CHAPTER 9

MEASUREMENT OF LIFE-TIME OF MINORITY CARRIERS OF THE $MoSe_xTe_{2-x}$ SINGLE CRYSTALS

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9.1 Introduction

For finding a suitable photoactive, but stable semiconducting material, a systematical research for appropriate new type of electrodes for electrochemical solar cells had been initiated. The basic idea was that the visible light phototransition should not be an electro-transition from an anion valence band to the cation conduction band which is characteristical for polar semiconductors such as CdS, GaAs or GaP and breaks a polar bond but that it should occur between energy bands resulting from d-orbitals of the metal component of the semiconductor. The investigation consequently concentrated on transition metal dichalcogenides for efficient conversion of light energy to electrical or chemical energy[1-11] with a maximum of d-d splitting which would be necessary for the absorption of a photon of approximately 2 eV. The photoelectrodes constructed from TMDC's are found to be stable to photocorrosion reactions over extended periods. Better energy conversion efficiency is obtained when optical band gap lies in the range 1.1 eV to 2.1 eV[12-15] TMDC's form a wide range of solid solution[16,17] with either

mixed metal or chalcogenide composition or both. Keeping in view, the single crystals of $MoSe_xTe_{2-x}$ ($0 \leq x \leq 2$) have been grown by chemical vapour transport technique and it has been found that the band gap of compounds of grown series increases with 1.1 eV to 1.4 eV[18].

The crystal structure, band gap, band positions and stability to corrosion are the properties of interest, which will effect the conversion of efficiency. Also a key element of any PEC device is the semiconductor--electrolyte interface. The charge transfer taking place at the interface has a direct bearing on the ultimate energy conversion efficiency of the PEC sclar cell. It is well-known that illumination of a semiconductor at the semiconductor electrolyte interface leads to the generation of excess carriers. For photovoltage to develop i.e. for efficient solar energy conversion. These charge carriers should be separated by the built--in- potential before they recombine. This recombination will depend upon the life-time of the carriers. A determination of this parameter will be helpful for an efficient photoelectro chemical (PEC) solar cell.

The rate of charge transfer can be improved by operating the PEC cell at a suitable temperature, as the temperature effects the life time of the charge carriers. It is therefore worthwhile to study the variation of lifetime with temperature so that an optimum temperature can be determined at which the cell may be operated for efficient solar energy conversion. The present chapter describes the results thus obtained with $MoSe_xTe_{2-x}$ ($0 \leq x \leq 2$) single crystals.

9.2 Results and Discussion

Charge carriers life time measurements

The experimental set up for the measurement of life time of the charge carriers is shown in figure 9.1. Light pulses from the stroboscopic pulsed light source Toshniwal, India is allowed to be incident on the window of the PEC cell. The output open circuit voltage is fed to the Y-deflecting plates of a cathode ray oscilloscope (CRO) 505 D Systronics, India, which is operating in sweeping mode. The figure observed on the CRO is made steady by synchronising the

sweep time with the help of vernier time of the CRO. A typical observed figure is shown in figure 9.2.

We have Q = CV, in the present case excess of Q = excess of ne = $C.V_{O.C.}$ Here 'C' can be approproximated as junction storage capacitance.

$$\therefore \quad \frac{d}{dt} \quad \text{excess of (ne)} = C. \frac{dV_{O.C.}}{dt}.$$

Thus the rate of fall of open circuit voltage would be proportional to the rate of fall of excess carriers population due to recombination. In other words, the time during which the excess of charge carriers fall to (1/e) of the starting value can be equated to be the time taken to reduce the $(V_{O.C.})_{max}$ to $(V_{O.C.})_{min.}$ / e. This time interval is the life time (τ) to be measured.

The life time (τ) was measured at different temperatures of the PEC cell for the $MoSe_xTe_{2-x}$ ($0 \leq x \leq 2$) series. The results obtained have been tabulated in Table 9.1 and are shown in figures 9.3 and 9.4).

Table 9.1

Observed lifetime (τ) for the series $MoSe_xTe_{2-x}$ ($0 \leq x \leq 2$) with temperature

Temperature (degree K)	$MoSe_2$ (μs)	$MoSe_{1.5}Te_{0.5}$ (μs)	MoSeTe (μs)	$MoSe_{0.5}Te_{1.5}$ (μ s)	$MoTe_2$ (μs)
298	61.54	57.69	37.03	27.57	20.50
303	46.87	59.52	34.48	25.32	18.20
308	35.71	97.22	40.18	24.14	17.12
313	34.61	110.20	40.38	22.15	17.18
318	34.09	117.50	41.66	20.40	15.62
323	30.00	125.00	41.30	18.39	12.61

9.3 Conclusion

The value of life time at room temperature is more in the case of $MoSe_2$ as compared to $MoTe_2$. It decreases as the amount of tellurium in the series $MoSe_xTe_{2-x}$ is increased. At each particular temperature the life time increases gradually attains a maximum value and then decreases with composition of the series $MoSe_xTe_{2-x}$ ($0 \leq x \leq 2$). In each case the life time is observed to be maximum for the composition $MoSe_{1.5}Te_{0.5}$

REFERENCES

1. Tributsch, H. (1977)
Z. Naturforsch Teil., A 32, 972.

2. Tributsch, H. (1981)
J. Electrochem. Soc., 128 1261

3. Tributsch, H. and Bennett, J. C. (1977)
J. Electroanal. Chem. Interfacial
Electrochem. 81, 97.

4. Lawerenz, H. J., Heller, A. and
Disalve, F. J. (1980)
J. Am. Chem. Soc., 102, 1887.

5. Menezes, S., Disalve, F. J. and
Miller, B. (1980)
J. Electrochem. Soc., 127, 1751.

6. White, H. S., Fan, F. R. F. and
Bard, A. J. (1981)
J. Electrochem. Soc., 128, 1045.

7. Nagasubramanian, G. and Bard, A. J. (1981)
J. Electrochem. Soc., 128, 1055.

8. Canfield, D. and Parkinson, B. A. (1981)
J. Am. Chem. Soc., 103, 1279.

9. Schneemeyer, L. F. and Wrighton M. S.,
Stacy, A. and Sienko, M. J. (1980)
Appl. Phys. Lett., 36, 701.

10. Fan, F. R. F., White, H. S., Wheeler, B.
and Bard, A. J. (1980)
J. Electrochem. Soc., 127, 519.

11. Kline, G., Kam, K., Canfield, D. and
Parkinson, B. A. (1981)
Solar Energy Mater., 4, 301.

12. Tributsch, H. (1977)
Ber. Bunsenges, Phys., 81, 361.

13. Loferski, J. J. (1950)
J. Appl. Phys., 27, 777.

14. Butler, M. A. and Gingley, D. S. (1980)
J. Mat. Sci., 15, 1.

15. Sinha, A. P. B. (1983)
Energy Digest (India) 2, 1.

16. Schneemeyer, L. F. and Sienko, M. J. (1980)
Inorg. Chem., 19, 789.

17. Mentzen, B. F. and Sienko, M. J. (1978)
Inorg. Chem., 15, 2198.

18. Agarwal, M. K., Patel, P. D. and
Joshi, R. M. (1987)
Bull. Mater. Sci. 9, 337.

19. Agarwal, M. K., Patel, P. D. and
Joshi, R. M. (1986)
J. Mat. Sci. Lett., 5, 66.

20. Agarwal, M. K., Patel, P. D. and
Joshi, R. M. (1987)
Cryst. Res. Tech. 22, 2, 279.

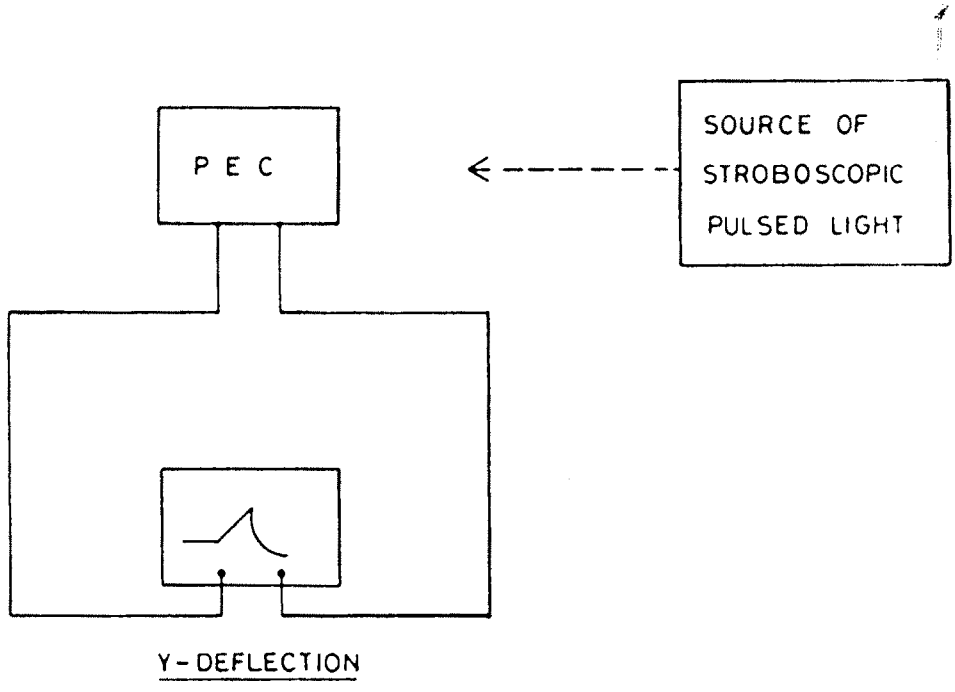

Fig. 9.1 Experimental set up (block diagram) for the measurement of life time.

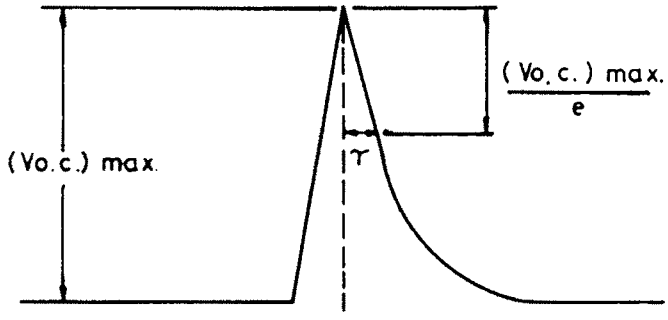

Fig . 9.2 A typical figure observed on the cathode ray oscilloscope

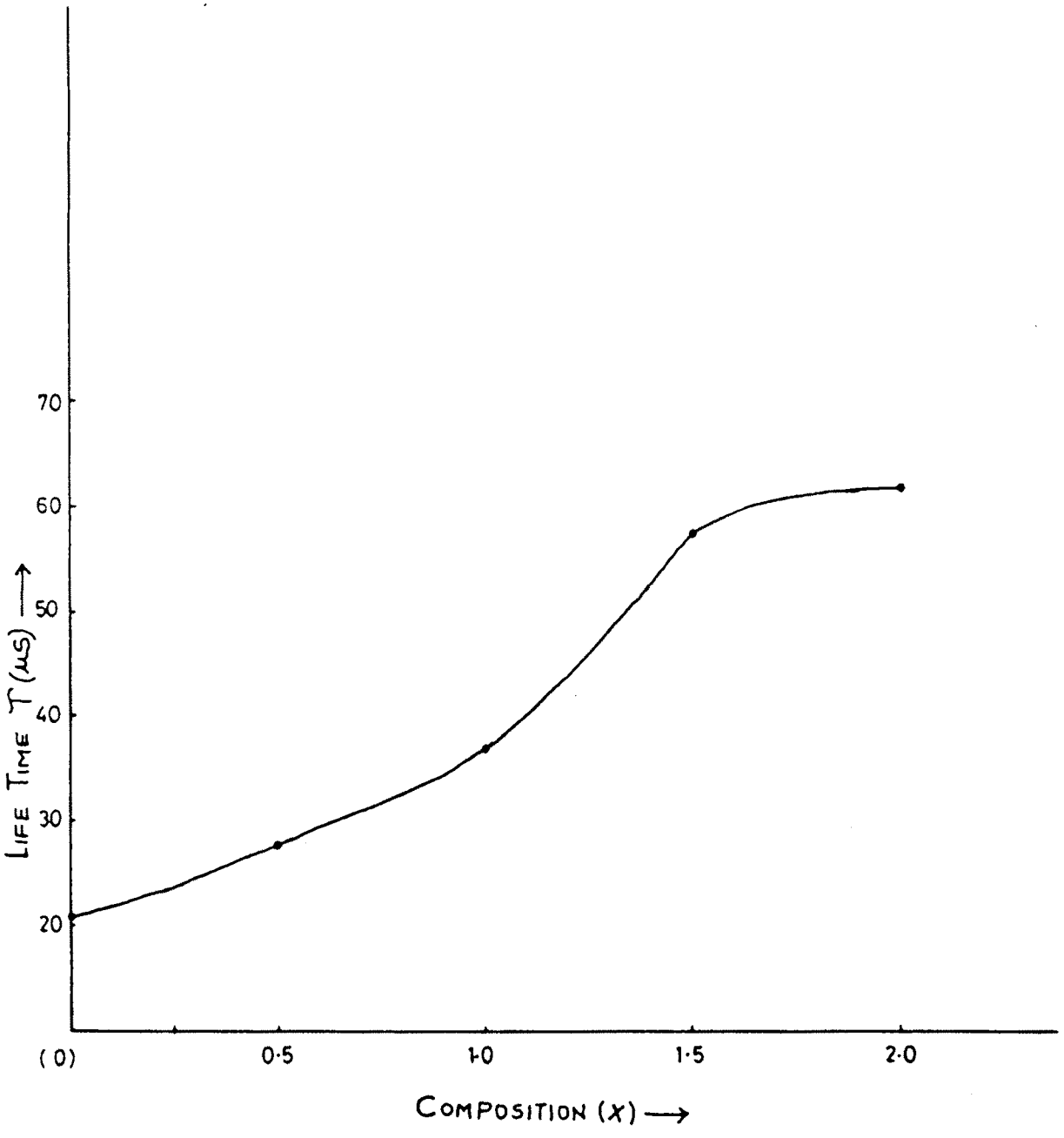

Fig. 9.3 Life time versus composition of the crystal $MoSe_xTe_{2-x}$ $(0 \leq x \leq 2)$ at room temperature

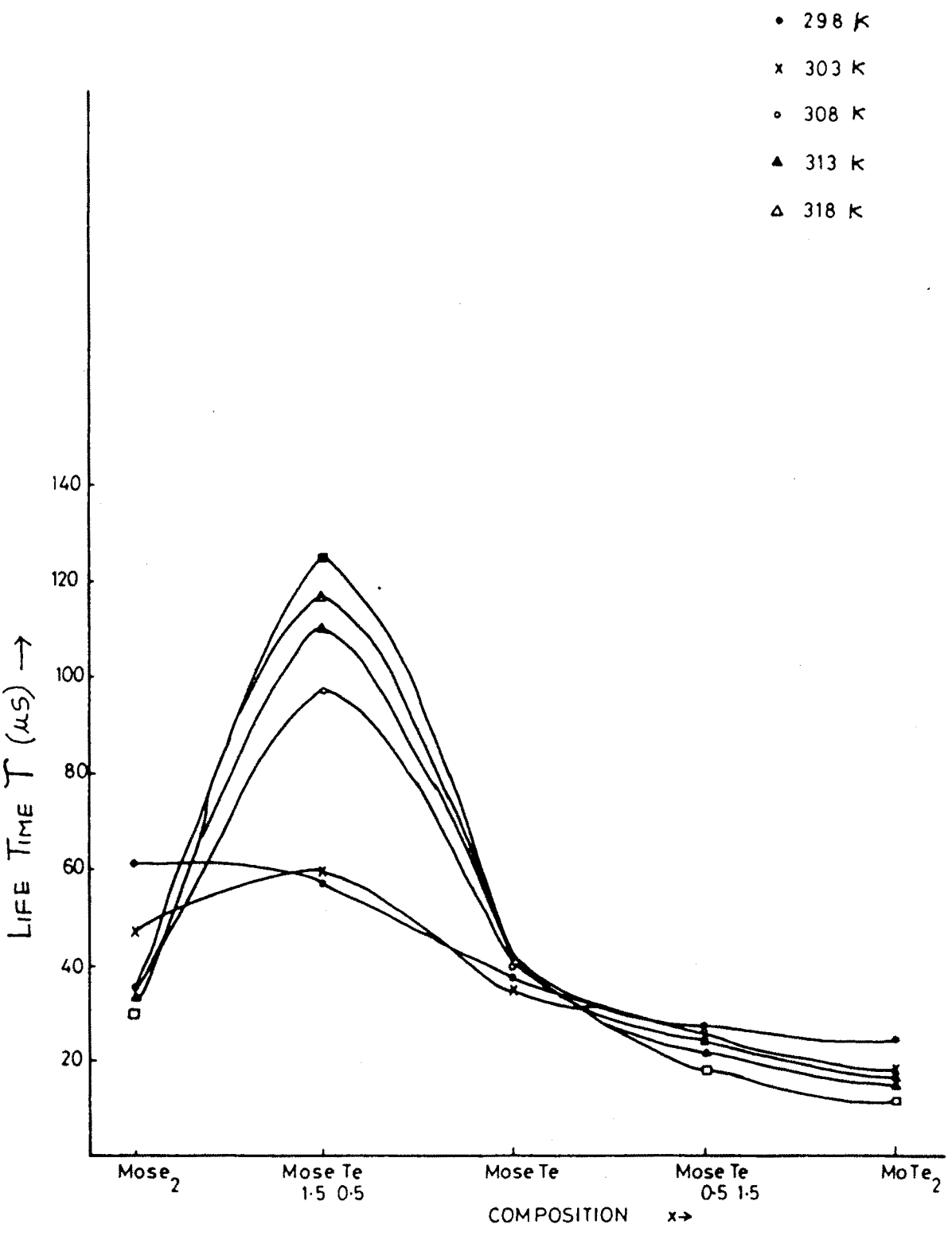

Fig. 9.4 Life time versus composition ofthe crystals $MoSe_xTe_{2-x}$ $(0 \leqslant x \leqslant 2)$ at different temperatures.