microparticles into colloidal nanoparticles in a free liquid jet, Applied Physics A, 2010, 101, 435–439

9126-93, Session PS1

Two band superlinear luminescence from GaSb-based nanostructures with AlSb/InAsSb/AlSb deep quantum well

Maya P. Mikhailova, Eduard V. Ivanov, Leonid V. Danilov, Andrey A. Petukhov, Karina V. Kalinina, Nikolay D. Stoyanov, Sergei I. Slobozhanyuk, Georgy G. Zegrya, Yury P. Yakovlev, Ioffe Physico-Technical Institute (Russian Federation); Alice Hospodková, Jirí Pangrác, Jirí Oswald, Markéta Zíková, Eduard Hulicius, Institute of Physics of the ASCR, v.v.i. (Czech Republic)

We report on study of the two-band superlinear electroluminescence (EL) in nanoheterostructures with deep AlSb/InAs1-xSbx/AlSb quantum well (QW) (d=5 nm)MOVPE grown on n-GaSb substrate.

Narrow-gap InAs1-xSbx well considered 15% of Sb. Two band El was measured in the photon energy range 0.5-0.8 eV with emission energy h?1=0.635 and h?2=0.695 eV at 300 K.

According to theoretical calculation there are two electron levels in QW in the QW and three hole levels at room temperature. Photon energy of the radiative transitions from the first electron level corresponded to the participation of the first hole level h?1=0.76 eV and the second hole level h?2=0.704 eV at T=300 K. At low temperature there are 2 electron levels and only 1 heavy hole level. It agrees with EL band maximum h?1=0.73 eV. Superlinear behavior of EL and the optical power dependence on drive current P=A?TB was found for both bands at T=300 K, where B=1.72-2.

These effects were explained by the contribution into radiative recombination of the additional electron-hole pairs which were created due to impact ionization by electron heated at high band offset Ec=1.284 eV between AlSb barrier and the first electron level Ee1 (inverse Auger-effect [1]). Temperature dependence of the two-band EL was measured in the range of 90-300 K. It was shown that with temperature decreasing a ratio between energy of the valence band offset ΔEv and the second heavy hole level position Eh2 changes due to temperature transformation of the energy band diagram. It was found that radiative transition on the second hole level “disappears” at T≤200 K, and we can see only one band in the EL spectrum.

[1] M.P. Mikhailova, E.V. Ivanov, L.V. Danilov et al., J.Appl.Phys., 112, 023108 (2012).

9126-94, Session PS1

Photoinduced polarized luminescence enhancement and darkening in an ensemble of CdSe/ZnS quantum rods

Maria V. Mukhina, Vladimir G. Maslov, Alexander V. Baranov, Anatoly V. Fedorov, National Research Univ. of Information Technologies, Mechanics and Optics (Russian Federation)

Colloidal semiconductor nanocrystals, or quantum dots, have become efficient light-emitting or energy-transferring elements in a range of applications from sensors, labels and lasers to solar cells, optical storage and quantum computing. In all of these applications it is very important to understand properly, how the optical, first of all, luminescent, properties of the nanocrystals will change under continuous irradiation with light. Therefore, the photoinduced processes, occurring on the surface of irradiated nanocrystal, have attracted considerable attention in recent years. Different photoinduced effects such as photoinduced luminescence enhancement (PLE), photooxidation, photoionization, photoannealing are well known for spherical nanocrystals. In this research PLE and photooxidation effects have been used to induce the photoluminescence (PL) anisotropy in initially disordered Quantum Rod (QR) ensemble under continuous irradiation with polarized light. Quantum rods, elongated nanocrystals with axial symmetry, absorb and emit light anisotropically because dipole moments of their lowest excitonic transitions are directed along their long axes. Therefore, if disordered QR ensemble is irradiated with polarized light, the incident radiation will be absorbed mainly by the nanocrystals whose dipole moments coincides with the direction of polarization of the light. The surface of these QRs and their luminescent characteristics are modified due to selective photochemical reaction (photoinduced effect), but the luminescent properties of the other part of a QR ensemble do not change. This is the reason of an appearance of the PL polarization. In experiment QRs were embedded in pores (12-15 μm) of filter paper from toluene solution to achieve disordered ensemble. Next, the sample was irradiated through a polarizer. An orange light emitting diode, with a centre wavelength of 595 nm and a converted power 23 mW, was used for sample exposure. The observation of photoinduced PL polarization in a QR ensemble was carried out by comparing of the intensities of the luminescence components with vertical and horizontal polarization that were recorded separately. PL polarization appeared as a result of photochemical reactions in the initially isotropic sample. The polarization direction coincided with the polarization direction of the light initiating the photoreaction. A photoinduced process led to a blue shift of the PL band around 15 nm (for 80 hrs irradiation). The PL as a function of time is well fitted by a double exponential with time constants 35-40 min and 2-18 hrs, indicating that two processes are occurring in the system. Using the previously published and obtained experimental data, the photoprocess with time constant 35-40min was identified as PLE due to photopassivation of surface defects, and the photoprocess with time constant 2-18 hrs was attributed to photooxidation. The observed degree of polarization was calculated to be 16%. Investigation of the relaxation process in the QR ensemble in darkness after continuous irradiation allowed to reveal the depolarizing factor attributed to rotational diffusion of the QR in the pores of matrix.

9126-95, Session PS1

Split-ball resonator

Arseniy I. Kuznetsov, A*STAR - Data Storage Institute (Singapore); Andrey E. Miroshnichenko, The Australian National Univ. (Australia); Yuan Hsing Fu, A*STAR - Data Storage Institute (Singapore); Vignesh Viswanathan, National Univ. of Singapore (Singapore); Mohsen Rahmani, Vytautas Valuckas, Zhenying Pan, A*STAR - Data Storage Institute (Singapore); Yuri Kivshar, The Australian National Univ. (Australia); Daniel S. Pickard, National Univ. of Singapore (Singapore); Boris Luk’yanchuk, A*STAR - Data Storage Institute (Singapore)

We introduce a new concept of split-ball resonator as a nontrivial generalization of more familiar split-ring resonator composing electromagnetic metamaterials. We realize this novel concept experimentally by employing the laser-induced transfer method to produce near-perfect spheres and helium ion beam milling to make cuts with the nanometer resolution. Due to high quality of the spherical particle shape, governed by strong surface tension forces during the laser transfer process, and the clean, straight side walls of the cut made by helium ion milling, magnetic resonance is observed at 600 nm in gold and at 565 nm in silver nanoparticles. We demonstrate a strong omnidirectional magnetic dipole response, for both gold and silver spherical plasmonic nanoparticles with nanometer-scale cuts, and also realize tunability of the magnetic dipole resonance throughout the visible spectral range by a change of the depth and width of the nanoscale cut. Structuring arbitrary features on the surface of ideal spherical resonators with nanoscale dimensions provides new ways of engineering hybrid resonant modes and ultra-high near-field enhancement.