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Tunable plasmofluidic lens for subwavelength imaging

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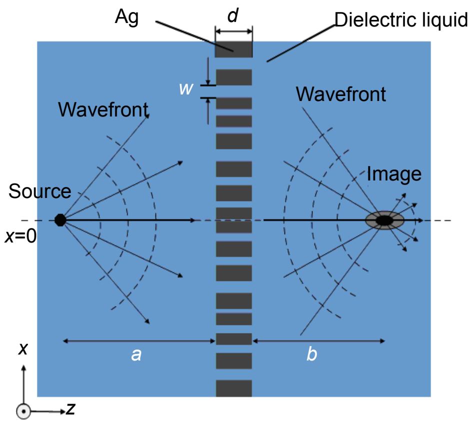

Schematic of the optical imaging by the tunable plasmofluidic lens.

Abstract: Overcoming the diffraction limit has been pursued for a long time in the optics research. Planar metallic slab with arrayed nanoslits of varying widths have been demonstrated theoretically and experimentally to focus light at the subwavelength region in far field. Each nanoslit in the metallic slab is designed to transmit light with specific phase retardation. Therefore, arbitrary phase modulation on the wavefront could be realized. When transverse-magnetic polarized light waves impinge on the entrance surface of the silver slab, surface plasmon polaritons (SPPs) are excited. SPPs propagate through the nanoslit region with specific waveguide modes until they reach the exit surface where they return into the light mode. It is the diffraction and interference of the surface plasmon waves that contribute to the transition from the evanescent waves to the propagating waves in far field, which is the coupling mechanism for far field subwavelength imaging. The nanoslit arrays with constant depths but varying widths could generate desired optical phase retardations based on the propagation property of the SPPs through the metal-dielectric-metal nanoslit waveguide. However, due to the strong frequency dispersion of metals, applications are limited since the plasmonic lens can only operate at one specific frequency when the geometries of the nanoslits are fixed. As the incident wavelength changes while other parameters are fixed, the required phase change and the permittivity of metal would vary, resulting in a change of propagation constant in each nanoslit. Therefore, the point-to-point subwavelength imaging could not be achieved again. In this work, a tunable plasmofluidic lens consisting of nanoslit arrays on a metal film is proposed for subwavelength imaging in far field at different wavelengths. We demonstrate the tunability of the plasmofluidic lens for subwavelength imaging by changing the surrounding dielectric fluid. As the dielectric fluid varies to fulfill the requirement of the invariable effective wavelength at different incident wavelengths, the propagation constant in each nanoslit changes so little that it could be ignored. The phase retardation of light transmitted through the nanoslit could also be maintained at different wavelengths. Therefore, both the required phase change and phase retardation are invariable at different incident wavelengths, resulting in that the imaging process will be slightly influenced by the wavelength variability. In addition, the overall focusing efficiency of the proposed lens is around 45%~55% (P_{focus}/P_{in}) at different operation wavelengths, which is relatively high for practical applications. This work provides a novel approach for developing integrative tunable plasmofluidic lens for a variety of lab-on-chip applications.

Keywords: surface plasmon polaritons; subwavelength imaging; optofluidics; wavefront modulation

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