Light-Emitting Structures of CdS Nanocrystals on Oxidized Macroporous Silicon

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Nanotechnology of colloidal CdS nanoparticles and its incorporation in the two-dimensional photonic structures of macroporous silicon was provided for the manufacture of compact light emitting elements. We investigated the contribution of electron-phonon interaction to Wannier–Stark effect and photoluminescence in macroporous silicon with nanocoatings.

The macroporous silicon structures to be studied were made using photoelectrochemical etching. SiO_2 coatings with thickness of 5÷200 nm were formed on macroporous silicon samples in dry oxygen. The layer of CdS nanocrystals 1.8÷2 nm in size was deposited from colloidal solution with polyethylenimine (PEI) onto oxidized macroporous silicon.

We measured the near-IR light absorption oscillations in 2D macroporous silicon structures with surface CdS nanocrystals and SiO_2 nanocoatings. The model of the resonance electron scattering on surface states is realized due to large-time electron scattering in the electric field of the "silicon–nanocoating" boundary, and the Wannier–Stark electro-optical effect is confirmed. We determined the influence of broadening on the oscillation amplitude in IR absorption spectra as interaction of the surface multi-phonon polaritons with scattered electrons.

The photoluminescence quantum yield of CdS nanoparticles on the surface of oxidized macroporous silicon with optimum thickness of SiO_2 layer increases of 3-4 times during the first 2 weeks due to evaporation of water molecules from the nanoparticles in the polymer layer and reaches 28%. With further storage of samples range and photoluminescence quantum yield almost no change. High intensity of photoluminescence was obtained due to increasing the flow of electrons from the silicon matrix in the direction of the nanocrystal layers at the maximum of the electric field on the boundary of Si-SiO_2. That significantly reduced the rate of nonradiative recombination.

Thus, nanotechnology of synthesis of CdS nanoparticles with the ordered crystal lattices was developed. We prove the possibility of achieving of high efficiency of the nanoparticle photoluminescence on oxidized silicon matrix by the controlled variation of the size of nanoparticles and thickness of the SiO_2.layer.