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Peculiarities of luminescence properties of Ag- and Cu-doped nonocrystals

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The interest to luminescent colloidal semiconductor nanocrystals (NCs) is highly motivated by their potential application in opto- and photoelectronics, biology, medicine, etc. The introduction of dopants in such systems is used as an effective tool for manipulation of their luminescence properties, i.e. luminescence intensity and color. In this report, the results of investigations of optical properties of water-soluble Ag- and Cu-doped CdSe and In_2S_3 colloidal NCs as well as the effect of doping on photostability of these NCs are presented.

It is found that doping of CdSe NCs with Cu- and Ag- impurities induces the corresponding dopant states within the band gap without changing the band gap energy of the main ensemble of the host NCs. In the photoluminescence (PL) spectra of doped NCs, the exciton emission is fully suppressed, and the PL bands caused by carrier recombination through appropriate levels of impurities appear in the green and red spectral ranges. In contrast to CdSe:Cu NCs, several well defined PL bands are observed in the PL spectrum of CdSe:Ag NCs. The PL bands are ascribed to different ensembles of the NCs.

The introduction of Cu- and Ag-impurities in the In_2S_3 NCs during the synthesis resulted in solid state solution of Cu-In-S and Ag-In-S, respectively. The PL spectra of these ternary NCs show the defect-related PL bands with the Stokes shift of about 0.4-0.5 eV. The increase of Ag- and Cu-content in the NCs shifts the PL band maximum to longer wavelengths. The PL spectra of the Ag-In-S NCs show two PL bands attributed to the NCs of different sizes. This is proved by centrifugation of raw NC solution which allowed to separate two ensembles of the Ag-In-S NCs of different emission color.

The Cu-doped NCs show higher photostability than the Ag-doped NCs. An irradiation with blue light of an aqueous solution of the Ag-In-S NCs resulted in the decrease of the PL intensity and darkening of the solution. The effect is ascribed to formation of light-absorbing species from the residual Ag-related compounds at the NC surface. The adding of gelatin to the NC solution prevented this effect and improved photostability of the Ag-doped NCs.