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Received 9 April
and accepted 15 May 1981

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Effect of d.c. and a.c. electric fields on the electrical resistance of thin samarium films

Recently, the effect of a.c. and d.c. electric fields on the electrical properties of thin metallic films has been reported by many authors [1–7]. Although the effect of deposition parameters on the electrical and structural properties has been the subject of many experimental investigations [8–11], the effect of d.c. and a.c. electric fields on the electrical properties has not been reported so far for any rare-earth metal films. In this letter we report the effect of a.c. and d.c. electric fields on the electrical resistance of samarium thin films in the thickness range 100 to 800 Å.

Samarium of purity 99.9% (Leico Industries, New York, USA) was evaporated at a pressure of 10^{-6} Torr onto a glass substrate held at room temperature (22° C) in the presence of a d.c. electric field of $150\,\text{V cm}^{-1}$. Two separate films of the same dimensions were grown on a single glass substrate, with and without the d.c. electric field. The resistance measurements were carried out *in situ*. Other experimental details are given elsewhere [12].

Fig. 1 shows the thickness dependence of electrical resistivity for films grown with and without the d.c. field. It is seen that the resistivity increases with the application of the d.c. electric field during deposition of the film. This behaviour is quite contrary to the decrease in resistivity with the applied d.c. field reported for thin tin [7], gold [3] and manganese [6, 13] films. We have reported [14] that samarium films exhibit an increase in resistivity with an increase in the substrate temperature, which is attributed to the greater tendency in the case of samarium thin films to form an island structure. We expect a similar enhanced tendency for the formation of islands in the presence of a d.c. field which might result in the increase of resistivity. However, it is not clear why the electrical resistivity increases even at greater thicknesses with the application of a field.

Although it is well known that metallic films exhibit very interesting frequency response characteristics very little work has been reported so far. To the best of our knowledge we are reporting for the first time the high-frequency response characteristics of d.c. resistance of thin samarium films in the frequency range 100 Hz to 1 MHz, for different film thicknesses. The a.c. signal was applied to these films after the film resistance had reached a steady value.

Fig. 2 shows a plot of R_f as a function of $\log f$, where R_f is the d.c. resistance of the film at a particular frequency f. It is seen that the frequency

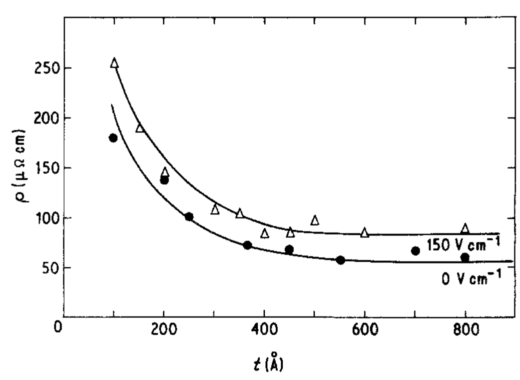

Figure 1 Thickness dependence of samarium film resistivity (ρ) with d.c. electric fields of 0 and $150\,\text{V cm}^{-1}$.

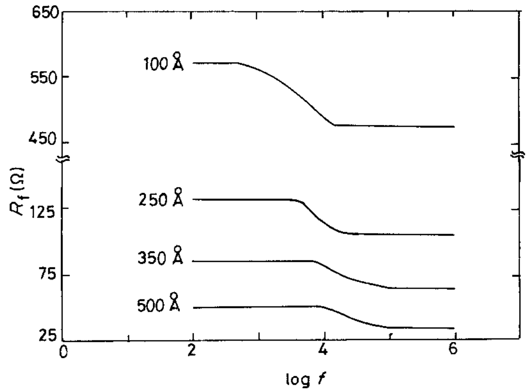

Figure 2 Variation of samarium film resistance (R_f) with frequency (f) for film thicknesses, 100, 250, 350 and 500 Å.

response is flat at lower frequencies (< 10 kHz) but exhibits a sharp decrease in resistance with an increase in frequency and finally attains a constant minimum value. Similar behaviour has also been observed for PbS films [15]. At lower thicknesses, metallic films lack electrical continuity between the islands and the inter-island space is filled with either air or some dielectric material. Hence, this metallic structure in which the islands are separated by small spaces can be treated as equivalent to a series of capacitors [16] and hence might lead to the frequency dependence of the resistance.

The study of high-frequency response characteristics on the a.c. resistance of thin metal films may confirm the validity of this simple model [16], which will be reported in a future communication.

Acknowledgments
One of the authors (PVA) is grateful to the Council of Scientific and Industrial Research, for the award of a Senior Research Fellowship. The financial assistance from the University Grants Commission, New Delhi, is gratefully acknowledged.

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Received 27 April
and accepted 20 May 1981

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Comments on the layer removal method for measurements of residual stresses in plastics

The phenomenon of residual stresses and their significance in polymeric materials have only recently received scientific and technological attention. The measurement of residual stresses in polymeric materials is still a subject for investigation. There are several methods reported for the estimation of residual stresses. They are based either on the disturbance of the state of stress equilibrium or on stress sensitive physical properties. The former include such methods as environmental stress-cracking [1], hole drilling [2], split cutting [3] and layer removal [4]. Other methods include surface hardness [5], stress relaxation [6] and bi-refringence [7]. None of these methods

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