A detailed account of this work will appear in the *Monthly Notices of the Royal Astronomical Society*.

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Conductivity induced in Mica by X-Rays

ALTHOUGH mica is not recognized as one of the highly insulating materials (its specific volume conductivity is quoted in standard reference books as between 10^{-14} and 10^{-17} ohm-cm.$^{-1}$ at 20° C.), its behaviour under X-irradiation is of interest in comparison with the organic plastic insulating materials which we have studied[1].

The experiments on mica were made with sheets 0·15 mm. thick, using the d.c. amplifier technique which we have previously described[1]. Mica shows relatively low values of induced conductivity, of the same order as those in polymethyl methacrylate and amber. The conductivity in mica is not greatly dependent on temperature, and in this respect also it is similar to 'Perspex' and amber. The equilibrium induced conductivity is almost linear with dose-rate, and the recovery after irradiation is rapid. These characteristics lead us to place mica in Class 1 of the insulators we have studied[2], together with plasticized 'Perspex' and amber. (Class 2 includes polystyrene, polytetrafluoroethylene, and unplasticized 'Perspex'.)

Dose-rate dependence. In the relationship between equilibrium induced current i_x and dose-rate R,

$$i_x \propto R^{\Delta}, \qquad (1)$$

we find $\Delta = 0{\cdot}95 \pm 0{\cdot}05$ for mica over the range R = 2–64 r./min. and between − 20° and 100° C. This value does not exclude the possibility of Δ being exactly 1; but it is likely that several of the materials generally believed to have $\Delta = 1$ do in fact have values of Δ slightly less than unity; recent measurements have indeed shown this to be so for red 'Perspex'. Physically, this deviation from unity means that the distribution of traps in depth (energy) is correspondingly non-uniform, with a greater number of shallow traps[3]. Accurate values of Δ are difficult to determine for mica, due to the large static conductivity. There is no doubt, however, that mica is among those materials with Δ closest to unity, and therefore on the basis of an electron-trapping model[3] the distribution of traps is likely to be comparatively uniform.

Dependence on temperature. Fig. 1 shows the graphs of log (conductivity) of mica plotted against the reciprocal of absolute temperature. The resulting straight lines are of slope proportional to the activation energy, according to the general formula,

$$\sigma = \sigma_0 \exp(-W/kT). \qquad (2)$$

In the case of static conductivity (that is, with no incident radiation), $W = 0{\cdot}45$ eV. This is a considerably lower value than those obtained for the

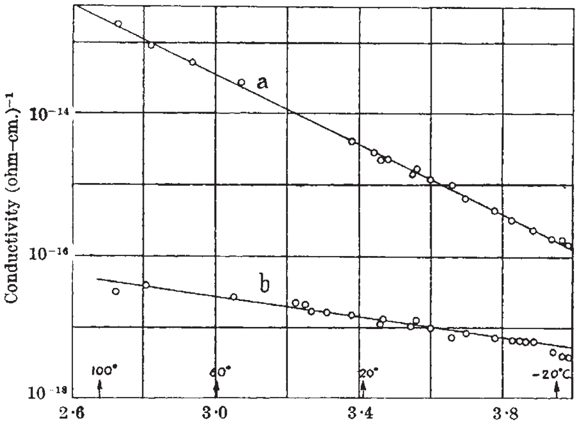

Fig. 1

plastic insulators studied (1·1–1·5 eV.), and to some extent correlates with the relatively high static conductivity of the mica.

For the equilibrium induced conductivity (Fig. 1*b*) at R = 7 r./min., the slope corresponds to $W = 0{\cdot}18$ eV. The current therefore increases by a factor of about 10 between 0° and 100° C. If we assume a slightly non-uniform distribution of traps corresponding to $\Delta = 0{\cdot}95$, the theoretical increase is by a factor of 30. (If $\Delta = 1$, the increase would be very small indeed.) The agreement with this model is reasonable.

Since the induced current in mica is seen as a small increase above the 'dark current', accurate measurement was achieved at the low dose-rates only by cooling the vacuum chamber and the sample to about − 20° C. by means of solid carbon dioxide. The dark current was thereby reduced by a much greater factor than the induced current, and the value of i_x could be determined.

Decay of induced current. The induced current falls rapidly at the end of irradiation to less than one-tenth of the equilibrium value. We were not able to determine whether there was any subsequent longer-term decay of residual current, as the recovery appeared to be complete within a few seconds.

Comparison with other results. Coleman (private communication, 1954) has reported a value of Δ equal to 1, and the actual values of induced conductivity measured by him[4] accord well with those given above. He finds an activation energy of zero for induced conductivity, which is in general accordance with our low value. The cause of this difference may lie in different degrees of impurity in the mica; but it is probably significant that the values of activation energy of insulators measured by different observers, or by the same observers on different samples of a given material, are not in such good agreement as are the values of Δ.

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