Westfälische Wilhelms-Universität Münster

Aktuelle Fragen der Nanophysik

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Spatial and spectral tailoring of spontaneous emission with semiconductor metasurfaces

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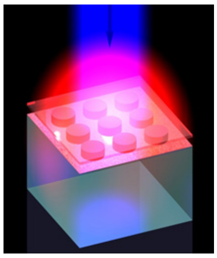

Nanoparticles consisting of semiconductor nanoparticles with a high refractive index support electric and magnetic multipolar Mie-type resonances, which can be tuned by the nanoparticle geometry and environment. Thereby they offer unique opportunities for engineering their near-field and far-field responses, while exhibiting very low absorption losses. In particular, semiconductor nanoresonators were extensively used as building blocks of wavefront-shaping metasurfaces [1] and Mie-resonant semiconductor nanoantennas can exhibit high directivities, Purcell enhancement, and near-unity radiation efficiencies at the same time [2,3].

This talk will provide an overview of our recent advances in enhancing and tailoring spontaneous emission in the visible and near-infrared spectral range by metasurfaces composed of designed Mie-resonant semiconductor nanoparticles. For precise fabrication of the metasurfaces, we employ electron-beam lithography on high-refractive-index semiconductor thin-films in combination with reactive-ion etching. We investigate various types of emitters, including semiconductor quantum dots, monolayers of transition metal dichalcogenides, as well as the intrinsic photoluminescence of the constituent semiconductor materials themselves. In order to characterize the emission properties of the hybrid systems, we perform micro-photoluminescence imaging, spectroscopy, and Fourier imaging for a variety of different active metasurface architectures. Our results show that tailored Mie-resonances provide a powerful platform for manipulating the spectral and directional properties of the emitted light.

References

[1] M. Decker & I. Staude, "Resonant dielectric nanostructures: a lowloss platform for functional nanophotonics", J. Opt. 18, 103001 (2016).
[2] A. E. Krasnok, A. E. Miroshnichenko, P. A. Belov & Y. S. Kivshar, "All-dielectric optical nanoantennas", Opt. Exp. 20, 20599 (2012).
[3] X. Zambrana-Puyalto & N. Bonod, "Purcell factor of spherical Mie resonators", Phys. Rev. B 91, 195422 (2015).