Recent advances on intersubband polaritons in dispersive resonators

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Intersubband polaritons are the result of the strong light-matter coupling between an intersubband transition (ISBT) in a semiconductor quantum well, and a photonic micro-cavity mode. They have been predicted to behave as composite bosons and - similarly to excitonic polaritons - they should be subject to final state stimulation [1]. Since their first demonstration in 2003 [2], most of the research has been devoted to the demonstration of the so called ultra-strong coupling regime in the mid and far infrared range of the electromagnetic spectrum [3], along with few demonstrations of electrically injected electroluminescent devices [4].

Our work focuses on the behavior of intersubband polaritons under resonant injection of coherent light in the mid and far infrared [5], in view of developing ISB polariton electroluminescent devices and lasers.

The first part of the talk will focus on the micro-cavity resonator that we have recently developed [6]. Based on a metal-insulator-metal geometry, it offers the electric field confinement required to operate in the strong coupling regime with an intersubband transition ($\lambda \sim 10\ \mu$m using the GaAs/AlGaAs system). Furthermore, a parabolic dispersion with an energy minimum at $k_{//}=0$ and the possibility to inject coherent light at a specific energy-wavevector value, make this architecture ideal for optical pumping experiments.

The second part of the talk will detail our efforts towards the improvement of the polaritons lifetime, a key parameter for the development of a polariton laser. To this goal, it is necessary to optimize *both* the ISBT and the cavity lifetime. On one hand the position of the dopants within the quantum well was optimized to reduce the scattering by ionized impurities. Secondly, different metals and cavity thickness were also investigated both theoretically and experimentally. Finally, we have experimentally observed that a simple linewidth averaging argument does not hold for this polaritonic system as an important line narrowing phenomenon systematically occurs, independently of the amount of inhomogeneous broadening present.

In the final part of the talk, preliminary data on the resonant injection of coherent light ($\lambda \sim 10\mu$m) into the polaritonic system will be presented. Results on ISB polaritons operating at shorter wavelength ($\lambda \sim 3\mu$m) using the GaN/AlN system will also be shown, which offers perspectives to implement such optical pumping experiment in a spectral region where more powerful optical sources are available.

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