Polarization Memory of The Luminescence of Si Nanoparticles in Oxide Matrix

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Measurement of the polarization of the photoluminescence (PL) is a powerful method to study the electronic symmetry of the absorbing as well as luminescent states. The phenomenon, when a certain substance excited by linearly polarized light emits light, which is also linearly polarized, is called polarization memory (PM) effect. Porous silicon and thin-film structures containing Si nanoparticles (nc-Si) embedded in the SiO_x matrix show an intense and wide PL emission peaking in the near-infrared or visible spectrum. However, they differ greatly in the polarization of their PL: PM effect is large in porous Si and non-essential in nc-Si–SiO_x nanocomposites [1].

In this report the PL polarization properties of the dense and porous nc-Si–SiO_x structures were studied for the first time. Investigated samples were fabricated by thermal evaporation of SiO powder in vacuum onto polished c-Si substrates arranged at angles of 0° and 60° to the normal to the substrate surface with the direction to the evaporator (normal and oblique deposition). The films were annealed in vacuum or helium atmosphere during 15 min at temperatures of 975 and 1000°C then were treated in the HF vapor. The PL was excited by linear polarized light of a nitrogen laser at $\lambda = 337$ nm and by a semiconductor laser with $\lambda = 415$ nm.

The obtained dense and column-like porous nanocomposite films containing nc-Si exhibited strong PL emission which can be attributed to recombination of excitons in nc-Si embedded into SiO_x matrix.

It was found that the PM effect is observed only after processing of nanostructures in HF, which is also accompanied by short-wavelength shift of PL maximum and the significant increase in PL intensity. In anisotropic porous nc-Si–SiO_x samples obtained by oblique deposition, there is also well-defined orientation dependence of the PL polarization degree in the sample plane. This dependence is related to the orientation of oxide nanocolumns that form the structure of the porous layer. The above effects are associated with the transformation during etching in HF of symmetric nanoparticles in asymmetric elongated nc-Si. The asymmetric nanoparticles in dense layers are oriented randomly; in the porous structures their preferred orientation is aligned with the orientation of oxide nanocolumns.

1. Kovalev D., Ben Chorin M., Diener J., Koch F., Efros Al. L., Rosen M., Gippius N.A., Tikhodeev S.G. Porous Si anisotropy from photoluminescence polarization // Appl. Phys. Lett. – 2005. – V.**67**, № 11. – P. 1585-1587.