Abstract: We report on the realization of electrostatic conveyers for indirect excitons and observation of a dynamical localization-delocalization transition for the excitons in the conveyer with varying exciton density and amplitude of the conveyer potential.

We report on the realization of electrostatic conveyers for indirect excitons in a GaAs/AlGaAs coupled quantum well structure. The conveyer is a laterally moving lattice potential for excitons, generated by laterally modulated electrode voltages. It is implemented by patterning a linear lattice of electrode stripes on the sample surface. The stripes are periodically interconnected, such that applying a set of voltages to the lattice sites creates a laterally periodic electric field in the $z$-direction $F_z$ and, as a result, a laterally periodic potential for the indirect excitons $\delta E \sim ed F_z$, where $ed$ is the dipole moment of indirect excitons. Applying a suitable set of AC sinewave voltages yields a traveling sinusoidal lattice moving laterally across the sample. The wavelength of this moving lattice is set by the electrode periodicity and the velocity can be controlled by the AC frequency.

In the reported experiments, the conveyer potential is created by 1 $\mu$m-wide electrodes spaced 1 $\mu$m apart and the conveyer periodicity is 7 electrodes. The sample mounts to a PCB in an optical He cryostat at $T = 1.5$ K and is driven by a set of coaxial cables with impedance-matching termination at the sample. The indirect exciton lifetime is controlled by DC bias $V_{bias}$ supplied separately at the PCB. The transmission lines are capacitively terminated to block DC heating at the termination resistors. A set of differentially phase-delayed AC sinewaves at $f \approx 50$ MHz created the traveling lateral sinusoidal potential at the sample. The reported voltage amplitude, which determines the amplitude of the conveyer potential $V_{conv}$, corresponds to the peak AC amplitude supplied after the shortest delay line at the top of the cryostat. The exciton density is controlled by the excitation power $P_{ex}$.

We observed the exciton transport via the conveyer over several tens of microns, see Fig. 1, and studied the transport as a function of the conveyer amplitude, exciton density, and exciton lifetime. We observed a dynamical localization-delocalization transition for the excitons in the conveyer with varying exciton density and amplitude of the conveyer potential. It is a dynamical counterpart of the localization-delocalization transition for the excitons in static lattices observed in Ref. [1]. In the case of a conveyer studied here, in the localization regime, excitons are moved by the conveyer, following the moving lattice potential, while in the delocalized regime, excitons do not follow the conveyer motion. The dynamical localization-delocalization transition is demonstrated in Fig. 2, which shows the spatial extension of the exciton cloud as a function of the conveyer amplitude. For a shallow conveyer (i.e. small $V_{conv}$), the exciton cloud extension is not affected by the conveyer motion indicating that the excitons do not follow the moving lattice, i.e. are delocalized. In contrast, at higher conveyer amplitudes $V_{conv}$, excitons are moved by the moving lattice, i.e. are localized.

Fig. 1. PL images of the indirect exciton cloud with the conveyer off (a) and on (b). The excitation spot is indicated by the circle. $V_{bias} = -3$ V, $V_{conv} = 1.5$ V, $T = 1.5$ K, $\lambda_{ox} = 690$ nm, $P_{ex} = 100$ $\mu W$. 
Fig. 2. The spatial extension of the exciton cloud as a function of voltage amplitude $V_{\text{conv}}$, which controls the conveyor amplitude. The spatial extension is presented by $2\sqrt{2\ln 2} M_2$, where $M_2$ is the second moment of the spatial profile of the spectrally integrated emission of indirect excitons.

$V_{\text{bias}} = -3 \text{ V. } T = 1.5 \text{ K. } \lambda_{\text{ex}} = 690 \text{ nm. } P_{\text{ex}} = 200 \mu\text{W.}$

References
1. M. Remeika, J.C. Graves, A.T. Hammack, A.D. Meyertholen, M.M. Fogler, L.V. Butov, M. Hanson, A. C. Gossard, “Localization-Delocalization Transition of Indirect Excitons in Lateral Electrostatic Lattices,” Phys. Rev. Lett. 102, 186803 (2009).