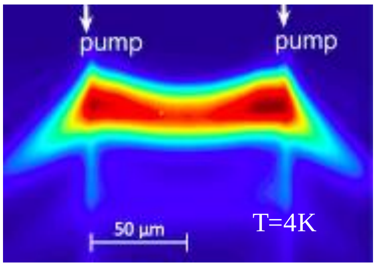
- Axe de GANEX : 2 - Laser et sources cohérentes
- Titre du sujet : **Collective states and devices based on indirect excitons in GaN QWs**
- Nom et e-mail du porteur de projet : Maria.Vladimirova@umontpellier.fr
- Nature de la thèse

  X Partagée académique : GANEX 50%, L2C sur ANR OBELIX 50%
- Date souhaitée de démarrage : 01/10/2017
- Lien avec un projet ANR ou H2020: ANR Obelix (blanc 2016-2020, gestion CNRS)
- Lien avec industriels : /
- Sujet développé :

Indirect excitons are bosonic quasi-particles in semiconductors with unique properties: they have long lifetime and spin-relaxation time, can travel over large distances before recombination, can be cooled down to low temperatures and form a quantum gas, and can be controlled by voltage in-situ. Due to these properties, they form a model system both for the studies of **fundamental properties of light and matter** and for the development of **conceptually new excitonic devices**. Excitons in polar GaN quantum wells can be considered as naturally indirect excitons, because of the strong built-in electric field in the growth direction.



Cross-section of an exciton cloud in a single GaN/(Al,Ga)N QW vs space (hor.) and energy (vert.) under a ring-shaped cw pumping. The exciton density at the center reaches 10^{12}cm^{-2}.

A close collaboration between the L2C (M. Vladimirova, T. Guillet) and the CRHEA (B. Damilano, Y. Cordier) recently lead to the demonstration of an efficient exciton transport from cryogenic to room temperature in GaN quantum wells homo-epitaxially grown on GaN substrates. This work is funded by ANR via the OBELIX project (tOwards Bose-Einstein Liquid with Indirect eXcitons), which aims to realize collective states of excitons in various semiconductor heterostructures. The transport of µs-lifetime excitons over tens of microns and high densities (cf figure) is the pre-requisite to create collective exciton states, which are at the heart of the present PhD project. The roadmap that we suggest consist in the trapping and the active control of a dense gas of indirect excitons within field-effect devices. This approach is promising for both practical excitonic devices and for the **realization of collective quantum states in solid state**.

The proposed research project consists in the exploration of indirect exciton liquids in GaN quantum wells by optical microscopy. The student will investigate GaN-based devices by **UV optical microscopy** available at L2C. He will closely interact with CRHEA in order to identify the optimal design **the excitonic traps and transistors**. The electrode patterns will be fabricated in CHREA by optical lithography on the chosen samples. The traps are expected to allow creating dense and cold gas of IXs. Different trap geometries will be tested by optical microscopy, combined with electric characterization and control, in order to demonstrate the formation of coherent collective state at low temperatures (T=4K). A combination of imaging techniques with spectral and temporal resolution will give access to **the quantum thermodynamics and the transport properties of the exciton liquids**. In parallel, the efficiency of the electric control of the exciton fluxes will be evaluated at different temperatures.

The funding scheme combines the present GaNeX application for the first 18 months and the OBELIX project for the final 18 month of the PhD. Both projects are managed by the CNRS. The funded man power within the OBELIX project alone would not allow for a full PhD.