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Recombination of intrinsic point defects in dislocation-free single crystals of germanium

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At present, there is a semi-quantitative understanding of growth defects in germanium [1]. The formation of structural imperfections is described with the help of Voronkov's recombination-diffusion model, which was developed for dislocation-free silicon monocrystals [2]. This model is based on the postulate of rapid recombination of intrinsic point defects near the crystallization front during the growth of a single crystal. Depending on the thermal growth conditions in the crystal, there remains a surplus of either vacancies or intrinsic interstitial atoms. Upon subsequent cooling of the crystal, either microvoids or interstitial dislocation loops are formed, respectively. On the basis of this physical model, quantitative models of the dynamics of point defects were developed [3]. Disadvantages and positive aspects of this model are analyzed in the monograph [3]. The authors hold the opposite viewpoint. They deny the rapid recombination of intrinsic point defects near the crystallization front [4]. This negation made it possible to develop a high-temperature precipitation model in silicon, which determines the development of the defective crystal structure during its growth and subsequent technological treatments [5]. The similarity of the structure of dislocation-free single crystals of silicon and germanium suggests that similar phenomena occur in germanium. The recombination parameters for dislocation-free germanium single crystals have been estimated using the terms and concepts of Voronkov's recombination-diffusion model. It is shown that at high temperatures in germanium there is a barrier against the recombination of intrinsic point defects. It is assumed that the formation of structural imperfections, as well as in silicon, proceeds through the interaction of "impurity-intrinsic point defect". It is shown that under the conditions of low-temperature studies, the recombination processes of intrinsic point defects take place at a sufficiently high rate. The theoretical calculations carried out by us confirm the model of the entropy barrier in germanium, the essence of which is that the decrease in the barrier is due to a decrease in the configuration entropy with decreasing temperature.

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