The Fabrication of Bipartite Plasmonic Arrays for Lasing Applications

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Metal nano-structure arrays with elements smaller than 100 nm, shown in Figure 1, can exhibit high quality factor optical resonances, known as surface lattice resonance (SLR), when illuminated with visible light[1], making them ideal laser cavities due to the long range coherent coupling between their structures[2]. Such arrays allow for more control over spatial and spectral beam properties than the comparable distributed feedback laser and require a smaller footprint due to the resonant nature of the plasmonic elements.

Recent work[3] has shown that bipartite arrays, which consist of overlaid lattices with different feature sizes, as shown in Figure 2, may be capable of even higher quality factors. In this case the quality factor is highly dependent on the size difference between the constituent structures, with the highest quality resonances found when the two arrays have a structure diameter difference of less than 20 nm. Bipartite arrays of this nature have not been fabricated previously and in this work we show that a significant resonance can be observed, despite typical fabrication imprecisions.

We have investigated the fabrication of gold and silver bipartite arrays using a RAITH 150 electron beam lithography system. Using a bilayer PMMA resist and metal lift-off we show the fabrication of monopartite arrays with periods as small as 100 nm and structure diameters down to 40 nm. Using the same method, we have also fabricated bipartite arrays with diameters around 70 nm and mean diameter differences as low as 10 nm, with RMS deviation of <5 nm. Here we present the measured extinction spectra (figures 1(b) and 2(b)) and confirm the resonant behavior of these arrays; we also show that these measurements are in good agreement with electromagnetic (EM) simulations obtained via the T-matrix method[4]. This work shows that the resonances are robust to typical fabrication errors – an important step towards experimental uses of bipartite arrays.

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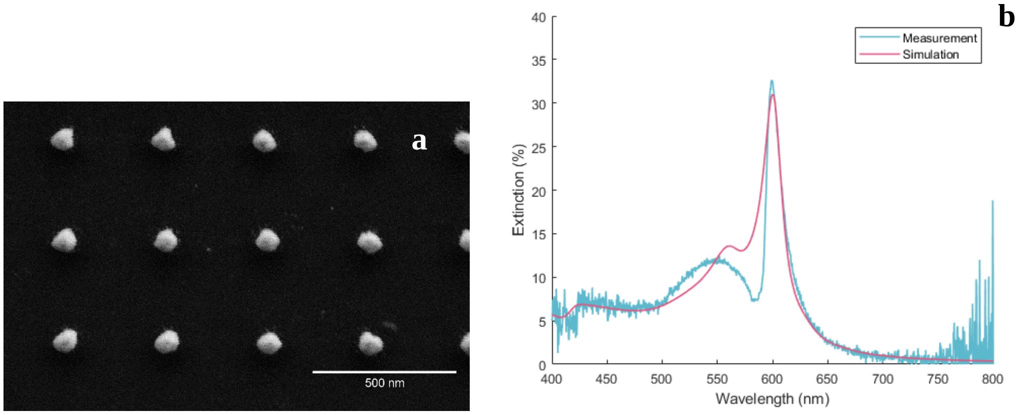
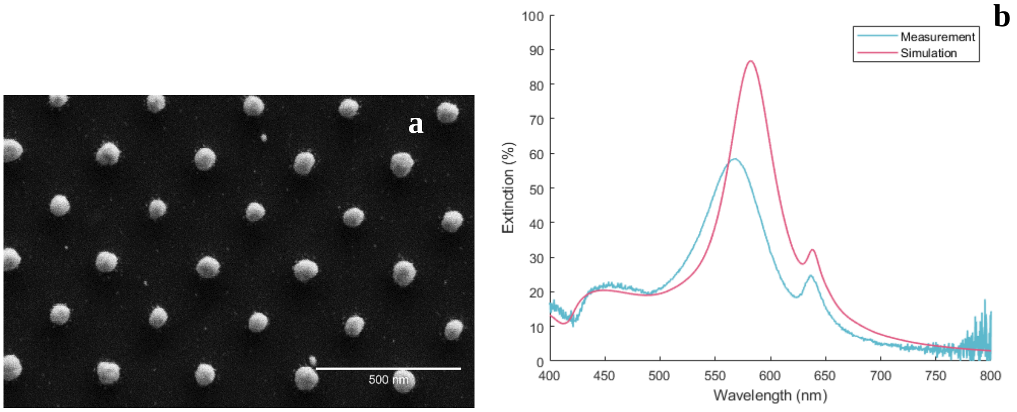


Figure 1: (a) SEM of monopartite Au array on fused quartz substrate with 400 nm period square lattice. (b) Measured extinction spectra (100-Transmission) compared to simulation results (using the same array parameters) obtained with T-Matrix method.



(a) Bipartite Au array on fused quartz substrate with 400 nm period square lattice and alternating structure diameters of 70 nm and 80 nm. (b) Measured extinction spectra compared to simulation results obtained with the T-Matrix method.