PhD Title: “From edge-emitting polariton lasers to nonlinear *on-chip* polariton circuits”

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Semiconductor planar microcavities operating in the strong-coupling regime, i.e. optical resonators in which the *eigenmodes* of the system are no longer purely excitonic nor purely photonic but a mixture of them, 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, including superfluidity [2] and topological defects generation [3], have been possible thanks to a mature fabrication technology of distributed Bragg reflectors (DBRs) and semiconductor heterostructures, mainly based in GaAs and CdTe [1,2,3]. This evolution has finally allowed for controlled polariton manipulation. However, all these experiments were carried out at low temperatures because, even if the strong-coupling regime can be kept up to room-temperature, the limited exciton stability of these materials at high temperatures and large particle densities precluded condensation at room-temperature (RT). Thus, if polariton condensation wants to be obtained at high temperature, i.e. RT or above, materials with large oscillator strengths and large exciton binding energies as those developed in CRHEA must be employed. This is the reason why so much attention has been paid lately to organic semiconductors [3], GaN [4] and especially ZnO. Indeed, CRHEA demonstrated for the first time room-temperature condensation in a vertical ZnO microcavity [4,5], which enabled us to study new regimes unattainable before with GaAs, such as polaritons condensates with an excitonic fraction larger than 90%

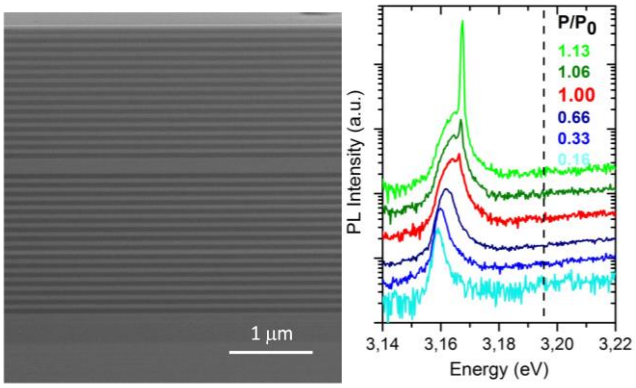

Figure. Scanning electtron microscopy of a typical vertical microcavity for strong-coupling studies (left). Nonlinear laser emission in a ZnO-based micorcavity operating at room-temperature (right).

While all previous experiments were carried out in vertical microcavities, recently the University of Sheffield has introduced a new configuration in which polaritons are formed by the coupling of a guided photonic mode and exciton resonances [6]. This leads to polaritons propagating at very large speeds, comparable to the speed of light in the material (in the order of 10-30% of it). In the current PhD the candidate will design, fabricate by molecular beam epitaxy (and eventually metalorganic vapour phase epitaxy) and characterize ZnO-and GaN-based “horizontal” microcavities with the aim of achieving polariton condensation with such fast-propagating polaritons. Once this necessary step will be achieved, on-chip polariton devices besides an edge-emitting polariton laser will be implemented, including polariton amplifiers, transistors, switches and interferometers. The final goal is to exploit simultaneously the fast propagation speeds of polaritons due to their photonic component and the large nonlinearities enabled by their excitonic component.

It is important to note that this PhD topic is associated to an ANR project (Plug-And-Bose), which began in 2017 and will extend during four years.

[1] J. Kazprzak *et al.*, *Nature* **443**, 409 (2006).

[2] A. Amo et al., *Nature* **457**, 291 (2009)

[3] S. Kena-Cohen and S. R. Forrest, *Nat. Photonics* **4**, 371 (2010).

[4] O. Jamadi *et al.*, *Phys. Rev. B* ***93,*** *115205 (2016)*

[5] F. Li *et al.*, *Phys.Rev. Lett.* **110** (2013) 196406. See also: http://www.cnrs.fr/inp/spip.php?article1899

[6] O. Jamadi et al., arXiv 1708.00501 (2017)