A THESIS

entitled

SOME APPLICATIONS OF INTERFEROMETRY TO LENGTH METROLOGY

Submitted to
Ain Shams University
In Partial Fulfilment of the Requirements
for the Degree of Master of Science

BY

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1971

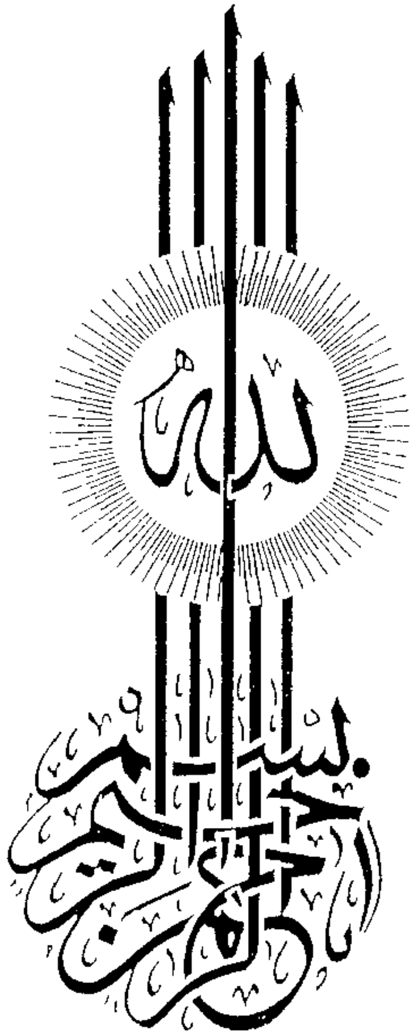
ACKNOWLEDGEMENT

I wish to express my gratitude to Professor Dr. N. Barakat, Dean of the Faculty of Science, Ain-Shams University for suggesting the subject investigated and for his helpful guidance.

I would like also to express my thanks to Dr. S.R. Haddara, Director of the National Institute of Metrology, where this work has been done, for his interest and encouragement.

My deep thanks and appreciation are due to Dr. S. Mokhtar, Head of the Unit of Optical Standardization of length for her continuous supervision of the work.

My thanks are also due to the members of the Unit for their assistance.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CONTENTS

CHAPTER I

Construction of a New Fabry-Perot Etalon Mirror and Its Application in Length Metrology.

Page

CHAPTER II

Determination of the Optical Constants of Selenium Film.

Page

CHAPTER I

CONSTRUCTION OF A NEW FABRY PEROT ETALON MIRROR AND ITS APPLICATION TO LENGTH METROLOGY

GENERAL INTRODUCTION

Experiments on application of interferometry for the measurement of length in terms of light waves are continually performed in laboratories of Metrology. The main interference systems are basically Fabry-Perot fringes systems in transmission and at reflection using a single or compound Fabry-Perot interferometer.

Investigations on the spectroscopic characteristics of spectral sources used in length measurements, namely the half-width of the emitted spectral lines used illuminating the interferometer, are of considerable importance as the half-width affects fringe visibility on which many methods of length measurements are based. There is always a demand for increasing the maximum distance over which fringes have good visibility.

In the present work experiments were carried out on the possible use of the semi-conductor Se in alternation with the dielectric MgF_2 as a Fabry-Perot mirror since the evaporation process of Se is much easier and takes shorter time as compared with any other dielectric used in alternation with MgF_2. Also selenium thin films possess a high refractive index value and a very low absorption coefficient in the spectral region investigated. It has been found experimentally that an evaporated Se thin film of thickness 2000 Å possesses the properties characteristic of dielectric thin films where the absorption coefficient is nearly zero and is of a suitable high refractive index. It is most suitable for use as one of a multi-layer coating of Fabry-Perot etalon in alternation with quarter wave length film of MgF_2.

Chapter (I) deals with the construction of Fabry-Perot mirrors consisting of three, five and seven alternate multi-layers of Se and MgF_2 reaching a reflectance of 68%, 74% and 87% respectively and absorption of nearly zero, 1% and 1% respectively indicating the magnitude of the increase in the reflection coefficient with increasing the number of layers at λ 6438 Å.

Chapter (II) deals with the experimental determination of the optical constants of an evaporated Se thin film by the method derived by Valeev (1963)[1]. It is applied here for the first time in the visible region for Se and is based on the measurement of the transmission coefficient of uncoated substrate T_o and coated substrate T. Then from the variation of T_o and T with wave lengths, the refractive index of the substrate and the optical constants of Se are obtained.

The values of the optical constants n and k for Se are found to be in good agreement with the published data.

1.1. Previous Work

It was Fabry and Perot[2] who, in 1[illegible], introduced a new era of precision into optical interferometry by developing both the theory and practice of their celebrated plane parallel plate interferometer.

Single and Multi-layer coating of high and low refractive index dielectric are used for enhancing the reflectivity of the glass plate.

In the visible region, Pfund (1934)[3] increased the reflectivity of a glass plate to 31% by depositing $\lambda/4$ film of ZnS. By evaporating alternate layers of cryolite and TiO_2, Cartwright and Turner (1939)[4] obtained a reflection coefficient of 0.85. Banning (1947)[5], Dufour (1948)[6], Kluber and Jarrett (1952)[7], and Stone (1953)[8] studied the optical performance of multi-layers coating using ZnS and cryolite films. Kluber and Jarrett attained the value of 94% at λ 5461 Å and about 97% for nine multi-layers respectively, while Stone obtained the value of $R = 97\%$ for nine multi-layers at λ 5000 Å. A graphical vector method was described by Turner (1950)[9] for deriving the refractive index required in multi-layer reflection coating for obtaining best achromatic condition for compound anti-reflection layers.

Giacomo (1952)[10] obtained reflection coefficient for layers of cryolite and ZnS each of $\lambda/4$ thick which are in good agreement with those calculated from classical Fresnel theory.

Tolansky (1953)[11] used multi-layer film of alternate high and low refractive index of $\lambda/4$ thickness of reflectivity ranging from 0.31 - 0.97 for multiple beam interferometry at reflection. Vasicek (1953)[12] solved theoretically the problem of the reflection of light from glass with dielectric films.

Korolev and Sukhanovskii (1954)[13] produced Fabry-Perot etalon with dielectric mirrors consisting of multilayers coating of ZnS and $NaAlF_6$ each layer of thickness $\lambda/4$, by evaporation in a high vacuum. A high reflectivity of > 87% and higher resolution with practically no absorption were characteristic of seven layers in the visible and infra-red regions. Giacomo (1955)[14] computed the transmission of dielectric multi-layer thin film of thickness $\lambda/4$ and applied such method to Fabry-Perot interferometer.

Baumeister and Stone (1956)[15] obtained a broad region of high reflectivity exceeding 0.90 from λ 4000 Å - 7200 Å which was secured with a complex 15 alternate multilayers of ZnS and cryolite all of different thicknesses.

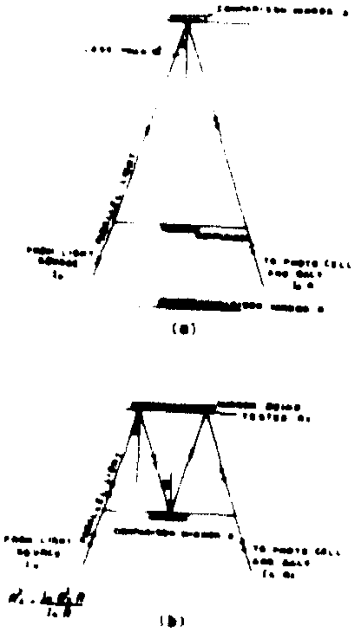

Figure (1)

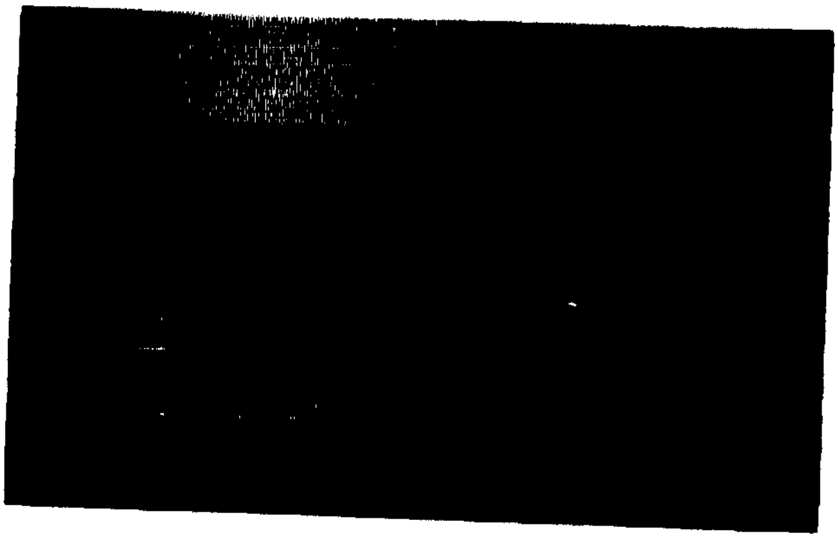

Plate (1)

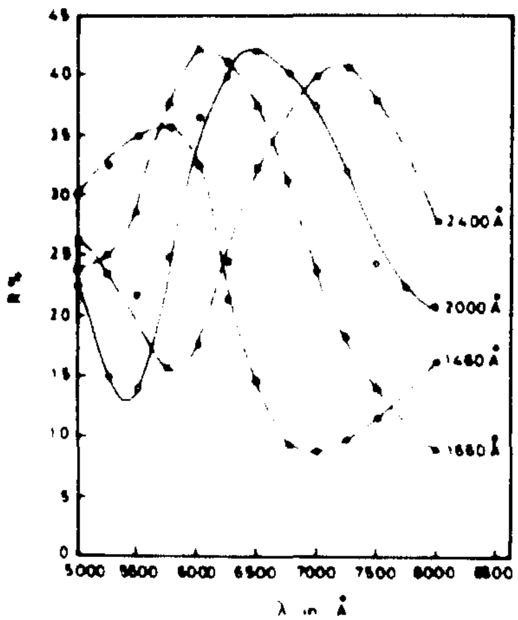

Fig (2a) Variation of reflectivity R with wave length λ at different thicknesses of Se-layer

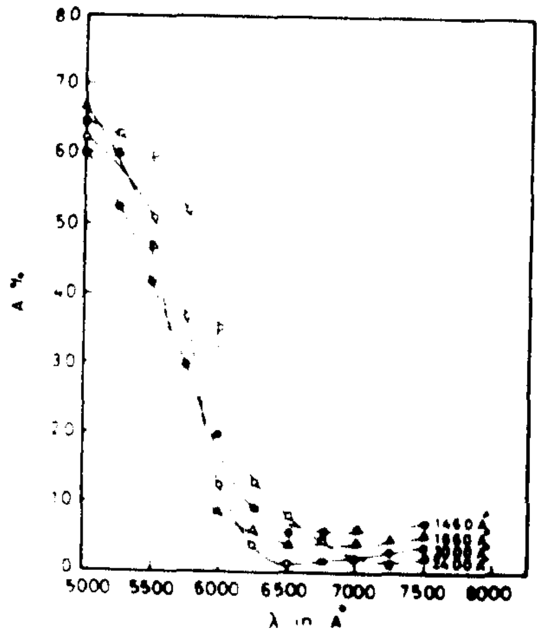

Fig. (2b) Variation of absorption A with wave-length λ at different thicknesses of Se layer