Contribution ID: **98** Type: **Poster**

Statistical Analysis of Photoluminescence Decay Kinetics in QD ensembles

Friday 24 September 2021 10:11 (10 minutes)

Semiconductor quantum dots (QDs) are considered ideal building blocks to produce materials with specific photonic and spectroscopic properties. The possibility of controlling their properties such as size and doping during preparation facilitates the fine tuning of their optical properties such as absorption and emission spectra. The optical properties of QDs are affected by their environment via energy and possibly charge transfer processes between the dots and surrounding materials. Time-resolved single photon counting (TCSPC) of the photoluminescence (PL) decay is a key experimental method used to characterize the excited state dynamics and explore these effects, having become a well-established quantitative tool.

However, understanding and modelling the fluorescence lifetimes obtained via TCSPC is far from straightforward. The main difficulties are that the QD systems are heterogeneous and the overall fluorescence decay is influenced by several different mechanisms. One such mechanism is the Förster Resonant Energy Transfer (FRET) that can take place for different environments including other QDs.

In this work we present two methods of statistical analysis of the decay kinetics using (I) the probability distribution function (PDF) and (II) statistical moments. Both methods reveal FRET occurring in a mixture of QDs of two different sizes and, specially, the latter can be more informative in terms of donor-acceptor spatial correlations.

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Session Classification: Quantum Materials and Quantum Technologies (Posters)

Track Classification: Quantum Materials and Quantum Technologies