Damping of open circuit photovoltage in a Si homojunction

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The paper continues the study of interaction of free electrons and holes with defect states in the illuminated photo junction [1]. The laser beam of selected energy photons was used to measure open circuit voltage V_{oc} versus illumination intensity dependence. Obtained results are compared with the proposed theoretical model [2,3].

In general, photo junctions are build of two different semiconducting materials with different crystal structure, electronic band structure as well as different minority and majority carriers. Free and trapped electrons and holes interact in the junction. In such a case the junction has different electrons and holes concentrations, n_{10} and p_{10} on side 1, and n_{20} and p_{20} on side 2. Under illumination in steady state conditions they change to new concentrations of n_{11}, p_{11} and n_{21}, p_{21}. The achieved steady state conditions will be approximately (Maxwell-Boltzmann approximation) described by the energy shifts corresponding to four values of quasi Fermi levels energies: $F_{1n1}=kT\ln(n_{11}/n_{10})$, $F_{1p1}=kT\ln(p_{11}/p_{10})$, $F_{2n1}=kT\ln(n_{21}/n_{20})$ and $F_{2p1}=kT\ln(p_{21}/p_{20})$ different from the common energy of the thermal equilibrium Fermi level F=0. The created difference of chemical potential between the sides of the junction are equal to $(F_{1n1}-F_{2n1})/e$ for electrons and $(F_{1p1}-F_{2p1})/e$ for holes. This difference of energies contribute to an open circuit voltage value $V_{oc1}=(F_{1n1}-F_{2n1})/e + (F_{1p1}-F_{2p1})/e$.

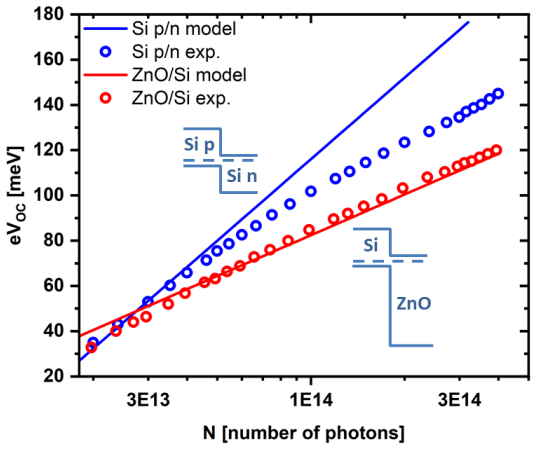

Fig. 1. A comparison of the measured open-circuit voltage with predictions of the presented model for a homo- and heterojunction.

We test the described model by comparing predictions derived from it with the results of the open circuit voltage measurements performed for two systems: a heterojunction n-type ZnO/p-type Si and a homojunction made of n-type and p-type Si. In the former, the ZnO top layer (Eg = 3.37 eV) is transparent to the photons of the energy hν = 1.91eV, so electrons and holes are generated only in the Si layer (the absorption edge at about 1.1eV). In the latter, the laser beam radiation is absorbed in both parts of the junction. The model satisfactorily describes the measured open circuit voltage in the heterojunction (Fig. 1), while for homojunction it fails to describe the experimental results for the high intensity illumination. Likely, stronger influence of the interface imperfections reducing the efficiency of the junction has to be taken into account if both sides of it are populated with electron-hole pairs.

References

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