Photoluminescence control by hyperbolic metamaterials and metasurfaces

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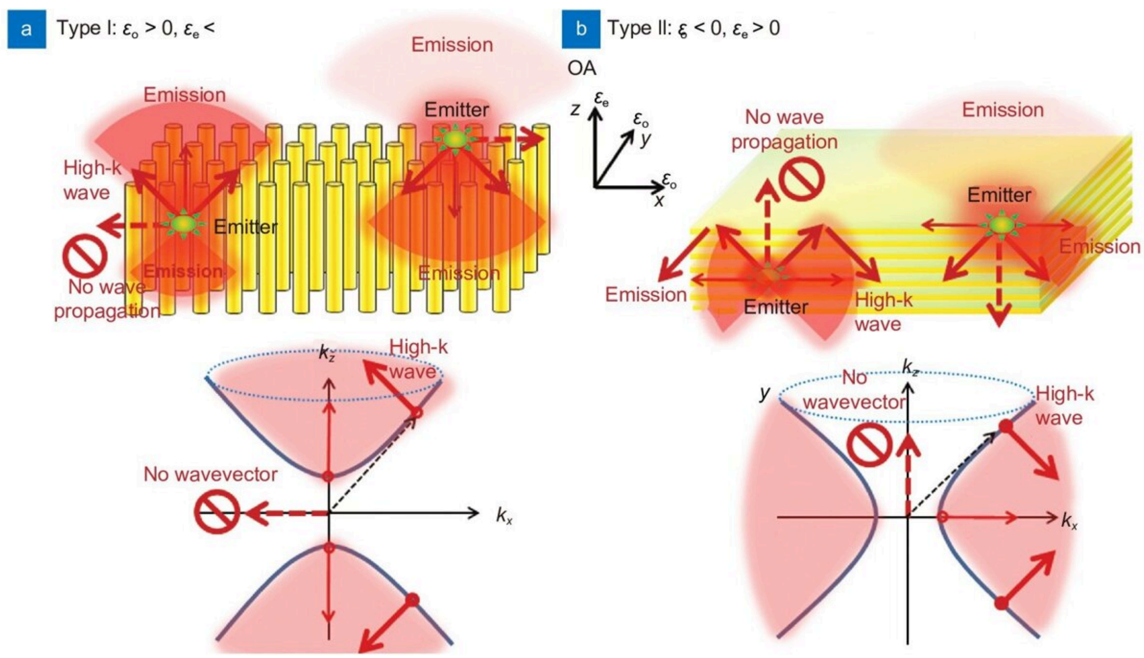

Schematic illustration of hyperbolic metamaterials and metasurfaces. (a) Type I hyperbolic metamaterials (εo > 0 and εe 0) in metal-dielectric multilayer configuration and their dispersion in the wavevector space. Credit: Compuscript Ltd

In a new publication from *Opto-Electronic Advances*, researchers led by Professor Andrei V. Lavrinenko and Dr. Pavel N. Melentiev from the DTU Fotonik-Department of Photonics Engineering, Technical University of Denmark, Lyngby, Denmark and the Nanoplasmonics and

Nanophotonics Group, Institute of Spectroscopy RAS, Moscow, Russia discuss photoluminescence control by hyperbolic metamaterials and metasurfaces.

Photoluminescence, emission of light from materials, including fluorescence, plays a great role in a wide variety of applications from biomedical sensing and imaging to optoelectronics. Therefore, the enhancement and control of photoluminescence has immense impact both on fundamental scientific research and aforementioned applications. Among various nanophotonic schemes and nanostructures to enhance the photoluminescence, the authors of this article focused on a certain type of nanostructures, hyperbolic metamaterials (HMMs) and metasurfaces. HMMs are highly anisotropic metamaterials, which produce intense localized electric fields, leading to enhanced light-matter interactions and control of emission directivity. Major building blocks of HMMs are metal and dielectric layers and/or trenches and metal nanowire structures, which can be made of noble metals, transparent conductive oxides, and refractory metals as plasmonic elements. What is very important, by their structure of HMMs, are not-resonant constructions providing photoluminescence enhancement in broad wavelength ranges. Hyperbolic metasurfaces are two-dimensional variants of HMMs.

In this review, the authors discuss current progress in photoluminescence control with various types of HMMs and metasurfaces. As losses are inevitable in the optical domain, active HMMs with gain media for compensation of the absorptive losses of the structures are also discussed. Such HMMs boost photoluminescence from dye molecules, quantum dots, nitrogen-vacancy centers in diamonds, perovskites and transition metal dichalcogenides for optical wavelengths from UV to near-infrared (λ = 290–1000 nm). By the combination of constituent materials and structural parameters, a HMM can be designed to control photoluminescence in terms of enhancement, emission directivity, and statistics (single-photon emission, classical light, lasing) at any desired wavelength range within the visible and near-infrared wavelength regions. HMM-based systems can serve as a robust platform for numerous applications, from light sources to bioimaging and sensing.

More information: Leonid Yu. Beliaev et al, Photoluminescence control by hyperbolic metamaterials and metasurfaces: a review, *Opto-Electronic Advances* (2021). DOI: 10.29026/oea.2021.210031

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