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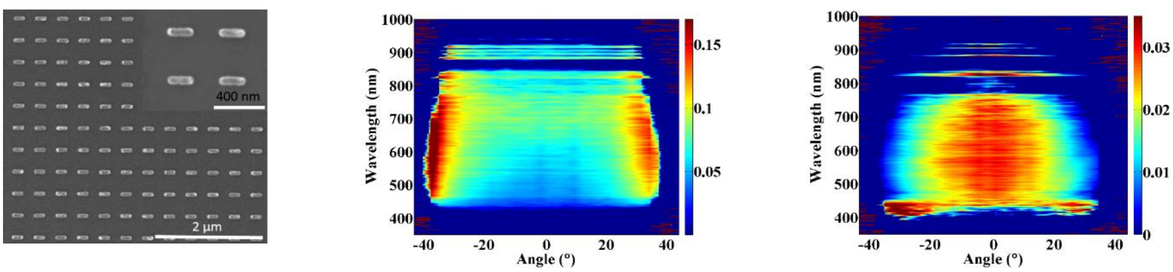
Angle Resolved Optical Characterisation of Large Scale Aluminium Nanoantenna Arrays

N. Dorh, J.R. Pugh, S. Nunez-Sanchez and M.J. Cryan
Department of Electrical and Electronic Engineering, University of Bristol, UK
Email: n.dorh@bristol.ac.uk

Nanoantennas are capable of enhancing observable fluorescence through an increase in the often low, quantum yield (QY) of fluorophores but also through increased directivity of the emission [1]. However, periodicity within nanoantenna arrays can induce coherent effects among the fields scattered by the individual elements, known as Surface Lattice Resonances[2]. As a result, the radiation pattern and by extension, any enhancement becomes directional [3]. In this paper, we present angle-resolved reflectance measurements of an aluminium nanoantenna array by Fourier microscopy.

This paper considers a 250 x 250 aluminium nanoantenna array (Fig 1a) fabricated using electron beam lithography on a 1 mm thick fused silica substrate. Each element was designed such that a higher order resonance could be excited at 396 nm, and was separated by a uniform 400 nm pitch. Fourier microscopy works on the principle of imaging the back focal plane of the objective which yields reflection as a function of angle relative to the surface normal at the focus spot. Fig 1b and c, show the resulting reflectance colour maps for *p* (long axis) and *s*-polarised (short axis) incident light respectively. The array shows strong polarisation dependence and overall reflectance was 5x larger for *p*-polarised light. It should also be noted that, back focal plane contains both the scattered and reflected fields which makes analysis non-trivial. When excited with light polarised along the long axis (Fig. 1b), strong reflectance (~0.15) can be seen near ±40° over a broad range of angles which suggests the cumulative effect of diffraction from the periodic arrangement of the nanoantennas and specular reflection. However, there is a band of elevated reflectance (0.1) near normal, from 650 nm to 750 nm which is likely due to scattering from the fundamental plasmonic resonance of the individual nanoantenna elements. The response to *s*-polarised light (Fig. 1c) shows an almost complementary feature. Stronger reflectance was observed at normal for wavelengths above 450 nm which shifts to angles above 20° as the wavelength approaches 400 nm. The angular response near 400 nm is related to the higher order resonance and pitch. These results highlight both the polarisation and angular dependent response of the nanoantenna arrays which can be exploited for applications within sensing, communications and nano-imaging.



(a) (b) (c)

Fig 1: (a) SEM image of Al nanoantenna array; each element was on average 234 nm x 146 nm (*l* x *w*) with 400 nm pitch (b) Reflectance colour map for array L3 (190 nm x 50 nm, *l* x *w*) for *p*- and (c) *s*- polarised incident light; measured using Fourier Microscopy

References

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