第２０回　未来化学創造センター セミナー
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“Photonic bandgap structures with organic materials for lasing and switching applications”

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The increasing bandwidth demand in datacom and telecom applications drives the research on highly integrated small form factor and high bandwidth optical components and subsystems. In this context organic semiconductor based devices offer some advantages with respect to traditional materials and devices e.g., easy processing, low cost and flexibility. If successful, lasers and switches based on organic semiconductors could become important due to their integration potential on arbitrary substrates. In the presentation we will address small factor devices as well as characterization results of materials for all-optical switching.

Hybrid photonic crystal structures for lasing applications offer great potential for opto-electronic applications. They exhibit high optical gain and a spectrally broad gain spectrum in combination with a low lasing threshold. To achieve a substantial decrease in the lasing threshold, optimum photon confinement and a large feedback are crucial. Therefore, we fabricated two-dimensional photonic band-gap structures where the corrugation is applied in a thin high index layer. Vertical-emitting laser devices have been fabricated. The measured reduced lasing thresholds and the spectral features are in excellent agreement with the predictions of the simulations, suggesting new design criteria for smaller devices.

Furthermore, combining organic materials with high Kerr-nonlinearities and resonant photonic nanostructures could lead to new fast switching elements. To determine the nonlinear coefficients of promising materials, we fabricate hybrid Fabry-Perot cavities by incorporating the organic material between two dielectric mirror stacks. Using an ultrafast pump and probe setup we spectrally resolve the nonlinear transmission of pulses that are spectrally broader than the cavity resonances. The experimental data are compared to finite-difference time-domain simulations in order to deduce the nonlinear coefficients.

In addition to organic materials there has been much progress in the rapidly growing field of semiconductor nanocrystal quantum dots (QD) due to their promising applications such as display devices, lasers, biological fluorescent tagging materials and photodetectors. Particularly favorable, the chemically synthesized colloidal QDs can easily be incorporated into conjugated polymer host systems allowing for novel organic/inorganic hybrid devices and combining the natural advantages from both organic as well as inorganic materials into one system. In order to optimize such hybrid systems in view of tailored optoelectronic properties a profound knowledge of the underlying electronic energy transfer processes between the inorganic and organic parts is necessary. We report on resonant energy transfer of non-equilibrium excitons in an amorphous polyfluorene donor CdSe/ZnS core-shell nanocrystal acceptor system. The fundamental question regarding transformation between small Frenkel excitons and more extended Mott-Wannier excitons will be addressed and we will indicate how such systems could lead to devices with optimized functionalities.

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