Review
of the Ph. D. thesis of Maxim V. Trushin entitled
"Enhanced Charge Carrier Thermoemission
From the Dislocation-related Electronic States in Silicon"
submitted for the degree of Doctor of Philosophy in Physics
at the St. Petersburg State University

The thesis is devoted to an experimental and theoretical study of important problem of the effect of dislocations on the electrophysical properties of semiconductors. It is well known that the dislocations are inevitably present in real semiconductor structures and may considerably affect their properties. The author of present study has considered theoretically and verified experimentally a special class of dislocation system, namely the regular dislocation network in silicon, which may be created at the interface of two crystals with some misorientation of their lattices. This is very model object with controllable two-dimensional (areal) density and type of dislocations that allowed to the author to formulate and to solve several particular problems. They are discussed in the first, introductory part of the thesis.

In the original chapter 2, the author has considered a theoretical model of the elastic strain field of a dislocation. He paid particular attention to the case of attractive potential, which arises in some directions perpendicular to the dislocation. The potential gives rise to the lowering of the potential barrier for carrier thermoemission from localized electronic states in the presence of external electric field, so called the Poole-Frenkel effect. The author has developed a calculation procedure for different orientations and density of dislocations and also has considered the influence of own charge of dislocation. As a result, the effect of deformation potential of the screw and 60-degrees dislocations on the carrier thermoemisson towards the valence and conduction bands in silicon was numerically simulated. In particular, the Poole-Frenkel coefficients were calculated for the dislocations with different orientations. Besides, the barrier lowering due to the own electric charge of dislocation line was also theoretically described.

Chapter 3 is devoted to an experimental study of several silicon heterostructures with the screw and 60-degrees dislocation nets of different densities. Several electrophysical methods, in particular, the deep level transient spectroscopy (DLTS), the isothermal DLTS, the capacitance-voltage and current-voltage measurements at different temperatures have been exploited to characterize the samples and to obtain valuable information about the dislocation-related electronic states. Particular attention was paid to study of the external electric field effect on the carrier thermoemission from shallow dislocation-related states as well as to study the influence of occupancy of these states on the thermoemisson barrier. Several important results have been obtained in this study. They are collected in conclusion section 4. In particular, it was found that the experimentally determined values for Poole-Frenkel coefficients well agree with those calculated for the 60-degrees dislocations.

There two comments on the study described in this thesis. In the heterostructure under study, there are two types of dislocation nets, namely, the regular square network of screw dislocations and an array of the 60-degrees dislocations. The density of screw dislocation can be accurately controlled during the preparation of samples by controlled misorientation of two crystals bonded. The 60-degrees dislocations, on the contrary, cannot be controlled with high accuracy because they are created by accidental misorientation of surfaces of two crystals

relative to the crystal planes. At the same time, the 60-degrees dislocations are mainly discussed in the thesis. The reason for that is unclear.

Second comment is related to photoluminescence, which is observed as a bright phenomenon for the heterostructures with these dislocation nets. The photoluminescence spectra contain valuable information about the energy structure of the dislocation-related electronic states. Besides, this phenomenon is of practical importance for silicon-based optoelectronic devices. The author studied this phenomenon and published results of this study but did not include these results in the thesis. The reason for that is also unclear.

In summary, I believe that present thesis covers a substantial body of work. It is well written and contains several valuable results, which are important for this field. I would like to stress that only four papers are included in the thesis. At the same time, Maxim Trushin is co-author of seventeen other publications that indicates his high qualification. In my opinion, the work satisfies the high standards of a PhD thesis and the author Maxim V. Trushin may be awarded a PhD degree.

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