Research topic

“Bose-Einstein Condensation of excitons”

The project is motivated by the quest for the experimental realization of a Bose-Einstein condensate of excitons in semiconductors. This field of research was founded in 1968 by the theoretical prediction of Keldysh and Kozlov [1]. The goal of our project aims for a fundamental understanding of the dynamics of excitons in terms of developing electrostatic traps being able to host a high-density exciton gas and, ultimately, an excitonic Bose-Einstein condensate [2,3].

One focus of our current research activity comprises detailed studies on the generation of tunable potential landscapes for long-living excitons. We employ semiconductor devices containing coupled GaAs quantum wells embedded in a field-effect structure to create spatially indirect excitons. These photo-generated indirect excitons exhibit extraordinarily long lifetimes exceeding 10µs at temperatures of 4K. We use spatially and time-resolved photoluminescence spectroscopy for directly observing the dynamics of indirect excitons. Based on the quantum confined Stark effect, we demonstrate that an excitonic shuttling motion between adjacent narrow top electrodes can be driven by appropriate temporal variation of the gate voltages [4]. Controlled drift of excitons across distances of several 100µm is studied by employing a laterally graded electrostatic potential induced by the quantum confined Stark effect via a current-carrying resistive gate [5]. Time-of-flight measurements allow us to determine the drift mobility of long-living, indirect excitons to be as high as 100,000 cm^2/eVs across several hundreds of microns at temperatures below 10 K. Up to now, this is the highest mobility of indirect excitons ever observed. With increasing temperature the excitonic mobility decreases due to exciton-phonon scattering processes.

Creating efficient traps for long-living excitons is another focus of our research interest. We discovered a new technique to create electrostatically defined traps for excitons [6]. Laterally micro-structured layers of SiO_2 of arbitrary shape applied on top of the double quantum well device are capable to confine excitons in narrow, line-shaped regions around the perimeter of the SiO_2 area. In contrast to other trapping methods such as mechanical stressing the sample [3] or using intrinsic potential fluctuations [7], electrostatic traps offer great advantages. This includes in-situ tunability of the excitonic confinement potential by gate voltages, giving a high degree of spatial, temporal and energetic control over the excitons. Moreover, the harmonic trapping potential we measured shows the highest confinement frequency for excitons ever observed up to now. In turn, by extending the approach towards full spatial confinement of excitons in all directions in space, the presented technique for exciton trapping is a very promising candidate towards the realization of an excitonic Bose-Einstein condensate.

References:

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