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Comprehensive Application of Information Systems and Image Processing Methods for the Analysis of Dislocation Defects in Semiconductor Materials

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The aim of this work is the development of methods and algorithms for segmentation, classification, and identification of dislocation defect types in semiconductor materials based on modern information technologies. Semiconductors constitute the foundation of all modern electronics, and their electrical, optical, thermal, and quantum properties are determined by their spatial structure. Any disruptions of the crystal lattice – such as dislocations, vacancies, or inclusions – can significantly affect the conductivity, reliability, and durability of electronic components and devices **[1, 2]**. The application of signal and image processing technologies in semiconductor defectoscopy provides opportunities for analyzing the spatio-temporal characteristics of their structure. Modern information technologies are extensively used in high-resolution electron microscopy and X-ray structural analysis, enabling automation of research, application of machine learning methods to predict defect formation during crystal growth, evaluation of material quality, and modeling of structural changes that influence the electrical properties of semiconductors. This study is devoted to the development of methods for processing technological images using information technologies to detect and classify defects in micro- and nano-electronic structures. The report presents approaches to information formation and processing in a diffusive medium, illustrated by the spatio-temporal response of a photodetector. The proposed methods are based on the corpuscular theory of light in modeling random responses of multi-element photodetectors **[3, 4]**. As a physical-mathematical model of detector response, technical parameters such as the number of resolution elements, dark current, and threshold sensitivity are employed. The methods rely on statistical analysis of technological images, incorporating stochastic-deterministic models of output signals, which enhances the accuracy of defect detection in semiconductor structures.

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