The influence of the exchange interaction of free carriers and defect states on the open circuit voltage of the photojunction

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The paper presents research of exchange interaction of free minority carriers and defects states on V_{oc} (open circuit voltage) of an illuminated photojunction. The measured dependence of V_{oc} value versus the intensity of laser photons was combined with theoretical model. The combined solutions are based on experiences partially presented in papers [1, 2].
The junction can posess electrons and holes concentration $n_{10} >> p_{10}$ on side 1 and $n_{20} << p_{20}$ on side 2 and under illumination in steady state conditions it changes on n_{11}, p_{11} and n_{21}, p_{21} reached on the sides. Under the achieved steady state conditions the energy shifts corresponding to four energy values of the Fermi quasi-levels are following: $F_{1n1}=kTln(n_{11}/n_{10})$, $F_{1p1}=kTln(p_{11}/p_{10})$, $F_{2n1}=kTln(n_{21}/n_{20})$ and $F_{2p1}=kTln(p_{21}/p_{20})$ from the common energy of the thermal equilibrium Fermi level F=0. The resulting chemical potential difference between the sides of the junction is equal to $(F_{1n1}-F_{2n1})/e$ for electrons and $(F_{1p1}-F_{2p1})/e$ for holes. Both of these energy differences contribute to the value of the open circuit voltage

$$V_{oc1}=(F_{2n1}-F_{1n1})/e + (F_{1p1}-F_{2p1})/e \qquad (1).$$

In the case of the ZnTe/CdTe photojunction, the top ZnTe layer (E_g =2.26eV) is transparent to illuminated laser photons with energy hν=1.91eV and is absorbed only in CdTe (E_g =1.45eV). For the correct choice of moderate illumination intensity, it is motivated to omit the values of F_{2n1} ,F_{1n1}, F_{2p1} in relation to the F_{1p1} parameter (side 1 minority carriers $p_{10} << n_{10}$) as dominant in formula (1) and leading to $V_{oc1}=F_{1p1}/e$.
The presented model allows for determining the location of a set of defects levels in the forbidden gap in respect to the common Fermi level F of thermal equilibrium. Level sequences can be correlated with extended dislocation states or other extended or local states interacting in the junction.

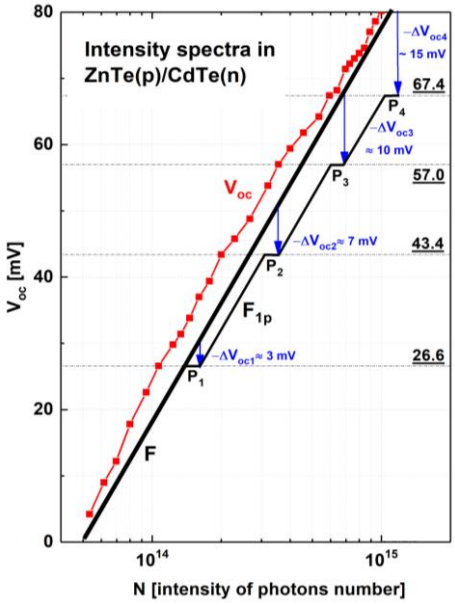

Fig. 1. Comparison of the V_{oc} measurement of a ZnTe/CdTe junction with defects (red) and the predicted theory without defects F (continues black). Density of defects states P_1, P_2, P_3 and P_4 suppressing $V_{oc1,2,3,4}$ in the exchange interaction with free minority holes. Step curve – as a result of damping of the $V_{oc1,2,3,4}$ values – delta$V_{oc1,2,3,4}$ – are shown as vertical arrows down.

1. B. A. Orlowski, K. Gwozdz, M. Galicka, S. Chusnutdinow, E. Płaczek-Popko, M.A. Pietrzyk, E. Guziewicz, B.J. Kowalski *Acta Phys. Pol. A*, **134**, 590 (2018).

2. B.A. Orlowski, K. Gwozdz, K. Goscinski, S. Chusnutdinow, M. Galicka, E. Guziewicz, B.J. Kowalski *Acta Phys. Pol. A*, **141**, 548 (2022).