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Time of Flight Determination of Hole Drift Mobility in *p*-Quaterphenyl Layers

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There are only a few reports[1,2] concerned with direct mobility determination in amorphous or polycrystalline organic layers. This situation is due to two reasons. First of all, for a very long time the main effort in the field of electrical conductivity studies was devoted to the studies of organic crystals and the problem of applying the band model to organic systems.[3] The other reason was the considerable technical difficulty encountered in the measurements of the drift mobility in thin films.[4]

Now, the band structure, especially of anthracene[3] is relatively well known, but the problems associated with the mechanism of electrical conductivity of many organic solids still are unresolved. There are many solids especially macromolecular ones, never obtained in monocrystalline form. Also, it can be anticipated that the properties of many low-molecular weight organic solids are different in amorphous layers than in crystalline form.

In the present note we wish to report our drift mobility determination in polycrystalline *p*-quaterphenyl layers. The material, *p*-quaterphenyl, is an organic aromatic compound (Fig. 1). *P*-quaterphenyl layers were obtained through vacuum (10^{-4}–10^{-5} *Tr*) deposition of the material on supports kept at room temperature. *P*-quaterphenyl manufactured by Flukka, puriss, was used. Some

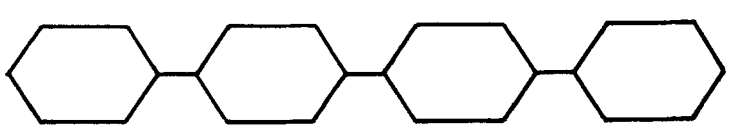

Figure 1. Chemical structure of *p*-quaterphenyl.

of the sample material was subjected to multizone vacuum sublimation, but there was no difference in drift mobility values.

The structure of the layers obtained was not carefully studied. It is believed that they are polycrystalline or partially crystalline. Electrical properties of *p*-quaterphenyl layers were extensively studied in our laboratory. We have determined trap structure from both TSC,[5] SCLC[6] and photoconductivity decay.[7] The work presented here is strictly related to these studies.

The difficulties encountered in doing drift mobility measurements can be avoided by following Grunwald and Blackney[8] suggestions.

In the electronic system used (Fig. 2) integration-differentiation

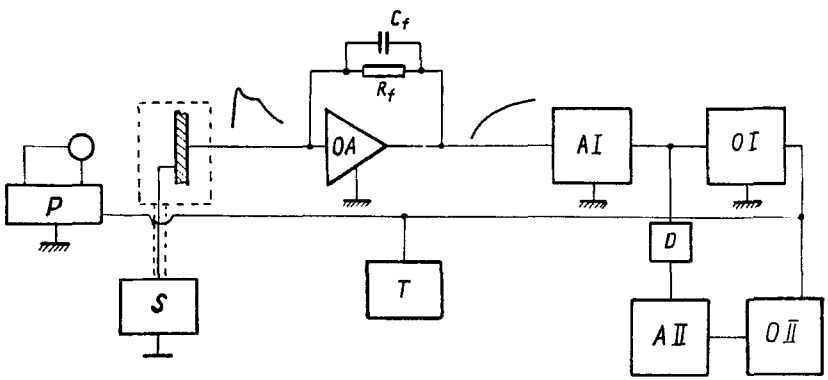

Figure 2. Schematic diagram of the apparatus used. OA—Operational Amplifier; R_f and C_f parallel resistance and capacitance of the integrating network, AI and AII—amplifiers, OI and OII—oscilloscopes, D—differentiating unit, *T*—triggering unit, *S*—power supply, *P*—flash lamp unit.

procedure was applied thus assuring the response to be independent of the input capacitance. An integration device Operational Amplifier (analog Devices 141) was used, the sample was flashed with the light from a xenon flash tube. It was possible to observe both integrated (voltage) pulse and differentiated (current) pulse. Both flash lamp and scopes were triggered from one point. Several typical pulses (Fig. 3) and pulse-height (h) voltage dependence ($h \sim V^2$) (Fig. 4) suggested strong signal (SCLC) mode. Therefore, mobility was calculated from the relation:

$$\mu_d = 0.79 \frac{d^2}{t_{\text{obs}} \cdot \text{V}}$$

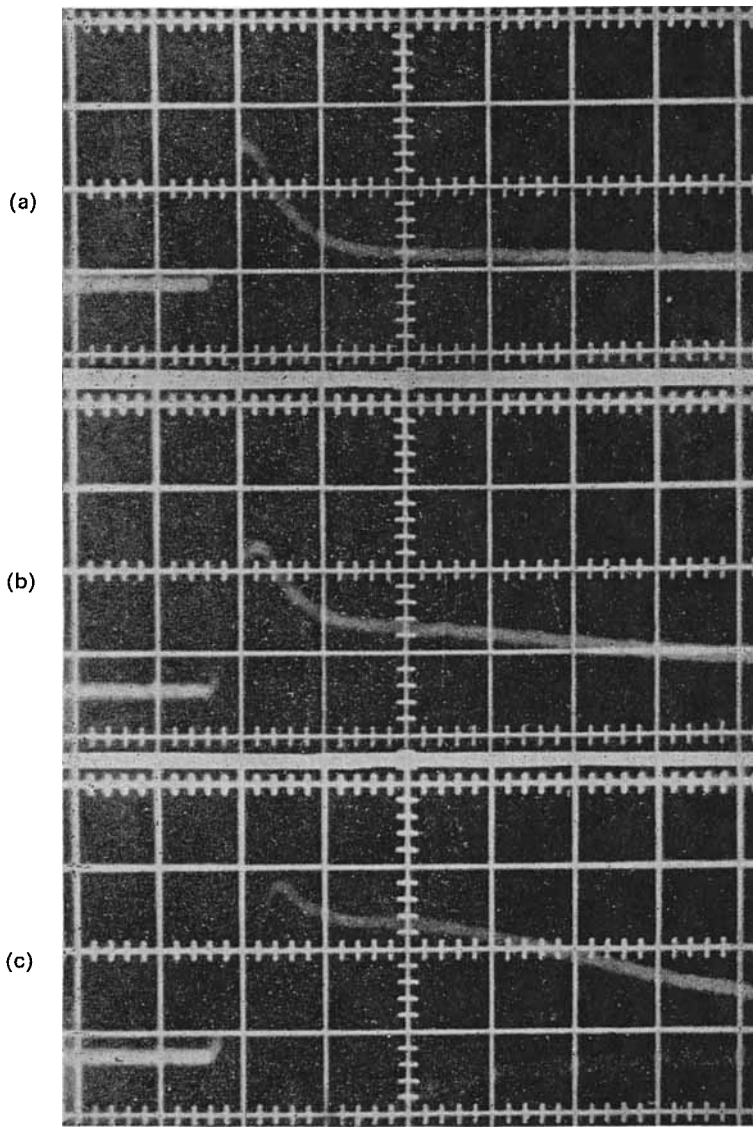

Figure 3. Photocurrent transients observed in *p*-quaterphenyl layers, time scale 50 μs/div.

Field strength: (*a*) $E = 15$ kV/cm
(*b*) $E = 30$ kV/cm
(*c*) $E = 40$ kV/cm

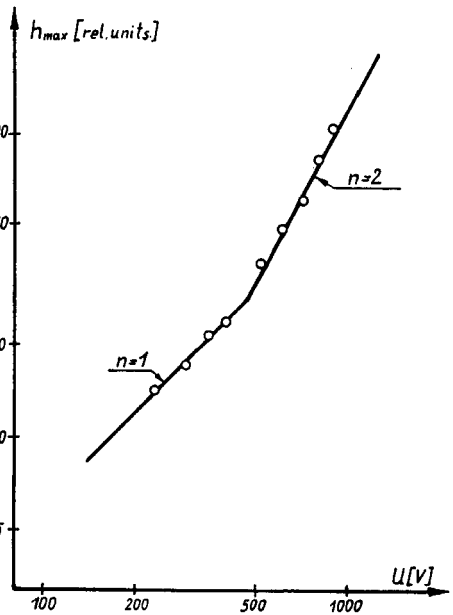

Figure 4. Pulse height–voltage dependence in *p*-quaterphenyl layers.

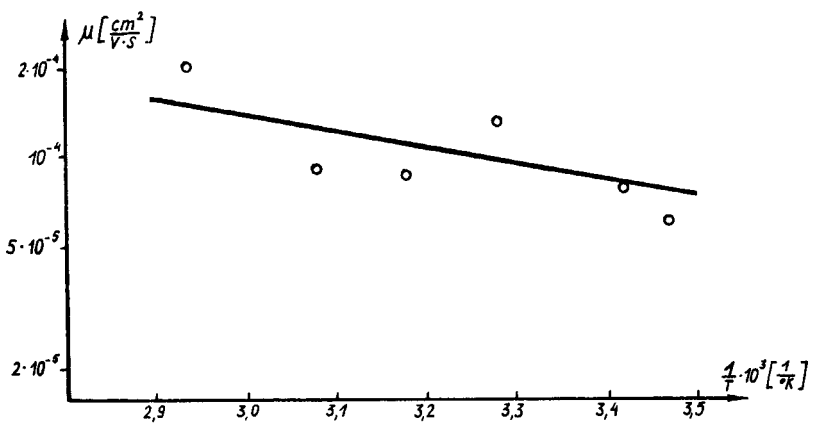

Figure 5. Drift mobility vs temperature dependence in *p*-quaterphenyl layers.

where: d—thickness of the layers,
V—voltage,
t_{obs}—time from " break " on the current pulse.

The temperature dependence of the drift mobility is shown on Fig. 5.

The relatively small thermal activation energy of mobility together with the low mobility values favour a hopping mechanism of current carrier transport.

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