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Report

on the thesis presented by Lozhkin Maksim Sergeevich, entitiled "Backscattering of Medium-Energy Electrons in Solids and their effect on the processes of hydrocarbons induced deposition" for degree of a Candidate of Sciences in 1.3.8. Condensed Matter Physics – The Saint-Petersburg State University.

Determination of the composition and physical properties of surface layers of solids by backscattered electrons (BSE) is of importance for both fundamental and applied sciences. While BSE current reflects the composition and thickness of near-surface layers of solid samples, the shape and extent of BSE emission region is usually overlooked, which should also be put into consideration. The thesis focused on the measurement of lateral distribution of the BSE by electron beam-induced hydrocarbon features, and the Monte Carlo simulation of the electron trajectories, by which the correctness of various models of electron scattering was investigated and an analysis method of the deep structure of solid sample was proposed. Therefore, the research presented in the thesis has both theoretical and practical significance for the subject of study.

In the first chapter the thesis begins by offering a comprehensive literature review on the general background of scanning electron microscopy methods and methods for layer-by-layer analysis of samples. Theoretic foundations and fundamental possibilities of studying the internal structure of solids in an electron microscope were discussed concisely.

In the second chapter the thesis introduces the experimental setups and methods directly used in conducting experiments and verifying the reliability of their results, as well as in preparing model samples.

In the third chapter, the thesis reports the theoretical methods involved in the study of electron scattering and interpretation of the corresponding experimental data in computer simulation. The scattering medium was assumed as homogeneous in chemical composition but amorphous in structure, i.e., a random distribution of scattering centers over the entire interaction region.

In the fourth chapter, the main results and discussion of the thesis is presented. Two types of nanostructures (nanopillars and microrings) formed during the deposition of hydrocarbons induced by a focused electron beam were investigated. A model of electron-induced deposition was proposed, which related the processes of surface diffusion of hydrocarbons and the formation of a lateral distribution of the current density of backscattered electrons. The results of computer simulation of electron scattering in solids and experimental induced deposition of microrings on samples of different chemical composition are compared. An original electron nanotomography method for deep probing of multilayer structures based on the established dependence of the lateral distribution

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of the current density of backscattered electrons on the elemental composition, density and thickness of the layers they cross, as well as the parameters of the primary electron beam was developed. The electron nanotomography method was further used to study a series of thin film samples with different thicknesses with a relative accuracy not inferior to other methods based on BSE current measurements.

Overall, the thesis presents a unique and interesting research on the backscattering of medium-energy electrons in solids and their effect on the processes of hydrocarbons induced deposition. Th output of the research is the electron nanotomography method that could measure the thickness of multi-layers in a simple way. The results of the research have resulted in 3 papers and 5 conferences reports. The main conclusion of the thesis will undoubtedly inspire the research on the subject related to BSE, and the electron nanotomography method holds the potential for practical technology.

Considering the high quality of both research contents and writing skill, I can fairly conclude that the thesis entitiled “Backscattering of Medium-Energy Electrons in Solids and their effect on the processes of hydrocarbons induced deposition”, by Lozhkin Maksim Sergeevich, deserves to be awarded the degree of Candidate of Physical and Mathematical Sciences.

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