Nondispersive trap-limited electron transport in macroporous *n*-GaP

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INTRODUCTION

Porous semiconductors such as macroporous *n*-type GaP, permeated with a liquid electrolyte solution or an electronic conductor, form the basis for efficient devices for converting light into electrical energy. In such a system, the dynamics of electron-hole pair separation are directly related to the micro-scale geometry. Porous GaP consists of a crystalline network and can therefore be considered as an ideal model system to investigate transport phenomena. Electron transport is an important feature in porous opto-electrical devices such as dye sensitised TiO_2 solar cells.

We studied electron transport in macroporous GaP networks permeated with electrolyte solutions under **steady state conditions**, by probing the harmonic photocurrent response, $j(\omega)$, to a small-amplitude modulation of the absorbed light intensity $\Phi(\omega)$ (ω is the modulation frequency), that is super-imposed on the steady-state light intensity Φ. The transfer function, $j(\omega)/e\Phi(\omega)$, is a fingerprint of the transport characteristics under given steady-state conditions (1,2); it provides a characteristic frequency that is unequivocally related to the average transit time of the electrons through the porous solid.

RESULTS

We found that electron transport is non-dispersive: thus characterized by a single average transit time for all electrons that depends on the thickness of the porous layer and the background light intensity as can be seen in figure 1.

The average transit time is determined by multiple trapping in interfacial states close to the electron Fermi level (3). The average transit time was measured with intensity-modulated photocurrent spectroscopy as a function of the steady state light intensity.

The density-of-trapping-states function (DOS), $2kT_B\,\Sigma_i s_i(E_F)$, in a considerable region of the band gap can be determined from this average transit time, by changing the energy of the electron Fermi via the background light intensity (see figure 2).

The DOS function increases approximately exponentially towards the conduction band edge, E_C, as indicated by the solid line in figure 2. The DOS function does not change if the porosity of the samples is changed from 25% to 50%.

REFERENCES

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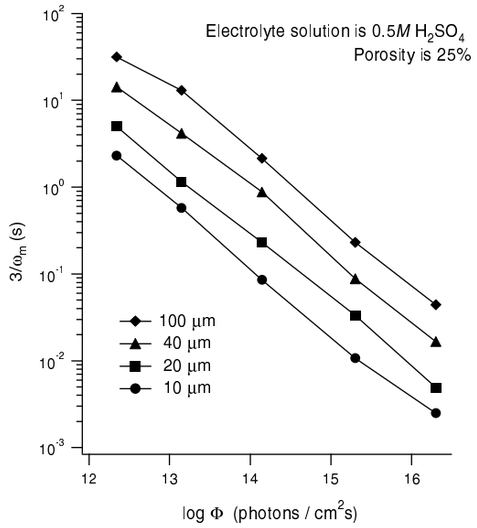

Figure 1: The transit time for the electrons in macroporous GaP as a function of the light intensity.

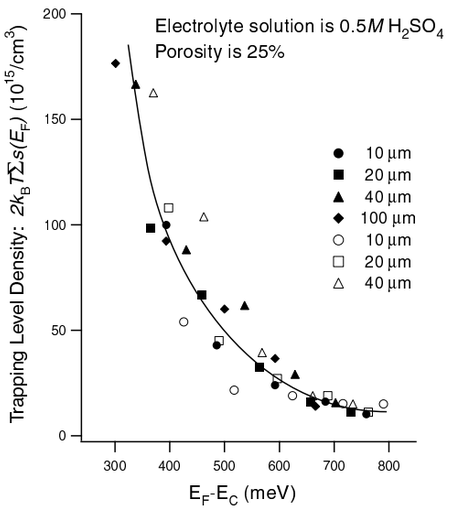

Figure 2: The density of trapping levels as a function of the position in the band gap of macroporous GaP. The density-of-states function is roughly exponential as indicated by the solid line.