Towards exciton polaritons at telecommunication wavelengths in GaAs-based microcavities

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Exciton polaritons are quasi particles resulting from a strong light-matter interaction between excitons and photons inside a high quality semiconductor microcavity. Their bosonic character and possible Bose-Einstein condensation give the opportunity to realize inversion-free emitter of coherent light which exhibits ultra-low threshold power.

Up to now, GaAs-based microcavities offered high optical quality with emission in the spectral range convenient for handling spectroscopic experiments employing standard and highly efficient Si-based detectors. In order to implement polariton lasers in optical telecommunication there is a need to extend the emission wavelength of the polariton systems further into the near infrared spectral range. This is possible in GaAs-based systems with properly chosen quantum well (QW) material. Particularly, insertion of multi-alloys as (In, Ga)(As, N, Sb) is a promising solution, offering both the spectral shift into the target range of 1.3 – 1.55 μm and the possible simultaneous oscillator strength increase [1] desired for enhanced exciton – photonic mode coupling.

We present optical investigations of GaAs-based planar microresonators with embedded quantum wells designed for the near infrared range. Reflection measurements together with angle resolved photoluminescence along the wafer radius (corresponding to different detuning between the exciton and cavity mode energy due to the wedge along the radius) were performed. Polariton eigenmodes emission in structures with embedded InGaAs quantum wells at the record wavelength of 1 μm was obtained and preserved to high temperatures up to 160 K with anticipation to significantly higher temperatures. The Rabi splitting of the eigenmodes in the investigated structures is approximately 7 meV and remains almost constant with temperature and, moreover, it is comparable with the expected exciton binding energy implying the very strong coupling conditions [2]. The latter explains forming the exciton-polaritons at temperatures corresponding to thermal energies exceeding the dissociation energy of Coulomb correlated electron-hole pairs in a quantum well. Diluted-nitride-based structures were also grown to obtain emission wavelengths in the telecom range, i.e. 1.3 μm. Significant improvement of the optical quality of InGaNAs quantum wells was gained by addition of antimony, which acts both as a surfactant for incorporation of N atoms into the structure during the epitaxial growth and as a fifth element of the quinary alloy. There will be discussed the current status of the exciton-photon coupling regime in this kind of InGaNAs(Sb)/GaAs QWs placed inside AlAs/GaAs resonators together with the system limitations and its possible future improvements.

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