ASOL-QDLASER
ALL SOLUTION PROCESSED COLLOIDAL QUANTUM DOT LASER

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Project context and objectives:

Colloidal quantum dots (CQDs) are favorable light-emitting materials that are promising for light-emitting devices and as well for lasers as an optical gain medium, where CQDs offer great potential with their broad-range spectral tunability along with high gain coefficients. To date, CQD-based lasers have been demonstrated using various cavity structures. Among these, solution processed cavities are expected to be advantageous because they would synergize with the solution processability of the CQDs. However, solution processed monolithically integrated CQD-lasers have not been shown to date. In this project, we plan to demonstrate all solution processed CQD-laser that employ solution processed distributed Bragg reflectors (DBR) to realize a vertical cavity surface emitting laser (VCSEL) architecture.

Brief description of the main results

In the project, we develop all solution processed vertical cavity surface emitting laser (AS-VCSEL) of core/shell CQDs. All colloidal DBRs, which are fabricated by spin coating of the oxide nanoparticles, can reach surface very high normal peak reflectivities by tailoring the number of repeating bilayer number. Thus, Q-factors that are very high can be achieved. Core/shell CQDs, which exhibit favorable properties as an optical gain medium including suppressed Auger recombination and increased stability, are employed as the efficient gain media. We sandwich these CQDs in between two pieces of solution processed DBRs. Then, via two photon absorption optical pumping of the AS-VCSELs of CQDs, these lasers demonstrate single mode lasing with a very low lasing threshold, which is attributed to the favorable characteristics of both core/shell CQDs, which exhibit amplified spontaneous emission in spin coated solid films with record low thresholds for two photon absorption pumping, and high quality of all solution processed DBRs.

Potential impact and challenges:

Our demonstration of all solution processed lasers of CQDs will be promising for realizing cheap and functional light sources for various application areas including telecommunication, sensing, spectroscopy, lighting and displays. The ease of large scale fabrication will be a game changer for various applications. Although there are various challenges, one of the main challenges is to reduce

the lasing threshold further to make these lasers pumped by affordable sources such as CW lasers or high power LEDs.