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Si-based nanocrystals and nanostructures for efficient optoelectronic devices

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At present silicon is still the basic semiconductor material in microelectronic technology. However, monocrystalline silicon shows low intensity emission properties because of its indirect band gap near 1.12 eV (1100 nm). Therefore Si single crystals are not suitable for optoelectronic applications. Now Si-based nanocrystals and nanostructures are some new optoelectronic materials in order to obtain an efficient near-infrared or visible luminescence [1-3]. Consequently Si-based nanomaterials have large potential applications for fabrication novel emitting semiconductor devices [4].

In this work we analyze luminescence properties of different Si-based nanosystem (nanocrystals and nanostructures) which are very promising for obtaining high-intensity near infrared emission devices. Low-dimension Si-nanoparticles were deposited on silicon single-crystalline substrates (c-Si) using pulsed-laser ablation technique. Photoluminescence spectra taken at liquid helium temperature ~ 4.2 K from such Si-ultrafine particles contain broad intense band at 1.17 eV related with radiative recombination of nonequilibrium charge carriers in separate nanocrystals. The experiments indicate that the luminescence intensity depends strongly on substrate temperature and post-deposition annealing temperature in range of 300 – 1000°C.

In this paper we also present experimental result on the Ge/Si multilayers with Ge quantum dots grown by molecular beam epitaxy (MBE) It is found that high-intensity photoluminescence band centered around 0.78 eV is related with spatially indirect nonequilibrium carrier recombination between holes confined in the Ge quantum dots with size ~ 3 – 10 nm and electrons in Si spacer tensile-strained layers.

In addition high-power pulsed laser melting of Si single crystals was used to create high-intensity dislocation-related luminescence in the spectral region 0.6 – 1.1 eV. The progress of Si-based nanocrystallyne materials for optoelectronic applications has been analyzed for nanocrystals and nanostructures.

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