Propagating exciton-polariton condensates in coupled waveguide structures

Beierlein Johannes,[1,*] Egorov Oleg,[2] Harder Tristan,[1] Gagel Philipp,[1] Karol Winkler,[1] Emmerling Monika,[1] Schneider Christian,[1] Peschel Ulf,[2] Klembt Sebastian[1] and Höfling Sven[1,3]

[1]Technische Physik, Physikalisches Institut and Wilhelm Conrad Röntgen-Research Center for Complex Material Systems, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany
[2] Institute of Condensed Matter Theory and Solid State Optics, Abbe Center of Photonics, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany
[3]SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews, KY16 9SS, United Kingdom
**e-mail: Johannes.beierlein@uni-wuerzburg.de*

In the past decades, exciton-polaritons (polaritons) have emerged as a new scientific field due to its light-matter nature. In addition, polaritons show a strong non-linearity when reaching the condensation threshold. Using a variety of etching techniques to create microcavity waveguides (WGs), long-range propagation and interference effects of polaritons have been demonstrated [1,2].
In this paper, we study coupling phenomena in two microcavity WGs, which are realized by etching the top and bottom DBRs. Due to pronounced evanescent coupling the condensate oscillates between the waveguides. This transfer of energy is clearly displayed in real-space due to the propagating nature of the condensate.(Fig 1) Depending on the device parameters a different phase at the end of the coupling area can be reached, resulting in different routing ratios. We study this two WG coupling as a building block for larger coupled WG arrays.
This arrays are manufactured using a well developed etch-and-overgrowth technique. Here, the barrier height and thus the WG coupling is highly controllable. In homogenous coupling WG arrays we clearly observe discrete diffraction patterns of polaritons propagating. Furthermore, we show that the precise control of the coupling parameters opens the way to study topologically non-trivial band structures and complex propagation behaviors such as Bloch oscillations and Zener-tunneling.

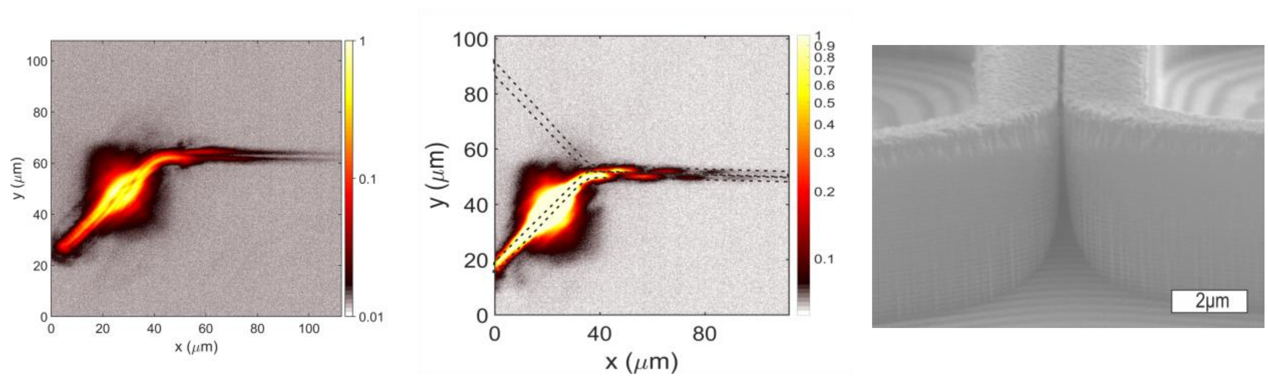

Fig. 1.a,b) Real space image of a propagating polariton condensate in a codirectional coupler with different coupling strength. **c)** SEM image of a codirectional coupler at an angle along the coupling propagation direction.

[1] E. Wertz et al., Nat.Phys., 2010, **6**, 860
[2] K. Winkler et al., PRB, 2017, **95**, 201302(R)