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Two dimensional subdiffraction focusing beyond the near-field diffraction limit via metasurface

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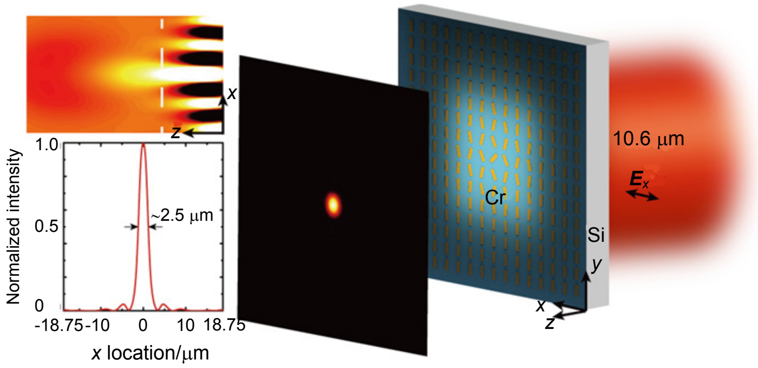

An illustration of radiationless electromagnetic interference and its corresponding subdiffraction focus.

Abstract: Subdiffraction focusing has enjoyed continued scientific interest, which leads to occurrence of the near-field plates with intriguing opportunity to set up a rapid oscillatory electromagnetic field that converges at a focus in the microwave band. However, abrupt π phase change and modulation of amplitude profile in the proximity of the surface have previously been seen as the main obstacles to scale such plates to visible or infrared regime, aggravated by loss and plasmonic feature comes into function. Severely, deep subwavelength spot is obtained at the price of decreasing the working distance, indeed, a near-field diffraction limit that could rarely go beyond in the nanofocusing system. In this paper, a radiationless electromagnetic interference (REI) approach based on metasurface is introduced which has not been reported to date. According to the back-propagation theory, a rapidly oscillatory electromagnetic field (simultaneously modulated amplitude and phase between subwavelength neighboring elements) in the proximity of NFP is necessary to force the incident wave to a subwavelength spot. The metasurface proposed here consists of periodic arrangement of chromium dipolar antennas with the same geometry but spatially varying orientations, which plays the dual roles in achieving the prescribed amplitude modulation and the abrupt π phase change. When a linearly polarized (LP) light illuminates the structure, partially scattered wave converts into the cross polarized light, the modulated amplitude is determined by the orientations of the dipolar antennas and the tuned phase is binary (0 and π), depending on the angle between the incident polarization and spatial orientations of the dipolar antennas. As a result, two dimensional subdiffraction focus as small as $0.037\lambda^2$ at ~0.15λ above the metasurface is presented which breaks the near-field diffraction limit at mid-infrared region (10.6 μm). The significance of the study lies in that our design of the metasurface based NFP combines a number of important advantages: precise amplitude and phase control, ease of fabrication, broadband subdiffraction focus at the same focal plane and three dimensional spot exceeding the near-field diffraction limit. This work is reminiscent of, but the physics inside is different from the previous REI methods. Different from the continuously various thicknesses of the metal film or refractive index of the insulator layer proposed before, the metasurface based NFP relaxes the problems of optimization and fabrication since the REI process (oscillatory modulations of amplitude and phase) is dependent on the rotation angle of the dipolar antenna. This design simplifies the manufacturing technology and bridges the gap between the theoretical investigation and valuable applications such as near-field data storage, subdiffraction imaging and nanolithography.

Keywords: metasurface; radiationless electromagnetic interference; near-field focusing; subdiffraction
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