PhD THESIS DEFENSE: Exciton engineering for quantum confinement in an electrostatically defined PN-junction

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10:00

ICFO Auditorium and Online (Teams)

We investigate the physics of quantum-confined excitons in an electrostatically defined PN junction. Such a PN junction can be generated in an encapsulated monolayer \MoSe{} along the patterned edge of a top-gate electrode. Applying a voltage gradient between the top and bottom gates results in the formation of an in-plane electric-field gradient in the depletion region and strong doping gradients in the P- and N-doped regions of the PN junction. The exciton experiences an attractive force within the electric field gradient and repulsion from exciton-charge carrier interactions. The combined effects are sufficiently strong to quantize the number of available excitonic states within the potential. We show measurements of

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these quantum-confined excitons in reflection contrast and photoluminescence spectroscopy. We demonstrate how the confinement potential results in fine structure splitting with linearly polarized excitonic states that are aligned either along or perpendicular to the top gate edge. The states can be gradually tuned between linear and circular polarization using an out-of-plane magnetic field. Our particular sample geometry, where the formation of the PN junction electrically isolates the sample from ground, allows us to investigate the electrostatic model of a photo-biased PN junction, with the bias voltage as an additional tuning parameter of the confinement potential. The bias voltage is modified by the measurement itself and varies with the location of the measurement. We demonstrate how the combined impact of exciton dissociation and Auger-assisted hot-hole tunneling modifies the bias voltage over a timescale up to. The bias voltage can be further controlled using second laser, which enables the tuning of the energy of the quantized states over the rang of. Ultimately, these findings allow us to simulate the exact shape of the confinemen potential and to investigate how the in-plane electric field modifies the internal excito structure, impacting the exciton oscillator strength, lifetime, and dissociation. The results o this thesis illustrate the possibilities to pattern tailored exciton potential shapes for photoni and quantum technologies

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Thesis Directors: Prof. Dr. Frank Koppens and Dr. Antoine Reserbat-Plantey
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