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DRIFT MOBILITIES IN SINGLE CRYSTAL NORMAL ALKANES

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INTRODUCTION

The normal alkanes have been of interest for some time as model substances for saturated alkane polymers[1]. Theoretical estimates of the electron drift mobility have been made by several authors[2,3,4] with results in the range 5×10^{-3} to 10^{-2} m^2 v^{-1} s^{-1} and an associated lifetime of the order of 10^{-10} s. Measurements on n-alkanes have been mainly confined to the liquid phase where highly degassed samples yielded fast negative carrier drift mobilities in the range 10^{-6} to 10^{-4} m^2 v^{-1} s^{-1} [5,6,7,8].

In contrast only two investigations of crystalline material have been made. In these experiments using time of flight techniques, the results were either curtailed by the absence of an observable transient[9] or the signals were in equilibrium with the excitation pulse[10].

The present study forms part of a general investigation into charge mobility in solid phase straight chain alkanes using the time of flight technique, and to date satisfactory transients have been observed in high quality single crystals of Octadecane and Eicosane.

EXPERIMENTAL

Single crystals of Octadecane and Eicosane were produced from the melt by a modification of the method of Horton and Glasgow[11]. Samples were prepared between 2×10^{-4} m and 5×10^{-4} m in thickness for use in conventional time of flight drift mobility measurements[12]. Excess charges were induced via 50 KeV or 80 KeV electron pulses in a modified transmission electron microscope. The irradiation period ranged from 2×10^{-7} to 5×10^{-7} sec and the resulting induced charge transients were detected with a broadband charge amplifier and displayed on a Tektronix 7623 storage oscilloscope.

At the upper end of the usable positive bias range, i.e. 3 KV, the signals were typified by Figure 1a and are what might be expected from such a time of flight measurement[12]. However at lower positive bias a negative-going section of the transient appears as in Figure 1b, while at zero applied voltage a finite wholly negative-going signal was observed as depicted by Figure 1c. For negative bias the signal has the expected polarity. The reverse polarity component of the signal was found not to be dominated by the net dose of charge deposited by the electron beam. Consequently it appeared that bound polarization charge within the samples might be producing regions of field reversal. The assumption of the presence of such a net trapped charge distribution was supported by D.C. tests.

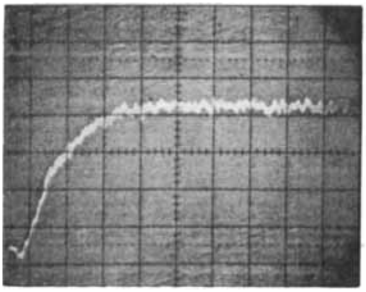

FIGURE 1a Signal at
+ 2·6 kV bias.
1 μsec/large div.

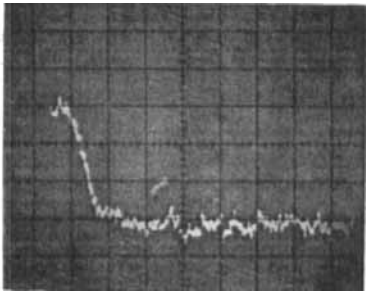

FIGURE 1b Signal at
+ 1·1 kV bias.
1 μsec/large div.

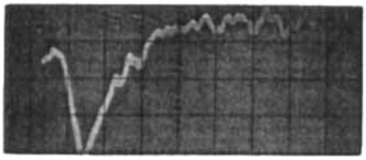

FIGURE 1c Signal at
zero bias.
1 μsec/large div.

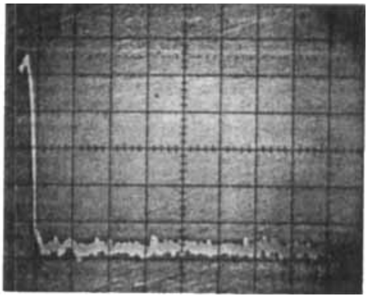

FIGURE 1d Charge injected by electron beam.
1 μsec/large div.

RESULTS

By analysing the behaviour of an irradiated insulator subjected to a fixed internal polarization field and an externally applied voltage it was possible to predict the behaviour of the observed induced charge signals over the range of conditions used. The analysis involved is extensive and consequently inappropriate to this presentation; however the key physical point is that the mobile charges are drifting over regions of positive or negative field whose extent and mean value vary with applied bias. Very crudely this results in the mean drift distance divided by the mean field being only weakly dependent upon applied voltage.

At the same time the proportion of negative and positive contributions of a given species vary significantly with bias. Consequently the polarity of the observed signals changes with applied field but the typical "break points" in the transient used generally for transit time determination are almost bias independent.

The general features of the predicted behaviour are insensitive to the fine detail of the fixed polarization charge distribution; however accurate mobility determinations do depend on this information. In the absence of precise data the simplest possible fixed charge profile was assumed and consequently this places large error bounds on the drift mobilities. Initial estimates are given in Table 1. Work is proceeding to refine the transport data estimates and extend the measurements to longer chain alkanes where phase charges impose difficulties in the crystal growth process.

The details of this work and the charge transient analysis used will be reported in full subsequently.

TABLE 1 Drift mobility values in n-alkanes

	+ve species × $10^{-4} m^2 Volt^{-1} sec^{-1}$	−ve species × $10^{-4} m^2 Volt^{-1} sec^{-1}$
Octadecane	0·5 ± 0·3	1·2 ± 0·5
Eicosane	0·3 ± 0·2	

REFERENCES

1. W.L. McCubbin, Trans. Faraday Soc., 59, 769-774, (1963).
2. D.D. Eley and M.R. Willis, Conf. Electronic Conduction in Organic Solids, Duke Univ., N. Calif., Interscience 1960, 257.
3. W.L. McCubbin and D.C. Gurney, J. Chem. Phys., 43, 983-987 (1965).
4. R.J. Fleming, Trans. Faraday Soc., 66, 3090-3102 (1970).
5. R.M. Minday L.D. Schmidt and H.T. Davies, J. Chem. Phys., 54, 3112-3125 (1971).

   Ibid. 76, 442-446 (1972).
6. P.G. Fouchi and G.R. Freeman, J. Chem. Phys., 56, 2333-2341 (1972).
7. W.F. Schmidt, G. Bakale and I. Sowada, J. Chem. Phys., 61, 5275-5278 (1974).
8. I. Kalinowski, J.G. Rabe and W.F. Schmidt, 1976 An. rep. Conf. on Elec. Insulation and Dielectric Phenomena, Nat. Acad. Sci., Washington D.C., 1978.
9. D.M. Taylor and I.E. noble, J. Phys. D. Appl. Phys., 13, 2123-2133 (1980).

   Ibid. 13, 2115-2121 (1980).
10. K. Yoshino S. Harada, J. Kyokane and Y. Inuishi, J. Phys. D. Appl. Phys., 12, 1535-1539 (1979).
11. A.T. Horton and A.R. Glasgow, J. Res. Nat. Bur. Stand. C., 1965, 69C(3), 195.
12. W.E. Spear, J. Non.Cryst. Sol., 197-214 (1969).