Nanocomposites and nanomaterials

Polarization memory effect in the photoluminescence of nc-Si−SiO_x light-emitting structures

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We report on the polarization memory effect (PM) in the photoluminescence (PL) of silicon nanoparticles (nc-Si) arranged into the optically anisotropic SiO_x matrix possessing a porous column-like structure. The investigated nc-Si−SiO_x light-emitting structures were produced by evaporation of SiO powder in vacuum and oblique deposition on Si wafer, oriented at the angle 60^0 between the normal to the substrate surface and the direction to the evaporator. Deposited SiO_x films were annealed in the vacuum chamber at 975^0 C to grow nc-Si. Passivation of such-obtained nc-Si−SiO_x structures was carried in the HF solution or vapor in the presence of etching-assisting ultraviolet light. The PL spectra was excited by linearly polarized light at nearly normal incidence to the surface of the samples and emitted light is collected in the direction normal to the surface. Dependence of the PL polarization characteristics of nc-Si−SiO_x structures on the etching time in HF and PL excitation energy was investigated.

It was found that the PM is observed only after passivation of nanostructures: during etching in HF the initial symmetric nanoparticles become asymmetric elongated nc-Si. We can assume that passivation of nc-Si−SiO_x structures is an anisotropic process and occurs apparently through the pores along the walls of columns. It has been shown that high degree of the PM (degree of polarization ρ is equal 20–40%) is achieved only when the polarization of exciting light is parallel to the projections of oxide nanocolumns, that form the structure of porous layer, onto the sample plane. For orthogonal polarization of the exciting light ρ is decreased almost three times. Obtained results are consistent with the studied angular dependencies of the PL intensity which indicate on the well-defined orientation dependence of ρ in the sample plane.

It was established that ρ values are much higher in the short- wavelength region of PL spectrum than in the long-wavelength region. It was found also that PL of nc-Si−SiO_x structures is polarized even for a non-resonant high-energy

excitation at a significant loss of excitation energy but PM effect at 337 nm excitation is considerable lower than for excitation by 415 nm. The experimental results concerning PL and ρ spectral dependences of nc-Si−SiO_x structures are analyzed on the basis of quantum confinement effects in nc-Si.