SOME OPTICAL AND ELECTRICAL PROPERTIES OF SEMICONDUCTING MATERIALS IN THIN FILM FORM

THESIS

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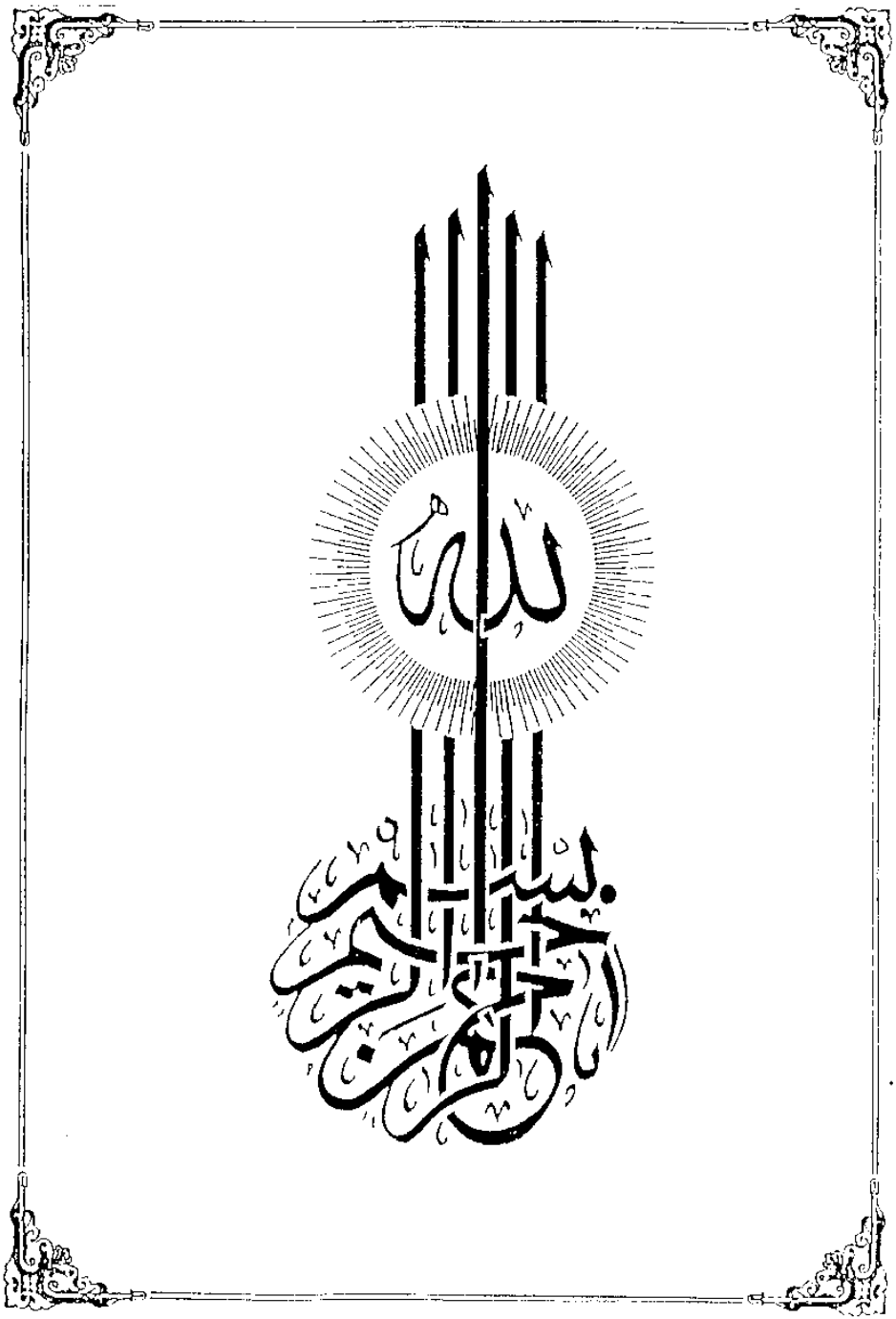

Contents

Abstract

Lead selenide thin films of different thicknesses (25–1400 nm.) were deposited onto glass/quartz substrates in vacuum of 10^{-5} Torr as well as 10^{-10} Torr. X-ray diffraction patterns showed that these films have polycrystalline structure.

The optical constants (the refractive index, n, the absorption index, k and the absorption coefficient, α) of the **lead selenide** films were determined. n and k were independent of the film thickness in the range 30–1000 nm. n showed anomalous dispersion in the region of the fundamental absorption edge (~ 3 μm).

These optical constants were used to determine the high frequency dielectric constant ($\epsilon_\infty \approx 20$) and the static permittivity ($\epsilon_o \approx 195$).

The linear relations of $\alpha^2 = f(h\nu)$ and $\alpha^{1/2} = g(h\nu)$ indicated the existence of both direct and indirect optical transitions, with energy gap values 0.35 and 0.27 ev respectively.

The electrical transport properties (resistivity, Hall coefficient and thermoelectric power) of **lead selenide** films were studied in air, in vacuum and in ambient gases. The electrical resistivity dependence on film thickness, measured in air or in vacuum had basically the same behaviour. The Hall measurements showed that the majority of the **lead selenide** films of thicknesses below 800nm were p-type; and above this thickness the films were usually n-type.

The ambient gases Ar, He and N_2 had no considerable effect on the resistivity and Hall measurements of the films. On the other hand, oxygen had an obvious role in altering the identity of the free charge carriers of the **lead selenide** films.

The concentration of the charge carriers calculated from the electrical resistivity, Hall and thermoelectric power measurements had the same order of magnitude (10^{17}-10^{18} cm^{-3}).

The interaction between oxygen (as well as the other ambient gases) and **lead selenide** surfaces was studied through surface scans carried out on the ESCA III

The effect of oxygen on the different Se and Pb photolines was studied in details. Oxygen reactivity appeared more pronounced in the Se-excess samples; being p-type in conduction. The oxide layer formed at exposures of 10^{12}L of oxygen was estimated to be in the monolayer range.

INTRODUCTION

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Semiconductors, which could be chemical elements, metallic oxides, sulfides and selenides, as well as halide and carbide compounds; possess properties which commend them to our most interested attention. In the course of seeking new sources of energy, different semiconductors were used in varistors, thermistors, transistors and photoelectric devices which infilterated and revolutionized the field of electronics.

They are usually classified according to the nature of the particles which carry current into ionic and electronic semiconductors.

The characteristics of a family of polar semiconductors, consisting of PbS, PbSe and PbTe, have played an important role in providing experimental foundation for theories of various semiconductor phenomena.

These compounds have the cubic rock-salt structure which typifies ionic compounds, and although their chemical behaviour can best be described by regarding them as ionic, their electrical properties bear a greater resemblance to those of group IV elements.

A number of researchers have found that these lead chalcogenides possess a number of interesting features, among which are the following :

(i) They defy the usual rule that in a series of similar compounds the energy gap falls as the molecular weight increases.

(ii) Their static dielectric constants are unusually high (178, 206 and 380 for PbS, PbSe and PbTe respectively) as estimated by Burstein et al. [1] among others. Putley [2] indicated that such high values may account for the absence of impurity activation energies even in the purest crystals; and for the absence of ionized impurity scattering at low temperatures.

(iii) Unlike the majority of semiconductors, the mobility does not fall as the temperature is reduced to the He range. It generally tends to a constant value or may continue to rise slowly. This behaviour is more like that of a metal; showing a constant residual resistance.

(iv) The mobilities of holes and electrons are of comparable magnitude; unlike those of say, the III-V compounds, which possess very high mobility ratios.