Observation of the dispersion relation of exciton-polaritons using ellipsoidal microlenses

N. Mitroczuk*, M. Furman, P. Oliwa, M. Muszyński, M. Nytko, A. Bogucki, Ł. Zinkiewicz, J. Szczytko, W. Pacuski, B. Piętka

Institute of Experimental Physics, Faculty of Physics, University of Warsaw, ul. Pasteura 5, 02-093 Warszawa, Poland

Exciton-polaritons are bosonic quasiparticles that emerge as a superposition of photon and exciton states in the strong coupling regime. They can undergo a transition into a nonequilibrium Bose-Einstein condensate [1]. The strong coupling regime can be distinguished in the dispersion relation, where an anticrossing of the exciton and photon modes is observed. However, observing this anticrossing experimentally requires a high numerical aperture (NA) objective, which might be challenging in cryostat-based experiments due to limited working distance.

In our approach, we replace the conventional microscope objective with a polymeric microlens printed directly onto the semiconductor microcavity surface. The use of high-NA elliptical microlenses [2] enables the observation of high-momentum polaritons and provides access to the excitonic reservoir forming at large in-plane wave vectors, all without the need for a microscope objective. Furthermore, we demonstrate how modifying the microlens shape influences the maximum observable momentum range and the quality of reciprocal space imaging. Our experiments can provide detailed insights into polariton dynamics and relaxation processes by extending the observable range of in-plane momenta.

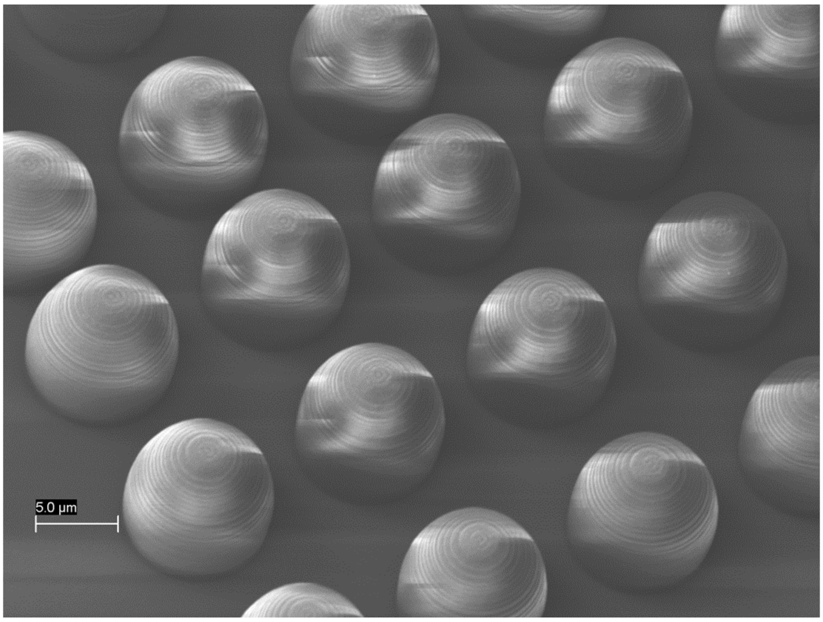

Figure 1: A scanning electron microscope (SEM) image showing an array of microlenses printed on the surface of a semiconductor optical microcavity.

References

[1] J. Kasprzak, M. Richard, S. Kundermann, et al., *Bose–Einstein condensation of exciton polaritons*, Nature **443**, 409-414 (2006)

[2] A. Bogucki, Ł. Zinkiewicz, M. Grzeszczyk, et al., *Ultra-long-working-distance spectroscopy of single nanostructures with aspherical solid immersion microlenses*, Light: Science & Applications **9**, 48 (2020)

*E-mail: n.mitroczuk@student.uw.edu.pl