QD SALT Laser

QD-salt mixed crystals as optical gain media

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Project context and objectives

Since their first description in 1960, laser became a significant instrument in a variety of application fields, including communication services, medicine and science. Starting with gases and discrete emitting wavelengths, solid gain media like Ti-sapphire enabled tunable wavelengths. In recent years, semiconducting quantum dots showed their potential as a new type of gain media. These materials showed comparable low gain thresholds and good amplification values. Furthermore, the tunability of their emission wavelength due to quantum confinement enables a versatile fabrication of differently colored lasers using one single material.

Still, the quantum dots suffer from a reduced stability under ambient conditions at high pumping intensities. Embedding the quantum dots into ionic matrices greatly improves their stability against photooxidation and under strong illumination. Therefore, these mixed crystals are a highly promising material to improve the applicability of quantum dots as laser gain media.

Brief description of the main results

Semiconductor quantum dots composed of either CdTe (synthesis in aqueous environment) or CdSe/ZnS (synthesis in organic environment) were successfully synthesized and incorporated into ionic matrices. Borax was found to be a more suitable matrix, since during the co-crystallization larger mixed crystals are formed, which are potentially easier to be polished to the right shape.

The mixed crystals showed no power dependencies in the excitons kinetics up to a pumping power of 200 W/cm^2, proving them to be suitable as laser gain matrices.

Final results, potential impact and use

In the framework of the project, we successfully produced mixed crystals using CdTe and CdSe/ZnS QDs as emitting species and NaCl and borax ($Na_2B_4O_7 \cdot 10\ H_2O$) as ionic host matrices. These mixed crystals showed similar optical properties in comparison with their parental solution in terms of spectral position and shape. Power-dependent time-resolved photoluminescence spectroscopy showed no dependency of the exciton kinetics on the pumping power up to 200 W/cm^2, proving the applicability of these mixed crystals as laser gain media. In comparison to solvent-based QD lasers, the mixed crystals show an extraordinary photometric stability under strong illumination. Based on this, this seed project provided a large step on the way to commercially produce durable, high power QD based lasers