Characterisation and Electrical Properties of Silicon–Silicon Oxide Nanosystems

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Heterogeneous nanosystems based on silicon attract attention of researchers due to the wide range of possible applications, in particular, single electron transistors [1], memory elements [2] and gas sensors [3]. Silicon oxide is the most natural dielectric material for silicon technology. The study of electronic processes that occur in the silicon–silicon oxide nanosystems opens new technological possibilities and constructive approaches for creating a new generation of sensor devices.

Silicon–silicon oxide composites were obtained by thermal oxidation of finely dispersed silicon powder. The silicon powder was separated from colloidal aqueous solution by sedimentation. Silicon oxide nanosystems were characterized by means of scanning electron microscopy, UV-vis transmittance and FTIR spectroscopy. Due to thermal oxidation of finely dispersed silicon powder we observed an increase of transmittance in the 12000–15000 cm^{-1} wavenumbers range. Transformation of optical spectra may be associated with a change in the band gap of silicon nanocrystals due to decreasing of their size.

To study the electrical properties of nanosystems the experimental samples were formed under 200 atm pressure. By means of impedance spectroscopy in the 25 Hz – 1 MHz range it was found that experimental samples show a decrease in electrical capacitance and internal resistance with increasing the frequency. To interpret the impedance of silicon–silicon oxide composite the equivalent circuit model was constructed. According to the model, the total impedance of the sample can be represented by two RC (parallel resistor and capacitor) sub-circuits, which correspond to the process of transfer of charge carriers through the boundary and in the bulk of silicon nanocrystals.

Based on the spectra of thermally stimulated depolarization current, the localized electron states in the experimental samples were found. Trap levels with non-equilibrium carriers are distributed quasi-continuously on the activation energy and exist in the ranges of 0.2–0.3, 0.35–0.45 and 0.55–0.65 eV. Such localized electron states influence the charge transport in the nanocomposites. Obtained results suggest the complex processes of transfer and relaxation of charges in the silicon–silicon oxide nanosystems.

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