Stimulated Emission through an Electron-Hole Plasma in Colloidal CdSe Quantum Rings

Carmelita Roda, Bastiaan B.V. Salzmann, Isabella Wagner, Year Ussembayev, Kai Chen, Justin Hodgkiss, Iwan Moreels, Kristiaan Neyts, Daniel Vanmaekelbergh and Pieter Geiregat.

Colloidal CdSe quantum rings (QRs) are a new class of nanomaterials synthesized via thermochemical edge reconfiguration of thinner CdSe nanoplatelets [1],[2]. In the latter, the photo-physics is consistently dominated by strongly bound electron-hole pairs, so-called excitons, that can merge to form excitonic molecules (biexcitons), giving rise to net stimulated emission along the molecule-to-exciton recombination pathway.[3] On the other hand, little is known on the nature of elementary excitations in thicker CdSe QRs - whether they are excitons or free electron-hole pairs- and their behavior at high density regime. Here, we show that charge carriers in QRs condense into a hot uncorrelated electron-plasma at high density opposed to the stable exciton gas found in thinner nanoplatelets. Through strong band gap renormalization, this plasma state is able to produce sizable optical gain with a broadband spectrum. Next, we show that the typical signatures of excitonic transitions are indeed absent in QRs. The gain is limited by a second order radiative recombination process and the buildup is counteracted by a typical charge cooling bottleneck. Overall, our results show that weakly confined QRs are a unique system to study uncorrelated electron-hole dynamics in nanoscale materials.

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[2] Salzmann, B. B. V.; Vliem, J. F.; Maaskant, D. N.; Post, L. C.; Li, C.; Bals, S.; Vanmaekelbergh, D. From CdSe Nanoplatelets to Quantum Rings by Thermochemical Edge Reconfiguration. *Chem. Mater* 2021.

[3] Geiregat, P.; Tomar, R.; Chen, K.; Singh, S.; Hodgkiss, J. M.; Hens, Z. Thermodynamic Equilibrium between Excitons and Excitonic Molecules Dictates Optical Gain in Colloidal CdSe Quantum Wells. *J. Phys. Chem. Lett* 2019, 10, 3637-3644.