OPTICAL PHASE PROPERTIES OF THIN FILMS AND ROLE OF OPTICAL PHASE IN LENGTH MEASUREMENT

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Presented by
FEDIA ABD ELAZEZ IBRAHEEM
(M.Sc.)
National Institute For Standards

N. Bashar
Samira
Shaalan
Sobee

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SUMMARY

SUMMARY

The field of the present investigation comprises determination of some optical phase properties of thin silver and manganese films and the role of phase properties in length measurement.

Chapter I deals with optical phase properties of thin films and their relation to the effective optical constants. Thin thermally evaporated silver films were prepared and their effective optical constants n_e and k_e were determined. This was achieved by two methods :

a) Deduction from experimentally measured Reflectivity R_2 at air/film, R_1 at substrate/film and Transmissivity T of silver films and at three wavelengths.

b) Calculated from formulae based on proposed models for the structure of the thin films. The optical phase properties determined are the phase change at reflection air/film β_2, substrate/film β_1 and the phase change in transmission γ through the metallic film. Electron microscopic examination of such films served to provide information necessary to apply both Maxwell Garnet theory, based on the presence of spherical particles forming the films and Schopper's modification of the previous model, based on the existence of ellipsoids of revolution characterized by their $\frac{b}{a}$ ratio

between minor and major axes, termed f, and its mode of distribution around a prefered value $\bar{f}$. Applying Schopper's model to the specified range of thickness for silver films from 85 to 145 Å, the value of $\bar{f}$ was chosen to lie in the range 0.9 - 1.0. Such choice is in accordance with electron microscopic findings. The volume fraction q which is the percentage of bulk material to geometrical volume has been utilized to calculate the effective optical constants. Critical comparison between the values obtained for n_e and k_e for silver films over the thickness range 85 - 470 Å applying the three previously mentioned approaches has been performed and the result reported.

The optical phase properties of silver films namely β_1, β_2 and γ have been calculated, based on the values of n_e and k_e.

This chapter includes, also, the deduction of the optical constants of comparatively thick films of silver, antimony and bismuth from exprimentally determined values of the change of phase in transmission through these films.

Chapter II deals with the optical phase function F of thin films and its role in fringe intensity distribution at reflection. It is known that the optical phase function F which equals ($2\gamma - \beta_1 - \beta_2$) controls the intensity distribution of multiple beam reflected fringes. In multiple beam Fizeau at reflection localized on the Feussner surface of zero order, the F value of the metallic layer coating the upper component of the interferometer plays an important role in the formation of the interference systems. Dark sharp symmetrical fringes on a bright background which is a valuable tool in measuring thickness of thin films to a high degree of accuracy are formed only when $|F| = (2n+1)\ \pi$, emphasizing one aspect of the role of optical phase properties in length measurements. When $|F| \neq (2n+1)\ \pi$, fringe intensity distribution is no longer following the complementary Airy summation in transmission. Partial reflection - like fringe distribution takes place as the $|F|$ value deviates from the previous value. They change to partial transmission like, reaching symmetrical transmission - like fringes at reflection when $|F| = 2n\pi$. Some application of such fringe system have been reported.

Formation of images resulting from a wedge interferometer and contributing to the multiple beam intensity distribution has been investigated and accomplished. The relation between the intensity ratios of the images and the formation of transmission-like, partial transmission and reflected systems has been investigated.

In the present work, the variation of the optical phase function F with thickness has been investigated for silver films of thickness from 85 to 470 Å and for manganese films from 155 to 685 Å for λ 5461 Å. Two methods have been performed to determine the optical phase function F. The first is based on computing the fringe intensity distribution at reflection for different values of F and phase difference Δ between successive interfering beams takeing into account the contribution of the change of phase at reflection air/Ag coating the two components of the interferometer and comparing it with the experimental microphotometric intensity distribution, followed by itterations. The second is based on computing the phase at both I_{max} and I_{min} and determining the difference $(\Delta_{I_{max}} - \Delta_{I_{min}})$. Now $(\Delta_1 - \Delta_2) = 2\,\psi - \pi$, the values of ψ for each thin silver film was computed for F value ranging from 0 to 2π. Determining Δ_{12} which is the difference in phase at I_{max} and I_{min} enabled calculating the angle ψ and consequently the corresponding F value for the thin silver coating of the upper component of the interferometer forming the fringes at reflection. This is based on the fact that the angle ψ is a function of a trigonometric function of F in terms of r_1, r_2, r_3 and T_1. Comparison between the F values resulting from the two previously mentioned methods and that based on determining experimentally each phase property namely γ, β_1 and β_2 is presented. Agreement in F values for silver thin films of specified thickness is shown and tabulated.

Chapter III deals with the role of the optical phase properties in length measurements. In the process of calibration of gauge blocks, the secondary standards of length, the Köster interference comparator is often used. The steel gauge block is wrung to a flat plate of either glass, quartz or steel and introduced in one arm of the interferometer./Two systems of interference are formed, one belongs to the upper surface of the gauge block and the reference mirror while the other system results from light rays reflected from the upper surface of the substrate to which the gauge block is wrung and the reference mirror. A fringe shift appears between the two systems of stright line fringes with two - beam intensity distribution following a cosine