Recent Advances in Quantum Dot Lasing: From Zero-Threshold Optical Gain to Light Amplification with Electrical Pumping

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Chemically synthesized quantum dots (QDs) can potentially enable new classes of highly flexible, spectrally tunable lasers processible from solutions. Despitea considerable progress over the past years, colloidal-QD lasing, however, isstill at the laboratory stage. A major complication is fast nonradiative Augerrecombination of gain-active multicarrier species such as biexcitons. Recently, we explored several approaches for mitigating the problem of Auger decay bytaking advantage of a new generation of “designer” QDs with a radially graded composition that show a considerable suppression of Auger decay. Using these novelQDs, we have been able to realize optical gain with electrical pumping [1],which has been a long-standing goal in the field of colloidal nanostructures. Further, we apply these dots to practically demonstrate the viability of a “zero-threshold-optical-gain”concept using not neutral but negatively charged particles wherein thepre-existing electrons completely block ground-state absorption [2]. Suchcharged QDs are optical-gain-ready without excitation and, in principle, canexhibit lasing at vanishingly small pump levels. All of these exciting developments demonstrate a considerable promise of colloidal nanomaterials for implementing solution-processible optically and electrically pumped laser devices.

1. Lim, J., Park,Y.-S., Klimov, V. I., Nat. Mater. 17, 42 (2018)

2. Wu, K., Park, Y.-S., Lim, J., Klimov, V. I., Nat. Nanotechnol. 12, 1140 (2017) page