MULTICOL-LASE
MULTI-COLOUR LASING COLLOIDAL QUANTUM DOTS FOR COLOUR-CONVERSION OF QUALITY LIGHTING

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Project context and objectives:

Colloidal quantum dots (CQDs), also known as semiconductor nanocrystals, are highly attractive materials for optoelectronic applications with their novel size tunable electronical and optical properties. The use of these material systems now offers great potential for lighting systems thanks to their advantageous optical properties including quantum efficiencies reaching almost near-unity, finely tunable emission spectra via size and composition tailoring, and enhanced stability compared to their organic counterparts. Utilization of these CQDs in color-conversion LEDs has been already demonstrated to enable high-efficiency and high-quality lighting. In addition, CQDs have also recently been investigated to make optically pumped lasers. However, CQD-based lasing media have not been studied for quality lighting purposes. Here, we introduce a new concept of color-conversion LED lighting systems that employ CQD color-conversion based on multi-color lasing, different than the previous reports of spontaneous emission based color-conversion.

Brief description of the main results:

In the project, we have demonstrated CQD-based optical gain media showing multi-color amplified spontaneous emission (ASE) with two different approaches. In the first approach, we studied optical gain performances of CdSe/CdS core/multi-shell CQDs exhibiting suppressed auger recombination (AR) and near-unity quantum yield. We prepared highly uniform and close-packed monolithic mixed structure of two different CdSe/CdS core/shell CQDs having different peak emission wavelength for optical gain study. By using two-photon absorption optical pumping, these monolithic mixed CQD solid films exhibited multi-color ASE when the excitation intensity is above the threshold. In the second approach, instead of using two different CQDs, we demonstrated multi-color ASE from blue-emitting CdZnS/ZnS core/shell CQDs without mixing two different types of CQDs, where multi-color ASE is originated from the radiative recombination of the higher order excitonic states. Investigation of the ASE of the CQDs as a function of excitation pump intensity revealed the multi-color ASE from the blue emitting CQDs for the first time. This indicates that nonradiative AR is substantially suppressed since higher order multi-excitons can contribute to the stimulated emission.

Potential impact and challenges:

Our demonstration of multi-color ASE from CQDs will be promising for the generation of white lighting using monolithic laser sources, which could exhibit better color-rendering performance as compared to the performance of the conventional incandescent lamps and white LEDs. The ease of large scale synthesis and solution processability of these CQDs will be great opportunity for the potential applications. However, in order to achieve the new concept of color-conversion laser lighting systems of CQDs, one of the main challenges is to reduce the lasing threshold further to enable these lasers to be pumped with conventional light sources such as high power LEDs.