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Band-edge emission from $AgInS_2$ semiconductor nanoparticles by the surface passivation with III-VI semiconductors

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Semiconductor nanoparticles Quantum Dots (QDs) are photoluminescent materials represented by cadmium sulfide and selenide, and they have recently been applied to the color conversion materials used in display devices. Despite their prominent monochromaticity, the use of cadmium compound is no longer allowed for commercial products and alternative nanoparticle materials like III-V semiconductors (InP and GaP) and I-III-VI ternary semiconductors (CuInS2 and AgInS2) have been proposed. The study reports, for the first time, a narrow band edge emission from the AgInS2 ternary semiconductor QDs, which had been developed by our group as photoluminescent QDs but obtained a spectrally broad defect emission (fwhm=200 nm). We focused on the surface of QDs rather than core crystals, since surface is as equally important as inside for the nanoparticles less than 10 nm. The direct factor for the successful observation of band-edge emission from the ternary material was surface passivation by III-VI semiconductors, indium and gallium sulfides (InSx and GaSx). Actually, core/shell structure has often been made using zinc sulfide as a shell, since it is an easily crystallize wide gap material (Eg¬=3.7 eV); however, it seemed not be suitable for passivating group 11 and 13 elements due to the mismatch of valency at the interface between core and shell. The narrow photoluminescence (fwhm~35 nm) was successfully obtained and photoluminescence quantum yield around 10% in the beginning of the research was improved by overall modifications to the synthetic procedures. The core AgInS2 nanoparticles of ca. 4 nm with tetragonal crystal structure prevented non-radiative relaxation pathways in the core crystal. The thickness of GaSx shell was increased by using more reactive sulfur sources. Finally, surface passivation of GaSx shell by alkyl phosphines improved the quantum yield to 56%.

Biography

Taro Uematsu has completed his PhD from Osaka University in 2010 and he has been working for nanomaterials related to semiconductors and metals. He has published several papers on the surface chemistry of quantum dots.

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