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Optical properties of $CuInSe_2$ nanocrystals prepared by electrical discharge induced chemistry in solution

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The paper discusses the results of characterization of $CuInSe_2$ (CIS) nanocrystals (NCs) synthesized by plasma treatment of a stoichiometric mixture of copper, indium, and selenium micropowders in an electric discharge in ethanol. From the analysis of the absorption spectra, the band gap values for particles obtained under different discharge conditions were determined. The effect of additional exposure to laser radiation on the change in the NCs optical properties is discussed. During the electric discharge treatment, the particles of the powders are heated, melted and evaporated in the channel of the generated discharge. Spectroscopic studies confirm the presence of excited atoms and ions of copper, indium, and selenium in the discharge gap. An important condition for the reaction is to ensure not only the required temperature range, but also the necessary time for the interacting particles to remain in the discharge plasma gap. As shown by TEM studies, the synthesized CIS NCs had a spherical shape and size of about 20–30 nm. The composition of the synthesized NPs was controlled using X-ray diffraction analysis and Raman spectroscopy. The results proved the formation of NCs with the chalcopyrite structure, which is a stable phase of bulk $CuInSe_2$ crystals at room temperature. The band gap values estimated from the optical absorption spectra were slightly higher than the value of 1.04 eV, which was reported for bulk CIS [1] and lay in the range of 1.1-1.2 eV. The additional irradiation of the prepared colloid by the second harmonic of the Nd:YAG laser (532 nm, laser fluence 0.4 J/cm^2) leads to a shift of the absorption edge to the blue region, which may indicate the reduction in particle size, as well as partial decomposition of the $CuInSe_2$ compound upon exposure to laser radiation. The synthesized nanocrystals exhibit a luminescence with the maximum in the range of 1192 - 1204 nm. The position of the maximum was shifted to the blue region compared to the position of the luminescence peak for bulk CIS material (1211 nm) [2]. The features of the luminescent properties of synthesized CIS nanocrystals are discussed.

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Resonance Raman Scattering and Entanglement in Transition-Metal Dichalcogenide Semiconductor MoS_2 QDs

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Molybdenum disulfide (MoS_2) is widely used in optoelectronic devices due to its properties like high mobility, effective luminescence and strong binding energy. When 2D TMDs are reduced to 0D (zero dimensional) then we have a single MoS_2 quantum dot (QD), and an entirely special electronic property arises due to its quantum confinement effect which exhibits a larger direct band gap (3.96 eV) when compared to monolayer 2D sheets (1.89 eV)[1]. Based on these by molecular dynamics(MD) simulation we obtain the Raman spectra of one monolayer Mos_2 and we have compared the results with the experiment[2]. Next a quantum-statistical model for a three-level MoS_2 QD(Fig.2) interacting with two initially coherent radiation fields is presented and the theory of resonant Raman scattering in the presence of intense incident and scattered light waves is developed, using the quantum-mechanical master-equation approach. The non-radiative and radiative decay terms was included in the master equation, and then we solved the two-time system correlation functions. Numerical results for the resulting spectrum are presented for different cases (Fig.1).

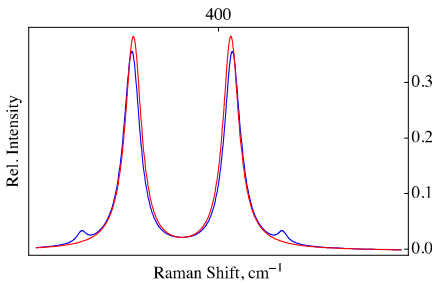

Fig. 1 Raman spectra of monolayer MoS_2 QD under two different strong fields, close to those previously determined in experiment[1]

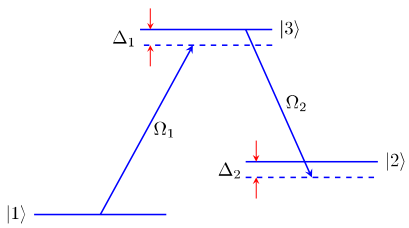

Fig. 2 MoS_2 QD energy levels, showing the absorption of the laser photon and emission of Raman photon, with their respective detunings