2015-THESE

Axe de GANEX : 2

Titre du sujet : GaN/AlGaN nanowires for quantum devices Microwire-based electrically-injected GaN polariton laser

Nature de la thèse :

CRHEA: 40%
Institut Pascal: 40%
INAC-Néel (équipe mixte): 20%

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Sujet développé :

Semiconductor microcavities operating in the strong-coupling regime, i.e. optical resonators in which the *eigenmodes* of the system are mixed exciton photon states, have seen a rapid development in the last years especially since the demonstration of polariton Bose-Einstein condensation [1]. The numerous and exciting discoveries that have followed, such as superfluidity and the formation of topological defects, have been possible thanks to a mature fabrication technology of distributed Bragg reflectors (DBRs) and semiconductor heterostructures, mainly based on GaAs and CdTe [1,2]. However, due to the weak excitonic binding energy in these materials, polariton condensation remains confined to cryogenic temperatures.

For practical applications, achieving room temperature (RT) polariton lasing under electrical excitation remains a long-standing challenge. Polariton lasing at RT under optical excitations has been demonstrated in large bandgap semiconductor material including organics [3], GaN [4] and ZnO [5]. Very recently, two independent claims of electrically-injected polariton lasers have been published: the first one involves a GaAs-based microcavity subjected to a strong external magnetic field (~5T or larger) [6]. In 2014, electrically-injected polariton laser operating at RT has been claimed using an original GaN-based microcavity design [7]. Both these results have triggered a high interest in the scientific community but remain highly controversial: on the one hand the role of the magnetic field is poorly understood, while the data presented in [7] are rather ambiguous. An unambiguous proof-of-concept based on a simpler and more efficient microcavity design is thus highly desirable.

In this PhD we propose to exploit GaN microwires to circumvent many of the difficulties encountered in DBR-based microcavities and fabricate, reproducibly, electrically-injected polariton microlasers operating at RT. The use of microwires will simplify the overall process: on the one hand we will make use of whispering gallery modes as optical modes [8] and, thus, we will not need highly-reflecting UV DBRs; on the other hand, we will exploit the dislocation-free nature of GaN microwires, which will provide a very high-quality active region (i.e. bulk-like quality) [9]. To achieve this, the PhD candidate will grow the microwires heterostructures at CRHEA, processing them subsequently in CRHEA's clean-room. Then, the candidate will characterize individual microwires, both optically and electro-optically, at Institut Pascal and INAC-Néel, in order to assess the nature of the lasing regime as well as to establish the main emission properties.

References

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