A Superoscillatory Metalens Array

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Abstract: A planar array of lenses made from spatially varying plasmonic meta-atoms generates multiple sub-wavelength focal spots in the post evanescent region.

We report a planar lens array made of polarisation independent meta-atoms, which focusses transmitted light into an array of sub-wavelength focal spots in the post evanescent zone of the sample. The focal spots reappear at fixed distances along the propagation direction, as predicted by the Talbot effect. Such a meta-lens array has potential for high resolution and high speed imaging, especially for delicate living biological specimens.

The metamaterial super-oscillatory generator produces sub-wavelength spots at post-evanescent distances which can be explained by the recently demonstrated phenomena of optical superoscillation [1]. Our meta-lens array exploits the resonant properties of individual meta-atoms that scatter light with amplitude and phase that can be controlled by the design of the meta-atoms. A cluster of 5 meta-atoms, which are ring slots on a 50 nm thin gold film, forms a single lens (dotted square in Fig 1a) in the metalens array. When illuminated with circularly polarised light, the central part of the cluster exhibits a different phase delay than passing through its outer area: the transmitted light wavefront becomes curved, as after a convex lens. A hot-spot is formed directly above the central ring of each unit, several wavelengths away from the lens surface.

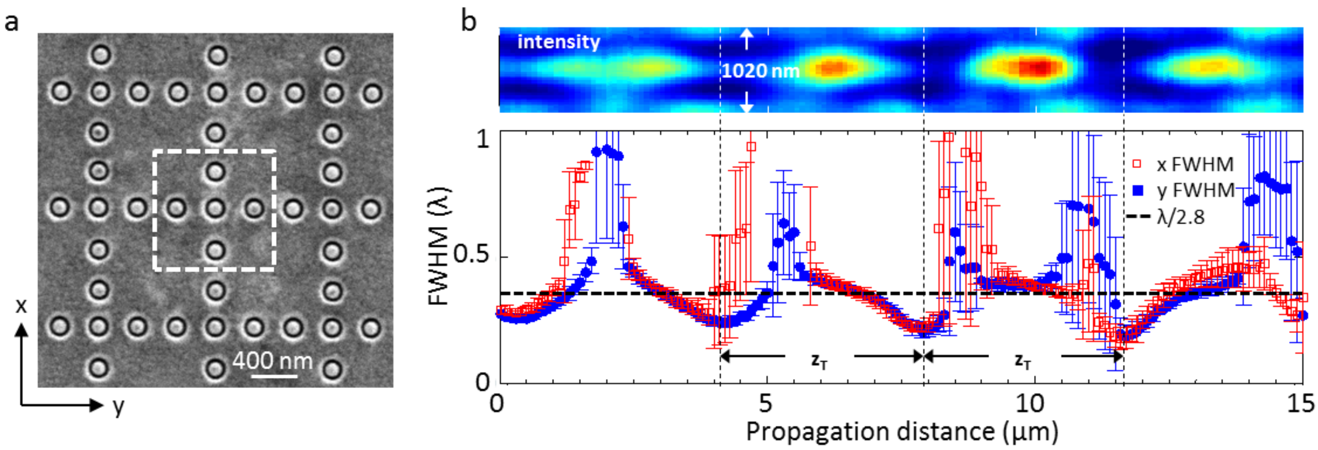

Fig 1. Superoscillatory metalens *(a) Scanning electronic microscope image showing a part of the sample consisting of 900 metalenses. A single lens unit consists of 5 ring slots as shown by the white dashed line. (b) Top: Intensity plot along the propagation direction shown for a meta-lens unit. (b) Bottom: FWHM along the propagation direction. The error bars are standard deviation obtained from FWHM measurement for four different spots. Spots measuring 0.2λ (160 nm) appear periodically along the propagation direction with a Talbot distance of* $z_T = 3.8\ \mu m$.

The transmitted intensity is recorded by a CDD camera through a liquid immersion microscope lens (NA=1.4) as a function of distance from the lens. The full width at half maxima (FWHM) for the focal spots is plotted along the propagation distance (Fig 1b). Focal spots measuring as small as 0.2λ (160 nm) appear as far as 11.7 μm away from the lens. The spots are repeated with a Talbot length (z_T) of 3.8 μm. The smallest spots appear in low intensity regions, a characteristic of superoscillation phenomena.

Reference:

1. “A super-oscillatory lens optical microscope for subwavelength imaging”, Edward T. F. Rogers, Jari Lindberg, Tapashree Roy, Salvatore Savo, John E. Chad, Mark R. Dennis & Nikolay I. Zheludev, *Nature Materials*, 11, 432–435 (2012)