Peculiarities in the exciton-polariton emission in InGaAs/GaAs quantum well - microcavity system under high excitation

M. Pieczarka[1], Ł. Dusanowski[1], M. Syperek[1], P. Podemski[1], J. Misiewicz[1], G. Sęk[1]
F. Langer[2], M. Kamp[2], C. Schneider[2], S. Höfling[2,3]

[1] *Institute of Physics, Wrocław University of Technology, Wrocław, Poland*
[2] *Technische Physik, University of Würzburg and Wilhelm-Conrad-Röntgen-Research Center for Complex Material Systems, Würzburg, Germany*
[3] *School of Physics and Astronomy, University of St. Andrews, UK*

For the last two decades much attention has been paid to exciton-polaritons - solid state quasiparticles formed from strongly coupled photons and excitons in the semiconductor quantum well-microcavity system. These quasiparticles are well understood in the conditions of low and moderate excitation, i.e., at carrier densities, where polaritons are described as composite, weakly interacting bosons and can exhibit condensed matter phenomena like Bose-Einstein condensation. At high densities, the system is pushed into the weak coupling regime and the conventional photon lasing is likely to appear via the stimulated recombination processes of uncorrelated electron-hole pairs. However, there is still a heated debate on the possible alternate scenarios and the proper understanding of the emission under the very high excitation. As it has recently been predicted, retained electron-hole pairs coupled to the cavity mode can be expected despite the occurrence of photon lasing [1].

In this report we use an unconventional, nonresonant excitation scheme in order to investigate the excitation-power-dependent evolution of photoluminescence from a GaAs-based planar microcavity with embedded InGaAs quantum wells. The system emits close to 1 μm photon wavelength at T = 4.2 K. The dynamic formation of polariton gas occurs after excitation with a train of femtosecond-long pulses focused to a small spatial area of about 5 μm in diameter. Angle-resolved photoluminescence measurements (Fig. 1) reveal the buildup of a polariton condensate at the second threshold, pronounced in the input-output curve. The quantum well-microcavity emission modes at different excitation conditions are examined by the time-resolved photoluminescence experiment in the characteristic regions of the k-space. Furthermore, photon correlation statistics are measured, giving additional insight into the character of the observed evolution. The analysis of a wide set of experimental data leads to the conclusion that at high excitation regime, where only the conventional photon lasing is usually expected, the strong coupling is preserved and correlated electron-hole pairs can coexist with the electron-hole plasma.

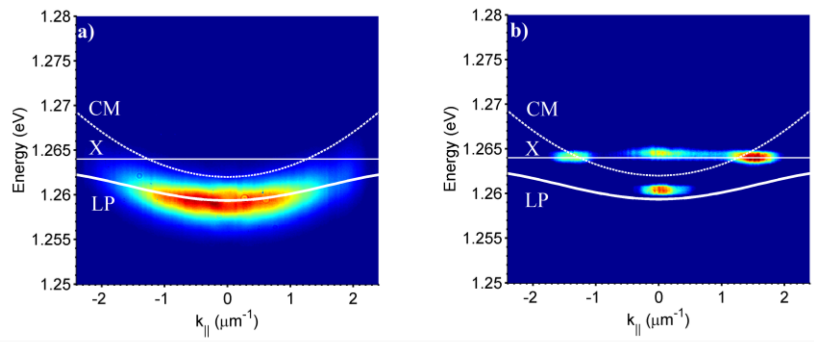

Figure 1: a) Normalized polariton dispersion under the weak excitation (below the first threshold). b) Normalized luminescence dispersion at the high excitation regime.

[1] M. Yamaguchi et al., *Phys. Rev. Lett.* **111**, 026404 (2013).