polymer reports

Field dependence of photoconduction in Kapton* polyimide film

P. K. C. Pillai and B. L. Sharma†
Department of Physics, Indian Institute of Technology, Hauz Khas, New Delhi-110029, India
(Received 27 February 1979)

Photoconduction in Kapton film under X-ray illumination has been reported by a number of workers[1,2]. However, Kapton is found also to be photosensitative to ultra-violet light which is potentially a more useful region particularly from the point of view of electro-photography. In this paper we have investigated some aspects of photoconduction in Kapton under u.v. illumination at 254 nm, in particular, its dependence on the applied electric field and the polarity of the illuminated electrode. The primary objective of the investigation is to understand the mechanism of photoconduction in this material.

EXPERIMENTAL

The Kapton film samples in different thicknesses were vacuum aluminized on one side to ensure good electrical contact and mounted in a sandwich type cell. One of the electrodes of the cell is made of fused quartz which is partly aluminized so as to transmit 50% of u.v. light incident to it. This electrode is in pressure contact with the uncoated side of the sample. Photocurrent measurements were made with a Keithley 610C Electrometer, at room temperature and under atmospheric pressure. Ultra-violet illumination was obtained from a high pressure mercury vapour lamp with the outer (glass) envelope removed. The intensity of illumination at the sample was kept at 300 $\mu W/cm^2$. The extent of the illuminated area of the sample was 3 cm^2. Care was taken to avoid the memory effect in the sample when the field polarity was changed. To erase the effect of previous polarization the sample was heated to a temperature of about 120°C and then allowed to cool slowly under open circuit conditions. Sufficient time (24 h) was allowed for the sample to relax to normal state before a second run was made.

RESULTS

The photocurrent (I_p) was greater than dark current (I_d) by two to three orders of magnitude. Typical kinetics of the photocurrent are shown in *Figure 1*. It took about 2 min for the current to become steady after the voltage was switched on and another 2 min were allowed for the photocurrent to stabilize after the start of illumination at each step. The current *versus* electric field (E) plots for 2 samples of different thicknesses are shown in *Figure 2*. In the low field region ranging from 10 to 100 kV/cm the photocurrent (I_p) was found to obey Ohm's law and was larger with the illuminated electrode positive (I_p^+). At high fields, above 150 kV/cm the photocurrent shows a superlinear dependence on the electric field (E) and the photocurrent with the illuminated electrode negative (I_p^-) becomes greater than the photocurrent with the same electrode positive (I_p^+). However, in this region both I_p^+ as well as I_p^- are found to obey the Poole Frenkel law: $\log_e I_p \propto E$.

DISCUSSION

Possible mechanisms for the superlinearity of photocurrents[3-5] at high fields may be considered to be: (1) Poole–Frenkel effect when the carriers are generated within the bulk of the film; or (2) Schottky barrier effect, when the carriers are injected from the electrodes; or (3) space-charge limited currents. The dependence of I_p on film thickness is too small to be considered significant and hence may eliminate the possibility of space-charge-limited currents. How-

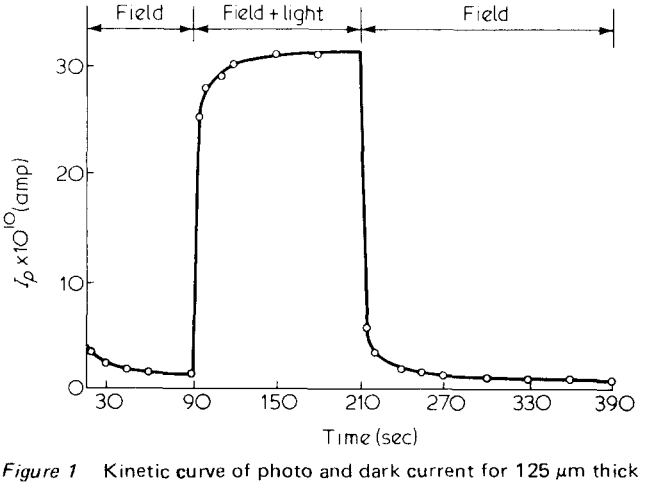

Figure 1 Kinetic curve of photo and dark current for 125 μm thick Kapton film. Illuminated electrode negative

* Registered trademark of I. E. Dupont de Nemours, USA
† Permanent address: Department of Applied Physics, Regional Engineering College, Kurukshetra-132119, India

0032–3861/79/111431–02$02.00

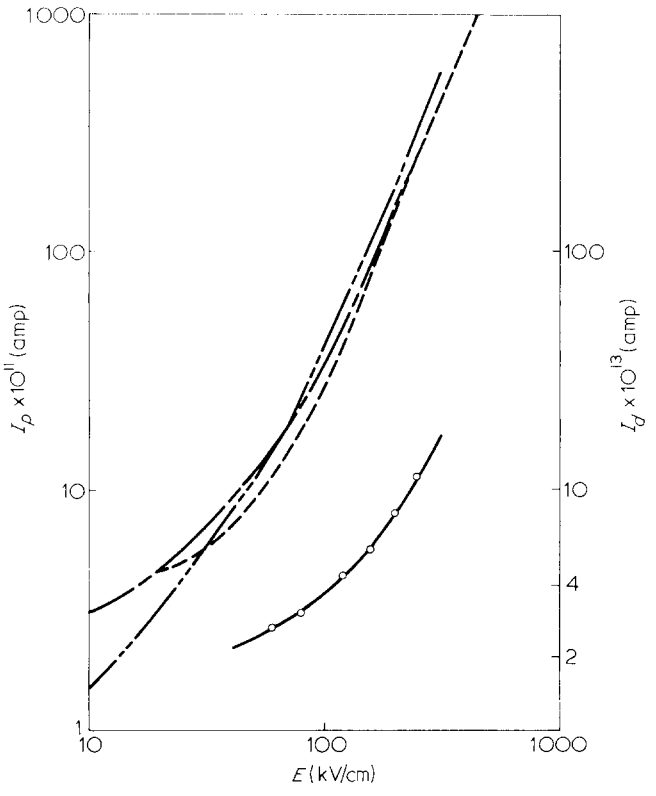

Figure 2 Photocurrent *versus* applied field for Kapton films (12.5 and 125 μm thick). I_p^+, positive electrode illuminated; I_p^-, negative electrode illuminated; I_d, dark current. All are limiting currents recorded after reaching steady state conditions. — · —, I_p^+ (125 μm); — · · —, I_p^- (125 μm); — — —, I_p^- (12.5 μm); — ○ — ○ —, I_d

ever, it is difficult to interpret the result $I_p^+ > I_p^-$ by the electron injection from electrodes. It is suggested that the photocurrent is due to positive holes produced by the u.v. excitation, which are not uniformly distributed across the thickness of the sample. In three different runs made on three different samples taken from the same sheet, I_p^+ was found to be consistently higher than I_p^- by 30 to 50% at low field. Similar results have been reported by Mizutani and coworkers[6] for polyethylene. Although a plausible explanation is suggested, the difference does not appear to be of much significance. At high field I_p^- exceeds I_p^+ possibly because of the enhancement of photo-injection of carriers from the electrodes due to the lowering of the contact barrier height by the applied field (Schottky effect). The relation $\log_e I_p \propto E$ is obeyed uniformly in all cases studied by us. This supports the possibility of Poole–Frenkel emission as suggested by Weingart[1], Barlett[2] and their coworkers.

ACKNOWLEDGEMENT

B.L.S. would like to record his thanks to the authorities of the Regional Engineering College, Kurukshetra, for giving him study leave. The financial support for this work was provided by the Indian Space Research Organisation (ISRO).

REFERENCES

1 Weingart, R. C., Barlett, R. H., Lee, R. S. and Hofer, W. *IEEE Trans. Nuclear Science* July, 1972, **NS-19**, 15
2 Barlett, R.H., Fulk, G. A., Lee, R. S. and Weingart, R. C. *IEEE Trans. Nuclear Science* 1975, **NS-22**, 2273
3 Hill, R. M. *Phil. Mag.* 1971, **23**, 59
4 Simmons, J. G. *Phys. Rev.* 1967, **155**, 657
5 Rose, A. *Phys. Rev.* 1955, **97**, 1538
6 Mizutani, T., Takai, Y. and Ieda, M. *Jpn J. Appl. Phys.* 1971, **10**, 1465

Crystallinity in polyethersulphone: a problem of definition

D. A. Blackadder and H. Ghavamikia
Department of Chemical Engineering, University of Cambridge, Pembroke Street, Cambridge CB2 3RA, UK

INTRODUCTION

A previous paper[1] described the dissolution of PES in chloroform when disc-shaped specimens of polymer were rotated in a large volume of solvent. In such experiments the solvent penetrates the solid polymer and loosens the structure so that polymer-rich globules are detached and float off into the bulk solvent. The product of dissolution is a dispersion of these globules in a solution, the concentration of polymer molecules truly dissolved in that solution being undetectably low. The present paper concerns the changes in physical properties which occur in the polymer-rich phase on a time-scale much longer than that of the dissolution experiments.

It has been shown[2] that PES can be crystallized with the help of a suitable solvent. Dichloromethane can bring about the necessary ordering of the polymer chains though it seems quite likely that the continuing presence of the solvent is essential for the maintenance of X-ray crystallinity. Removal of the dichloromethane leaves a polymer solid showing no X-ray crystallinity but which has the remarkable property of high susceptibility of recrystallization if it encounters dichloromethane a second time[2]. The recrystallization is so rapid that the material cannot be broken down to form a globular dispersion.

In view of the effect of dichloromethane it is now appropriate to return to the study of PES–chloroform mixtures

0032-3861/79/111432-03$02.00