Review of the PhD thesis

"Enhanced charge carrier thermoemission from the dislocation-related states in silicon" submitted by Maxim V. Trushin as a requirement for the scientific degree of Doctor of Philosophy in Physics at St.-Petersburg State University

The PhD thesis "Enhanced charge carrier thermoemission from the dislocation-related states in silicon" has been submitted by Maxim Trushin as a requirement for the scientific degree of Doctor of Philosophy in Physics at St.-Petersburg State University.

This thesis concerns the important dislocation-related phenomenon in silicon, namely, the enhancement of carrier thermoemission from the dislocation states resided near the band edges in silicon bandgap. Both, the theoretical and experimental studies are presented in the work under consideration. This subject is of high interest because we deal with the new properties of the most popular semiconductor material.

The thesis submitted for reviewing consists of 46 pages and copies of 4 peer-reviewed articles, of which Maxim V. Trushin is a co-author. The Introduction provides comprehensive information on the previous studies of the dislocation-related electronic states and conventional experimental technics.

Main part describes the theoretical calculations and experimental studies together with the required experimental details. Each part is a brief summary of the results obtained by the Author. Deep level transient spectroscopy, capacitance-voltage and current-voltage measurements are applied to confirm the theoretically predicted effects of the external field and own dislocation field on the carrier thermoemission from the dislocation electronic states.

One may conclude that the thesis and attached papers present original results about the interaction of the external electric field with the attractive deformation potential of dislocations. This interaction is resulted in the effect which is similar to well-known Poole-Frenkel effect developed originally for the point defects. Maxim V. Trushin's calculations reveal that the values of Poole-Frenkel (PFC)

coefficient in the case of dislocations are noticeably larger as compared to the point defect case. Two types of dislocations have been investigated. The value of PFC occurs to depend strongly on the mutual orientation of the external field and Burgers vector. Moreover, it is found that the own electric field originated from the dislocation linear charge initiates the carrier thermoemission.

In my opinion the most important achievements of the thesis are as follows:

-the exact calculations demonstrate the barrier lowering for electron and hole thermoemission from the dislocation states in the external electric field. This effect for the dislocation related states exceeds the conventional Poole-Frenkel effect for the point defect states.

-the dislocation electronic states occupancy is found to affect strongly the thermoemission characteristics.

-the predicted barrier lowering is confirmed experimentally and investigated in details by means of various currently available methods.

There are several minor shortcomings in dissertation and questions:

- the role of the initial doping level in silicon wafers is not discussed in the thesis.

- there is no information about the type of dislocation core and energy distribution around the core.

- do we consider the regular dislocation network as a sort of superlattice with a periodical potential which depends on the network parameters and carrier states occupancy?

- is it possible to use the dislocation-related luminescence, namely, its behavior in the external field as an extra characterization of the Poole-Frenkel effect and the dislocation states occupancy?

The results obtained by Maxim V. Trushin contribute significantly to the development of our knowledge concerning the phenomena and properties related to the dislocation networks in semiconductor crystals. The theoretical calculations are trustworthy, and the experimental results are reliable and reproducible. Maxim V. Trushin proved a good knowledge of literature in the wide field which embraces the dislocation investigations.

In my opinion both the quality and quantity of material presented in the thesis are sufficient to meet the commonly accepted requirements. The Author of thesis have presented the contributions at several international conferences, the papers included into thesis have been published in high ranking international journals.

Thus, I strongly support the awarding of scientific degree of Doctor of Philosophy in Physics at St.-Petersburg State University to Maxim V. Trushin.

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