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Diffusion of Ag through Se and its effect on interferometric thickness measurement

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Abstract. The effect of diffusion of silver through Se thin films, on the visibility of two and multiple beam interference fringes has been studied. For thickness measurements, Al has been found to be a suitable overcoating metallic layer as it does not diffuse through Se. The thickness was measured by multiple beam fringes at reflection.

Keywords. Selenium films; diffusion of silver; interference fringes.

1. Introduction

The choice of a suitable overcoating metallic layer for interferometric thickness measurements is restricted to semiconducting films as diffusion of some metals takes place in semiconductors.

In the present paper the diffusion of Ag through thin evaporated Se films has been studied by two and multiple beam interference fringes as well as by reflectivity measurements. Among early studies on the diffusion of Ag in Se, Kienel (1955) showed that when Ag and Se are evaporated on top of one, the film interdiffuses quickly to form Ag_2Se. Boltaks and Plachenov (1957) studied self-diffusion in amorphous and crystalline Se and showed that in amorphous Se, atoms diffuse between the tangled chain. Johnson and Brown (1969) studied the effect of varying both the thickness of Ag and Se and temperature on the diffusion of Ag through evaporated Se films. In our studies, it was found that a suitable overcoating metallic layer for Se is aluminium as diffusion takes place in overcoating with an opaque Ag layer.

2. Experimental details and results

2.1. *Reflectivity of Se films*

Se film was prepared by thermal evaporation from Ta boat in an oil diffusion pumping system at pressures less than 10^{-5} mm Hg. The film was left in vacuum until it attained room temperature. The rate of evaporation was ≈ 25 Å/sec. Two Se layers of the same thickness were evaporated on two glass substrates, one with Ag and the other with Al. The reflectivity of both systems were measured by an optical system shown in figure 1, which measured the square of absolute reflectvity at nearly normal incidence for Se thickness ranging from 90–2200 Å at λ 5461 Å. The thickness of

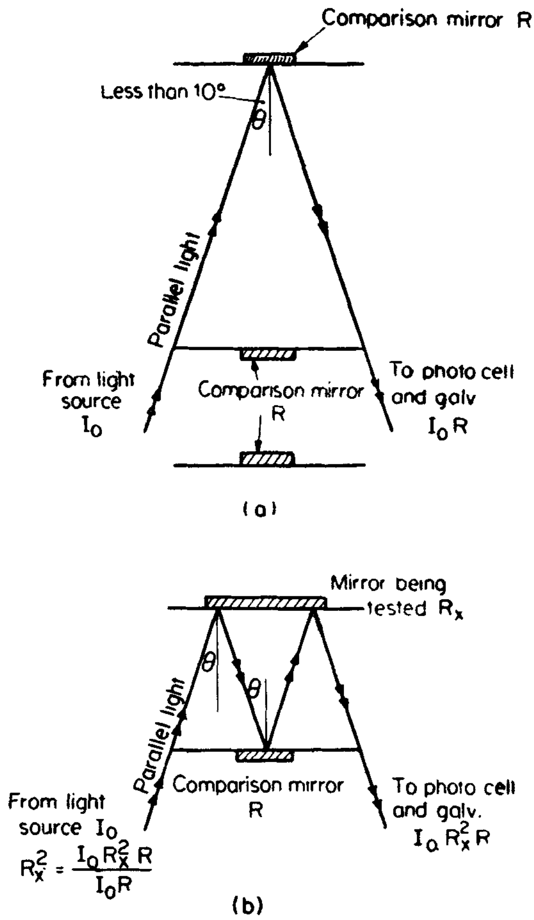


Figure 1. Optical system for reflectivity measurement.

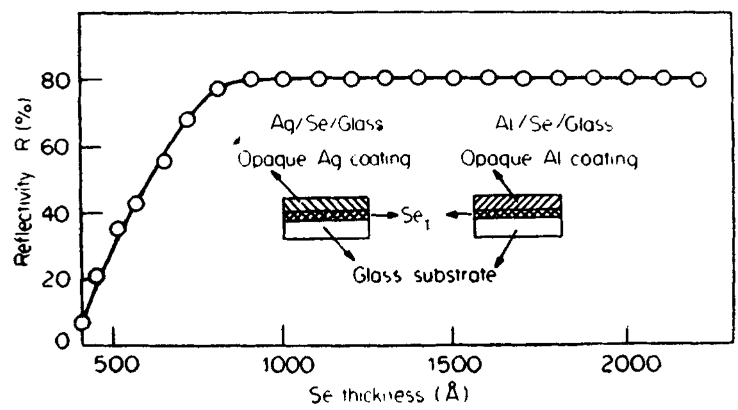
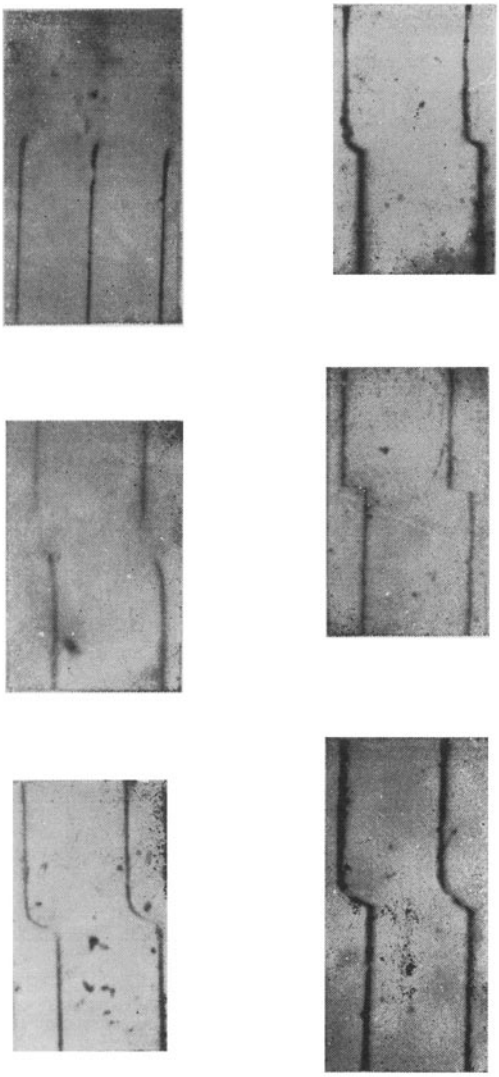


Figure 2. Variation of reflectivity with Se thickness overcoated with opaque Ag layer at λ 5461 Å.



(a) (b) (c) (d) (e) (f)

Figure 3. a and **b.** Appearance of multiple beam fringes at reflection for Se layer of thickness 230 Å overcoated with opaque layers of Ag and Al respectively. **c and d.** Layer thickness 655Å. **e** and **f.** Layer thickness 908 Å.

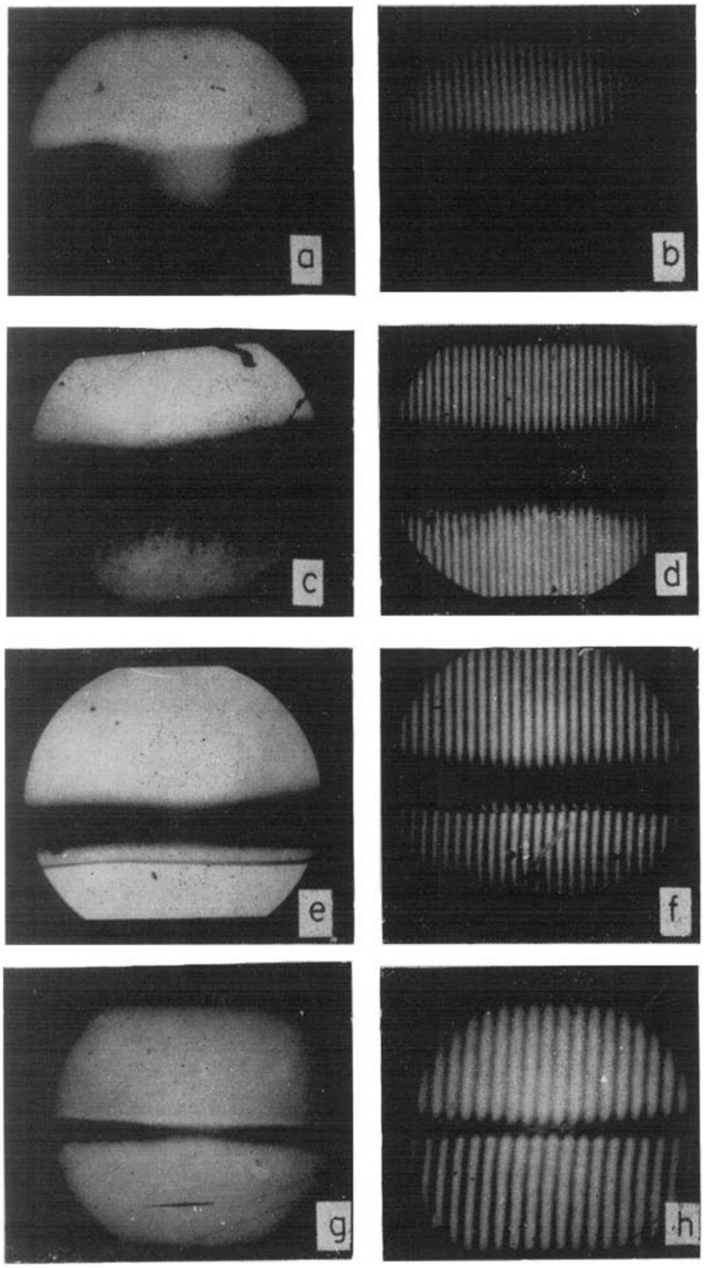


Figure 4. Appearance of diffusion area as formed by Linnik microscope as well as two-beam interference fringes with diffusion area for Se film overcoated with Ag. **a** and **b.** Film thickness 230 Å. **c** and **d.** 800 Å. **e** and **f.** 977 Å. **g** and **h.** 1600 Å.

the overcoated metallic layer was ≈ 1000 Å. The reflectivity for Al/Se/glass system showed a constant value of 88% for all Se thickness ranges while there was a drop in reflectivity for Ag/Se/glass system.

Figure 2 is the reflectivity versus thickness for Se overcoated with Ag. It shows a significant fall in reflectivity for Se < 400 Å while for Se > 400 Å, the reflectivity increases with Se thickness reaching a constant value of 80% at Se $\geqslant 800$ Å. The reflectivity of opaque Ag coating is 90% at λ 5461 Å. This variation signifies the presence of diffusion at the interface between Ag and Se. The diffusion also reduces the fringe visibility of both two and multiple beam interference fringes.

2.2. *Visibility of multiple-beam interference fringes*

To study the effect of diffusion of Ag through Se films, on the appearance of multiple-beam interference fringes at reflection each Se film was evaporated on one half of two optical flats. One of the optical flats was then overcoated with opaque Ag layer and the second with opaque Al layer where each one has been used as a lower component of an air-wedge interferometer. The visibility of multiple beam interference fringes at reflection falls significantly for all Se thickness less than 800 Å overcoated with Ag and then the visibility increases with Se thickness. On the other hand, no drop in visibility occurs for Se overcoated with Al. Figure 3 shows the appearance of multiple beam fringes at reflection for Se overcoated with Ag for Se and Se layers overcoated with Al. There was a difference in thickness between Se overcoated with Ag and Al for Se > 800 Å, which becomes smaller as Se thickness increases. Table 1 shows our results of thickness measurements.

A constant diffusion effect is seen to function and therefore, when the interferometric method using an overcoated opaque Ag layer is used, an incorrect thickness value for evaporated Se film is obtained.

2.3. *Visibility of two-beam interference fringes*

Se films of different thickness were prepared on one half of glass substrate following the same method as described earlier. The thickness corresponding to each layer is evaluated after over-coating with Al. The Ag/Se/glass system was studied by two-beam interference fringes using Zeiss-Linnik interference microscope. Evaporation of Ag over Se resulted in the immediate formation of a dark diffusion area which drops the visibility of the two-beam interference fringes. Figure 4 shows how the width of diffusion area varies with Se thickness as well as the appearance of two-beam interference fringes and diffusion area for the same thickness. Figure 5 also shows the variation of diffusion area width with Se thickness. Our results show that for

Table 1. Thickness measurements for Se overcoated with Ag and Al.

Al/Se/glass	SE overcoated with Ag/Se/glass	Difference in thickness t (Å)
1080	900	180
1126	974	152
1474	1365	110

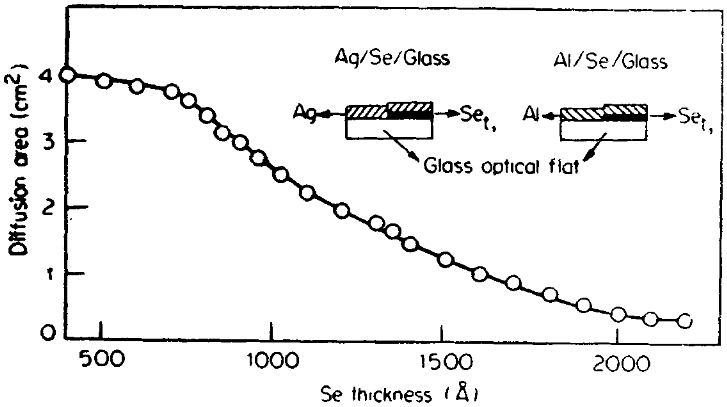


Figure 5. Variation of diffusion area with Se thickness overcoated with opaque Ag layer.

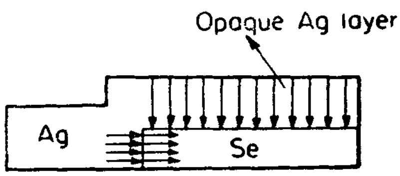


Figure 6. Lateral diffusion of Ag through Se.

Se thickness < 800 Å, the diffusion area appears to reach a maximum and then a constant value, while for Se thickness > 800 Å, the diffusion area falls to a small value. Hence, the drop in visibility is much significant for Se < 800 Å while the visibility appears to be high for Se > 800 Å.

3. Conclusions

The growth area is due to the lateral diffusion of Ag-Se and is controlled by the motion of Ag through amorphous Se films as shown in figure 6. Since the Ag overcoating layer is opaque in all the experiments, the lateral diffusion depends only on Se film thickness. As a result, the growth area is greater for Se thickness below 800 Å and falls to small value for Se thickness above 800 Å. It is believed that the peak growth area is related to the microstructure of Se film which in that thickness range consists of islands that become continuous as the film thickness increases. These islands touch and grow together and impinges on one-another quite early in the deposition process. Diffusion in such a film may be related to a form of grain boundary diffusion along the high disordered inner island region.

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