Fanned-out Plasmonic Waveguide Array for Subwavelength Line Imaging

Nina Podoliak[1], Peter Horak[1], Jord C. Prangsma[2], and Pepijn W. H. Pinkse[2]

1. *Optoelectronics Research Centre, University of Southampton, Southampton SO17 1BJ, United Kingdom*
2. *MESA+ Institute for Nanotechnology, University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands*

Light propagation phenomena in plasmonic waveguides have recently shown great potential for overcoming the diffraction limit and achieving high resolution imaging due to the possibility of confining light to the subwavelength scale. Here we design an array of fanned-out air-guided plasmonic waveguides and demonstrate its performance for subwavelength line image transforming at near-infrared wavelengths by finite-element simulations [1].

The geometry of the image transformer is shown in Fig. 1(a). The main part consists of curved air-guided slit channels in gold, which are shown to provide subwavelength confinement of light in the transverse direction with moderate propagation losses. An optimum channel width of 250 nm is suggested, while the out of plane dimension should be above 3 μm for maintaining overall propagation losses below a few dB for the device. High resolution is achieved at the input side by tapering the waveguide width down to 50 nm and decreasing the gold layer thickness to 50 nm, thus obtaining waveguide periodicity of 100 nm. By keeping the tapered part short, with a length of 2 μm, an additional loss of only 0.5 dB is observed with less than 0.4% optical power coupling between channels. For enhancing coupling to free space at the output and reducing back reflection, each waveguide is terminated by a tailored output coupler. We show that the proposed design minimizes unwanted cross-coupling between waveguides, in this way allowing for high signal-to-noise ratio, and suppresses the Fabry-Pérot resonance effect, thus enabling broadband operation in the wavelength range from 1 μm to above 2 μm.

The imaging capacity of the waveguide array is demonstrated in Fig. 1(b) by resolving two incoherent dipole point sources separated by 100 nm and emitting at 1550 nm, which are placed at an optimal distance of 30 nm from the input facet. At this optimal distance, up to 90% of light from the point dipole emitters can be coupled into the corresponding waveguides at the input and can be effectively transmitted to the output side magnifying the image. An imaging resolution of λ/15 is demonstrated. This device can be effectively applied as a high-resolution linear detector or, by operating in the reverse, for high-resolution optical writing.

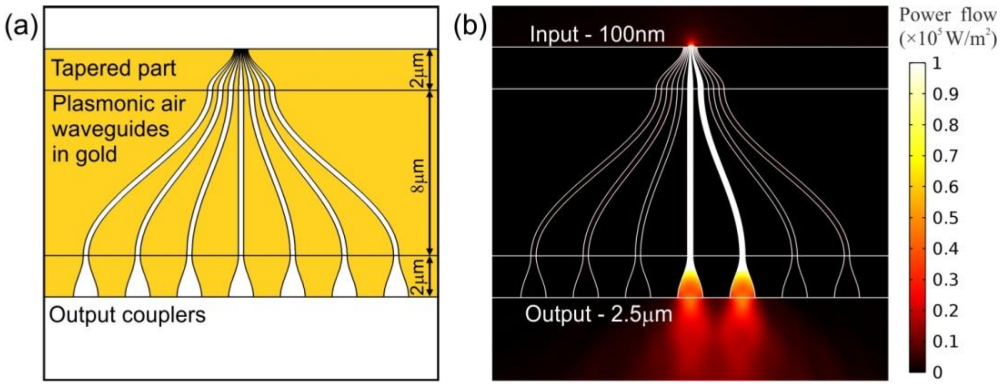

Fig. 1 (a) Geometry of fanned-out plasmonic waveguide array (top view). (b) Optical power flow inside the plasmonic waveguides excited by two incoherent point dipole sources separated by 100 nm.

References

[1] N. Podoliak, P. Horak, J. C. Prangsma, and P. W. H. Pinkse, "Subwavelength line imaging using plasmonic waveguides," IEEE J. Quantum Electron. **51** (2), 7200114 (2015).