Super-resolution imaging with metamaterials

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Nowadays, high-speed super-resolution imaging is at the heart of many game-changing applications ranging from medical sciences, material sciences, bioengineering, security sciences, to semiconductor industries. However, traditional optical microscopes are lack of the ability to meet the imaging requirements, e.g. imaging resolution, speed, signal-to-noise ratio, sensitivity, due to a number of fundamental obstacles such as the diffraction limit of light and the phototoxicity of fluorophores. To overcome these limitations, novel imaging techniques, engineered optical materials, innovative optical system, advanced reconstruction algorithms must be proposed and developed.

Recent discoveries in electromagnetic metamaterials have added new functionalities and possibilities to the exciting research field of advanced optical microscopy, and led to substantial improvements in imaging modality and resolution. In this talk, I will present my recent studies using metamaterials to develop super-resolution optical imaging techniques. The lateral resolution barrier was broken by a structured illumination technique with large-spatial-wavevector illumination patterns provided by the metamaterials, while the distance-dependent photobleaching dynamics of fluorophores on the metamaterial substrate enabled high-precision axial localization of each fluorophore; a three-dimensional super-resolution imaging is possible by combining both the lateral and axial dynamics. This metamaterials-assistant advanced imaging technique has significant impact on cell biology and nanophotonics, enabling researchers to unveil the subtle structure of cellular architectures and surface morphology of nanostructures.