S.p.23. Vijayakumar, K.P.–Surface Studies of some metallic thin films by optical methods–1984–Dr. C. Purushothaman

Optical properties of thin films are wellknown due to the practical applications of thin films in different fields. The main limitation in experimental as well as theoretical aspects of the same was the difficult calculations involved and this has been removed by the introduction of high speed computers. But the factors affecting the surface and structure of films, causing variations in their optical properties, are enormous in number. In this work, the effects of some among them are studied in detail.

The thesis aims to present the results of experimental investigations on the changes of optical properties of metallic thin films due to heating. The parameters which are measured are reflectivity, refractive indices and the ellipsometric quantities and Δ. The materials used in the studeis are metals like Silver, Aluminium andd Copper. By applying the optical method the interdiffusion taking place in multilayer films of Aluminium and Silver has also been studied. Special interest has been taken to reveal the mechanisms of the hillock growth and surface roughness caused by heating and their relation with the stress in the film.

The thesis contains nine chapters which are generally self-contained with separate abstracts; however I is of an introductory nature. It contains some general considerations regarding the scope and importance of the present work. It also gives a brief description of the ddifferent features affecting the optical properties of films and a summary of different methods for its analysis. A brief suvey of the earlier works is also included in this chapter. The present status and some aspects of the application of the optical studies are presented in the second half of this chapter.

The next chapter gives the details of the experimental procedure. It contains the description of method of preparation of the samples and the thickness measuring technique. The experimental set up for annealing and optical measurements are also included in the chapter.

The changes in the reflectivity of Silver films due to annealing in the temperature range 30° C to 300° C are discussed in chapter III. Here the results of annealing in air and vacuum are considered separately. The explanation of these changes is given on the basis of the relationship between the internal stress and the surface energy of the film.

In the chapter IV, the study of interdiffusion in multilayer films by using reflectivity measurements is presented. Here the materials are Aluminium and Silver with the former always forming the lower layer. The changes of reflectivity of both surfaces of the film are studied as a function of temperature. The effect of different thickness ratios of the two layers is also considered.

The chapter V contains the results of the studies on Copper films. Here the temperature variation is from 50° C to 200° C and the thickness of the samples varies from 500° A to 3000° A. From these results an attempt is made to calculate the intrinsic stress values of Copper films of different thickness.

A brief description of ellipsometry, including the basic theory, is presented in the next chapter. It also contains the details of the ellipsometric set up used for the investigation. In the second half of this chapter, the different uses of ellipsometry are included.

In chapter VII. the results of ellipsometric measurements of thermally induced surface roughness (hillock growth) of silver films are presented along with the required theory for the measurement of surface roughness by using ellipsometry. The variation of the hillock growth with thickness of the film is also brought under discussion. This chapter also contains the calculated values of intrinsic stress in Silver films of different thicknesses.

The ligh scattering measurements can give a lot of information regarding the roughness of film surfaces. Hence the surfaces of the samples analysed by using the ellipsometric method have been again examined by using light scattering technique and this is presented in the next chapter. These confirm the results of ellipsometric measurements mentioned in earlier chapter.

All these observations are summarised in chapter IX. This also points out the importance of the low temperature annealing.

A theoretical study of the lattice dynamics of ZnS crystal is also included as an appendix in the thesis. In this, the phonon frequencies for [100], [110] and [111] wave vector directions are calculated for both normal crystal and isotope substituted one ($Zn^{34}S$). From these two values the eigenvector magnitude is computed for the three wavevector directions.

Part of the investigations presented in the thesis has been published/communicated in the form of following papers:

1. Effect of annealing on the reflectivity of Silver film
   K.P. Vijayakumar and C. Purushothaman
   Thin solid Films 82, 225 (1981).
2. Temperature variations of reflectivity of A1-Ag double layer films
   K.P. Vijayakumar and C. Purushothaman
   Proceedings of Nuclear Physics and Solid State Physics Symposium held at Banaras Hindu University, Varanasi, Vol. 25C, p. 8JB5 (1982).
3. An optical study of the thermal effects on Cu films K.P. Vijayakumar and C. Purushothaman
   Thin Solid Films, 112, 71 (1984).
4. Optical study of surface diffusion in Silver films K.P. Vijayakumar and C. Purushothaman
   Proceedings of Nuclear Physics and Solid State Physics Symposium held at University of Mysore, Mysore, Vol. 26c, p.SAB8 (1983).
5. Lattice vibrations and eigenvector magnitudes in ZnS
   K.P. Vijayakumar and C. Purushothaman
   Indian Journal of Pure and Applied Physics, 19, 749 (1981).
6. Ellipsometric study of thermal effects on Silver films K.P. Vijayakumar and C. Purushothaman
   (Communicated to Surface Science).
7. Hillock growth measurement by light scattering technique
   (Communicated to Applied Optics).