Temperature-dependent polarized luminescence of exciton polaritons in ZnO films

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Semiconductor compound ZnO is well known by the remarkable excitonic properties – large exciton binding energy (60 meV) and longitudinal-transverse splitting (~10 meV for B and C excitons). These properties have allowed one to consider this material as a polaritonic medium suitable for sophisticated optoelectronic applications, such as microcavity polariton lasers [1]. On the other hand, the factor limiting such applications at high temperatures can be the outstandingly strong exciton – LO phonon coupling reported for ZnO [2]. In spite of the well documented excitonic character of the ZnO photoluminescence (PL) up to room temperature, most of the available experimental data on exciton polaritons have been so far limited to cryogenic temperatures.

In this work we have performed temperature-dependent studies of exciton polariton emission in a ZnO film grown by metalorganic vapor phase epitaxy. The 1200 nm thick layer was grown on the (0001) plane of a GaN template deposited on a sapphire substrate. To monitor the polaritonic nature of the excitonic spectrum, we detected the emission of mixed longitudinal-transverse exciton polariton modes. For this purpose, the PL spectra were measured in the geometry of an extraordinary beam, realized by the use of a large-aperture microobjective collecting light from the cleaved sample edge at different angles with respect to the principle axis **c** of the wurtzite crystal. In this geometry light is polarized in the plane containing both the **c** axis and the wave vector **k** of the photon. For a finite angle between the direction normal to the **c** axis and vector **k**, the longitudinal exciton couples to the electromagnetic field due to the non-zero projection of the extraordinary field on the direction of vector **k**, resulting in the emergence of the mixed polaritonic modes. The respective polaritonic features were detected in the range of 50-130 K. The elevated temperatures were found to facilitate the polariton emission due to the thermal population of both A and B exciton branches and, presumably, due to the enhanced polariton scattering into the photonlike mixed modes. The emission spectrum of mixed polaritonic modes becomes unresolved at higher temperatures, when the exciton broadening due to the coupling with LO phonons exceeds the values of longitudinal-transverse exciton splitting.

At room temperature the detected exciton broadening was as large as 70-80 meV that is comparable with the 120 meV vacuum-field Rabi splitting predicted for a microcavity based on ZnO [1]. This makes fabrication of the room-temperature microcavity polariton laser realistic but not easy.

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[2] T. Makino, C. H. Chia, N. T. Tuan, Y. Segawa, M. Kawasaki, A. Ohtomo, K. Tamura, H. Koinuma, Appl. Phys. Lett. **76**, 3549 (2000).