

Assembling NanoPhotonic Materials by Casting at the Nanometer Scale

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When it comes to making sophisticated 3D nanostructures to enhance light-matter interactions, traditional fabrication routes become problematic. We will demonstrate new routes to confined electronic and confined photonic structures on the 100nm length-scale and nm-scale and reveal some of their new properties, as well as showing the prospects for metamaterials with novel NanoPhotonic properties. Metal nanostructures fabricated exhibit many unusual optical effects due to their size scale, including plasmonic bandgaps and localised plasmons. We reveal a new strong coupling between the plasmonic-crystal modes and the localized plasmons, which allows ‘plasmonic atoms’ to communicate. We show that such nanostructured plasmonic substrates have widespread application in molecular sensing.

Nano-structured surfaces are formed by electrochemical deposition through an ordered template of self-assembled latex spheres.[1,2] The technique of casting intricate 3D objects was invented five thousand years ago in Mesopotamia. We have found a way to re-invigorate this technique on scales of billionths of a meter, to help us make nanostructures with extremely unusual optical properties.[3] Surface plasmons are efficiently excited due to the regular array of close-packed dishes; localized plasmons on the other hand reside in the deep cavities at larger sample thicknesses. By measuring the spectral response of the samples at different thickness and incident angles the full dispersion is revealed. Of particular interest is the strong mixing and anticrossing of surface and localized plasmons at intermediate thicknesses. These new mixed states correspond to the crossover to hopping plasmonic transport.[4] We are also able to deposit semiconductors inside such structures, and demonstrate the strong-coupling of excitons and plasmons, creating new mixed states with unusual emission and nonlinear properties.

Understanding the mixing of plasmon states leads to an in-depth knowledge of the electric-field distribution on the nano-structured surfaces allowing the optimisation of efficient plasmonic devices, such as SERS sensors [5-8].

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