Solid State Communications, Vol. 54, No. 3, pp. 295–296, 1985.
Printed in Great Britain.

0038–1098/85 $3.00 + .00
Pergamon Press Ltd.

ELECTRON DRIFT MOBILITY IN a-Si:H; COMPARISON OF TWO MEASURING TECHNIQUES

Wu Daohuai and Cheng Ruguang

Shanghai Institute of Ceramics, Academia Sinica, 865 Chang-ning Road, Shanghai, China

(*Received* 15 *October* 1984 *by J. Tauc*)

Time-of-flight measurements of the electron drift mobility in hydrogenated amorphous silicon are reported and compared with mobility values obtained by the traveling wave technique. The results obtained by the two methods on samples prepared under the same conditions agree within experimental error.

1. INTRODUCTION

THE DRIFT MOBILITY in hydrogenated amorphous silicon (*a*-Si:H) has been measured in several laboratories by the time-of-flight technique [1–4] and more recently by the traveling wave method [5, 6]. However, up to now a comparison of the results of the two methods always involved samples that were prepared under different conditions and in different laboratories. We report here, for the first time, drift mobility measurements by the time-of-flight (TOF) technique on material that was prepared under the same conditions and in the same r.f. plasma deposition system as the material that was used for the traveling wave mobility measurements.

Such a comparison is particularly important in view of the fact that two orders of magnitude higher mobilities were reported to have been observed in *a*-Si:H prepared in another laboratory [7].

2. EXPERIMENTAL DETAILS AND RESULTS

The TOF sample was prepared [8] by depositing first a 3.6 μm thick layer of undoped *a*-Si:H onto a semitransparent nickel electrode and then a 0.2 μm thick strongly *n*-type doped *a*-Si:H followed by a thin layer of Cr. By depositing the n^+ layer last contamination of the undoped layer by the phosphorus dopant was avoided. The plasma system and deposition conditions were identical to those used for the samples studied by the traveling wave technique [5, 6].

The sample was exposed from the glass substrate side to 6 ns long light pulses from a dye laser. The light pulses were delayed by 2 μs after the onset of 100 μs long bias voltage pulses. Care was taken to keep the intensity of the light pulses sufficiently low to avoid distortion of the applied field by the changes injected into the *a*-Si:H. The photons of the light pulses had an energy of $h\nu = 2.6$ eV. They were thus absorbed within a depth of about 2000 Å in the *a*-Si:H. The transient signal was amplified and displayed on the vertical axis of a fast oscilloscope (100 MHz) that was triggered by the light pulse. The measurements were taken from the oscilloscope display.

The results obtained at 295 K are shown in Fig. 1. The transient current is plotted logarithmically against the logarithm of time for three bias voltages. One observes the two straight line sections that are characteristic of multiple trapping [9, 10] in *a*-Si:H. The transit time t_T is defined by the intersect of the two straight lines. We find $t_T = 0.2\,\mu$s, $0.1\,\mu$s, and $0.07\,\mu$s for the bias voltages $V = 1$, 2, and 3 V, respectively. Using the expression

$$\mu_d = L^2/Vt_T$$

for the drift mobility μ_d, where $L = 3.6\,\mu$m is the

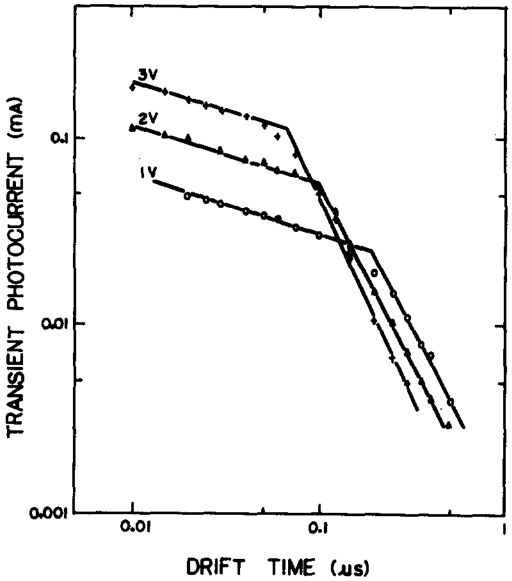

Fig. 1. Transient current as a function of time after excitation pulse for three bias voltages. The breaks in the curves markes the transit time t_T.

sample thickness, we obtain the electron drift mobility $\mu_d = 0.65 \pm 0.05\ cm^2/Vs$.

3. DISCUSSION

The TOF drift mobility obtained with this sample is about 30% less than the value reported by Tiedje *et al.* [3] for their sample at room temperature. This discrepancy can easily arise from a small difference in the slope of the exponential distribution of the conduction band tail states. This slope depends on the hydrogen concentration [11] and therefore on the preparation conditions.

Our TOF drift mobility agrees reasonably well with the value $\mu_d = 0.6 \pm 0.1\ cm^2/Vs$ obtained with the traveling wave technique on samples prepared in the same laboratory under the same conditions [5]. According to the multiple trapping theory the drift mobility decreases with time since more trap levels are able to thermalize with the transport states as time increases [9, 10]. The traveling wave μ_d corresponds to a time of 50 ns, the inverse of the traveling wave frequency. The TOF μ_d of this experiment corresponds to times between $t_T = 70$ and 200 ns. These times are close enough to permit a direct comparison of the mobility value. The values obtained by the two different methods for measuring the drift mobility agree within their experimental error.

Acknowledgement – We wish to thank Professor Hellmut Fritzsche in the Physics Department, University of Chicago for his valuable consultation and contributions to various aspects of this work. This research was made possible by the US-China Cooperation Science Program under Grant NSF INT 8203084.

REFERENCES

1. P.G. Le Comber & W.E. Spear, *Phys. Rev. Lett.* **25**, 509 (1970).
2. W. Fuhs, M. Milleville & J. Stuke, *Phys. Stat. Solidi* **(6) 89**, 495 (1978).
3. T. Tiedje, J.M. Cebulka, D.L. Morel & B. Abeles, *Phys. Rev. Lett.* **46**, 1425 (1981).
4. R.A. Street, *Appl. Phys. Lett.* **42**, 507 (1983).
5. H. Fritzsche & K.-J. Chen, *Phys. Rev.* **B28**, 4900 (1983).
6. K.-J. Chen & H. Fritzsche, *J. Non-Cryst. Solids* **59–60**, 441 (1983).
7. M. Silver, N.C. Giles, E. Snow, M.P. Shaw, V. Cannella & D. Adler, *Appl. Phys. Lett.* **41**, 935 (1982).
8. The sample was received from H. Fritzsche, The University of Chicago.
9. T. Tiedje & A. Rose, *Solid State Commun.* **37**, 49 (1981).
10. J. Orenstein & M. Kastner, *Phys. Rev. Lett.* **46**, 1421 (1981).
11. G. Cody, T. Tiedje, B. Abeles, B. Brooks & Y. Goldstein. *Phys. Rev. Lett.* **47**, 1980 (1981).