THE DIELECTRIC PROPERTIES OF THE ZnS FILMS

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The dielectric properties of the ZnS films obtained by magnetron sputtering on the glass and the mica are considered. Beginning from the thickness of 150 Å the films were solid. The dependence of dielectric constant on thickness shows the decrease of ε in the range of 0.1 mkm and less. The frequence dependence of $tg\delta$ increases, and versus the electrode resistance media it decreases. The moisture effect on the dielectric loss tangent is also shown.

1. INTRODUCTION

The dielectric properties of films are of great Interest both in studies of electroconductivity of such films and their application in different devices.

The description of dielectric properties in literature refers mainly to thick films intended for preparation of condenser in microelectronics. It is clear that for the condenser with a high capacity the films of low thickness and high dielectric constant are necessary. As the solid films of a very low thickness with permanent properties are very difficult to be prepared, rather thick films (more than 500 Å for oxide films) are usually used in condensers. Thus, the study of temperature and frequency dependences of dielectric constant and dielectric tangent of the ZnS films is the purpose of the present paper. The thin films of ZnS were obtained, by the magnetron sputtering method in argon medium [1].

The mica and glass were used as the substrates. The aluminum and golden electrodes were used as the contacts. The structure and morphology of films were controlled by electron diffraction camera.

2. RESULTS AND DISCUSSION

Theoretical calculations show [2] that the dielectric constant of films is independent of the thickness up to several atomic layers. This fact was confirmed experimentally [3] with organic films of cadmium stearate with perfect structure and thickness to 24 Å. The dielectric properties of the dielectrics films are estimated according to the results of a simultaneous measurement of capacity and dielectric tangent. The dielectric loss coefficient measured is composed of the dielectric losses of different mechanisms and the dielectric loss at series connection of electrode resistance with capacity.

The contribution of electrode resistance to electroconductivity depends on frequency and this fact should be taken into account. That is, in order to decrease the dielectric loss coefficient at high frequencies, the metallic electrodes of low resistivity should be used.

When deposited from the vapor phase, the atomic accumulation takes place during the growth. As a result, the thin films (200 Å) are usually porous and the dielectric constant values of such films decrease rapidly with decrease in thickness [4]. The dielectric constant (ε) of the ZnS films is shown in fig.1. When the film porosity effect on the dielectric constant is appreciable, the film thickness depends on the way and conditions of film deposition. In the case of ZnS, this thickness decreases with decrease of the substrate temperature. For the mica substrate it is lower than for the glass. A high inner mechanical tension usually existing in deposited films does not nearly affect their properties. In the case of cracking and shelling of these films under the effect of mechanical tension, their effective dielectric constant becomes lower.

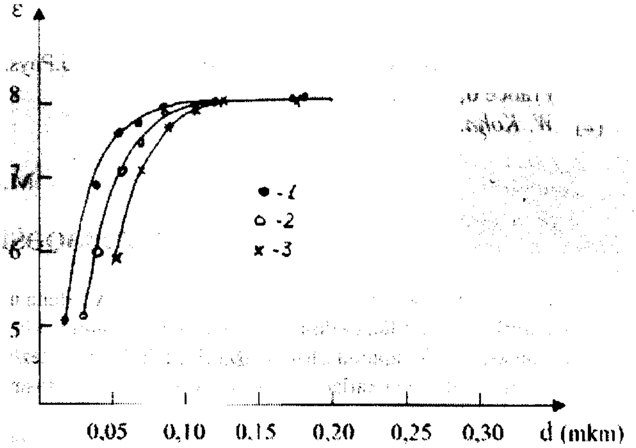

Fig.1 The dependence of dielectric constant on the ZnS film thickness: 1) Al-ZnS-Al on the mica at 25^0 C;
2) Al-ZnS-Al on the glass at 25^0 C;
3) Al-ZnS-Al on the glass at 300^0 C.

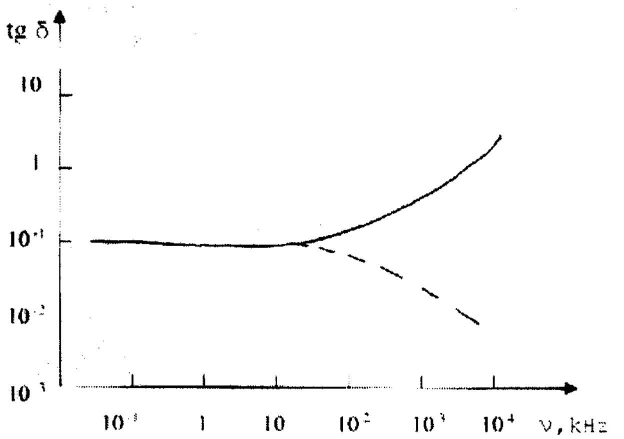

Fig.2 The frequency dependence of dielectric loss in the ZnS films: 1) The solid line – without account of the electrode resistance;
2) The dash line – with account of the electrode resistance.

The electric field applied to the thin film of the dielectric is usually of the order of 10^8 V/m that is close to the breakdown voltage value. If the polarization in the dielectric does not correspond to the change of the field, the dielectric losses, as is known, appear. Principally, the dielectric losses refer to the bulk properties and should be independent of the thickness if the structural defects are not involved into any relaxation mechanism. If the film is not very thin, the thickness does not affect the dipole reorientation. The dielectric losses can be varied by stoichiometry, Therefore, their magnitudes strongly depend on the deposition conditions. As the temperature increases and depending on the material of electrodes that diffuse in the dielectric film, the intensive increase in losses is observed [5]. The frequency dependence of the loss coefficient measured with the ZnS condenser of 1000 pF in capacity is shown in fig.2. The increase of the losses at high frequencies is due to unaccounted electrode resistance.

The solid lines in fig.2 denote the data without account of electrode resistance, while the dash line denotes the data with account of electrode resistance. The dielectric loss in such films can be explained by excess concentration of vacancies. The dependence of dielectric loss has the maximum at 200 and 450 K corresponding to the activation energies of 0,15 and 1,12 eV.

Subsequent to film deposition, their dielectric losses increase with the film aging. The loss coefficient and the capacity are higher, the lower the frequency. Hence, one can say that at frequencies below 100 Hz a certain relaxation mechanism takes place, while at frequencies about ~ 1 Hz the dependence of (ε) and $tg\delta$ has the form of the plateau which can be considered as the mechanism attributed to the joint action of the two mechanisms of losses, at least.

The absorbed moisture considerably increases the capacity and the dielectric loss even in the case of material insoluble in water. This increase of capacity and the dielectric losses is probably due to the effect of principal mechanisms of the change of ε and $tg\delta$.

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ZnS NAZİK TƏBƏQƏSİNİN DİELEKTRİK XASSƏLƏRİ

Məqalədə maqnetron tozlandırma üsulu ilə şüşə və slüda üzərində alınmış ZnS nazik təbəqəsinin dielektrik xassələrinə baxılmışdır.
Qalınlığı 150 $\AA$ –dən böyük təbəqələr sәlt təbəqələr idi. Təbəqələrin dielektrik nüfuzluğunun qalınlıqdan asılılığı göstərir ki. 0.1 mkm-dən kiçik qalınlıqlarda ε azalır. Dielektrik itkisi $tg\delta$ tezlik artdıqca artır. ancaq elektrodların müqavimətini nəzərə alsaq, azalır.
İşdə həmçinin su buxarlarının dielektrik itgisi $tg\delta$–ya təsiri göstərilmişdir.

М.М. Панахов

ДИЭЛЕКТРИЧЕСКИЕ СВОЙСТВА ПЛЕНОК ZnS

Рассмотрены диэлектрические свойства пленок ZnS. полученных магнетронным распылением на стекле и слюде. Пленки были сплошными. начиная с толщины 150 $\AA$. Толщенная зависимость диэлектрической проницаемости показывает уменьшение. ε начиная с 0.1 мкм и меньше. Зависимость $tg\delta$ частоты возрастает: а с учётом сопротивления электродов. уменьшается. Показано также влияние влаги на $tg\delta$ диэлектрических потерь.

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