, meeting my needs before I know I need them.

Acknowledgement

All praise are for Allah, Lord of the worlds, who helps me and gave me the power to complete this study.

My sincere thanks and appreciations to Laser Institute- Sudan University of Science & Technology Staff, and employee.

I would like to thank my supervisor **Prof. Dr. Nafie Abd ALatif Almuslet** for his valuable suggestions, guidance, assistance and patience during this work, and during his teaching some courses in the M.Sc. program (Application of Laser in Physics), his method of teaching was benefit to me and it's my pleasure to be one of his students.

Thanks to everybody who has helped me by any way through this work.

Abstract

In this work, a known concentration of CuSO_4 dissolved in distilled water in order to fabricate thin films on glass substrate of (1.5) refractive index and (1.2) mm thickness by evacuation method in the presence of laser source to control the thickness of the deposit film. Two laser types were used in control process, diode laser (532 nm) and He-Ne laser (632.8 nm). They were selected due to their emissions in the visible region, which aid in alignment between them and the optical detector.

According to the relation between the film thickness and the wavelength of the laser, the interference phenomenon in thin films, and for their low powers they were safe to operate with. Two films with different thicknesses were deposited on two glass substrate that have the same refractive index and the same thickness for each film the transmitted intensity in different monochromatic light sources was recorded before the deposition process. Then calculation were carried out for the Transmission percentage, refractive indices and the absorption coefficients. (The transmission percentages were calculated by considering the thin films not absorb any part of the intensity). The relation between percentage transmitted intensity and the wavelength was plotted for each film to represent part of its transmission spectrum, and then the calculated relations (refractive indices and absorption coefficients) were plotted as functions in wavelengths.

The same procedure was repeated for each film and the optical properties (transmission spectrum, refractive indices and absorption coefficients) for the two films, the relations of the optical properties was shown to be dependent on the film thickness.

The obtained results shows the possibility of the deposit material (thin film of CuSO_4 on glass substrate) as an optical filter in certain wavelengths or as reflector for other wavelengths.

في هذا البحث تم ترسيب اغشية رقيقة من كبريتات النحاس مذوبة في الماء المقطر بتركيز معلوم على شريحة من الزجاج ذات معامل إنكسار (١.٥) وسمك (١.٢ مم) بطريقة التفريغ وفي وجود الليزر بغرض السيطرة على سمك الغشاء المترسب.

أستخدم نوعين من الليزر في عملية السيطرة وهما ليزر الثنائي (٥٣٢ نانومتر) وليزر الهيليوم-نيون (٦٣٢.٨ نانومتر). حيث تم إختيارهما لان اطولهما الموجية في الجزء المرئي مما يسهل عملية التراصف بينهما والكاشف البصري. و بناء على العلاقة بين سمك الغشاء والطول الموجي في ظاهرة التداخل الموجي في الأغشية الرقيقة ولبساطة القدرة للعمل بهما . تم ترسيب غشائين و بسمكين مختلفين وفي شريحتين من الزجاج لهما نفس السمك ومعامل الإنكسار. لكل غشاء سجلت الشدة النافذة لعدة مصادر ضوئية أحادية الطول الموجي. من ثم أجريت حسابات للشدة النافذة كنسبة مئوية ومعاملات الإنكسار والإمتصاص وحسبت النفاذية باعتبار أن المادة لا تمتص أي جزء من الشدة. رسمت العلاقة بين الشدة النافذة كنسبة مئوية والأطوال الموجية لتمثل جزء من طيف النفاذ للمادة ومن ثم تم رسم العلاقات المسجلة (النفاذية كنسبة مئوية) والمحسوبة (معاملات الإنكسار والإمتصاص) مع الطوال الموجية.

أجريت نفس الخطوات لكلا الغشائين وتمت مقارنة الخصائص البصرية (طيف النفاذ ومعاملات الإنكسار والإمتصاص) لكلا الغشائين لوحظ إعتقاد هذه الخصائص على سمك الغشاء.

أظهرت النتائج المتحصل عليها إمكانية استخدام المادة المرسبة (الغشاء الرقيق من كبريتات النحاس علي سطح الزجاج) كمرشح عند بعض الأطوال الموجية أو كعاكس لبعض الأطوال الموجية الأخرى .