Large Scale Nanocrystal Arrays

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Nanoscale semiconductor and metal nanocrystals exhibit size dependent absorption, scattering and emission spectra. While there are many applications for these materials as ensembles, increasing interest has focussed on the potential optoelectronic applications for single nanocrystals in single molecule sensing, high density information storage, high-throughput DNA screening and plasmonic imaging. Typically, single nanocrystals are studied using confocal microscopy or dark field microscopy. The nanocrystals are spin-coated from solution onto substrates at random, which makes analysis and archiving tedious. Such nanocrystals cannot be routinely addressed by the user. To utilise these novel materials in optical or electronic devices, methods are needed for assembly of nanocrystals into ordered structures.

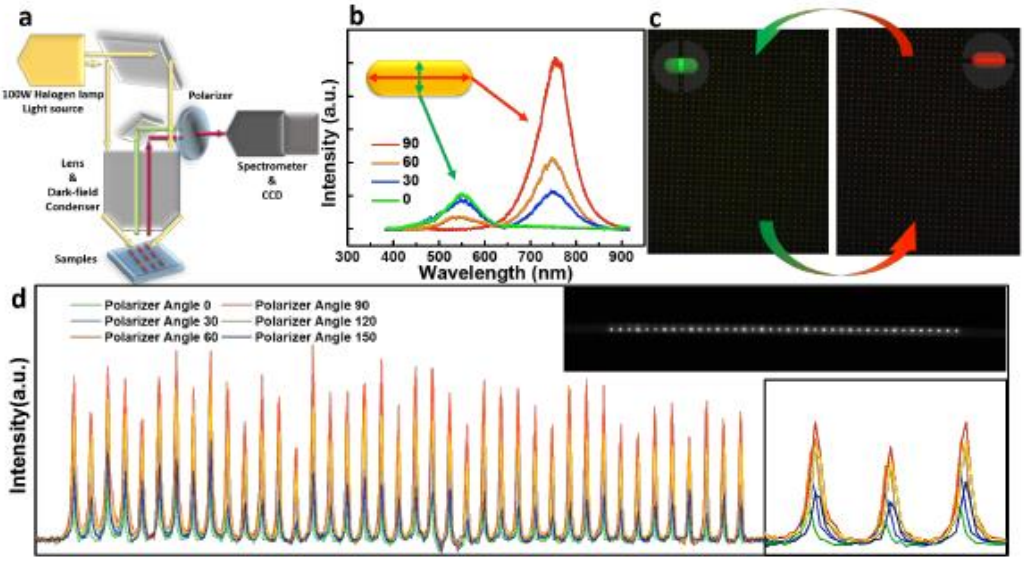

Fig. 1 Left- Experimental dark-field microscope set-up for single particle spectroscopy. Top Right: Deposited gold rods are aligned and exhibit ensemble-averaged polarisation-dependent spectra. Bottom: Intensity map across a row of gold rods as a function of polariser angle showing uniform alignment.

To date such assembly has been achieved by either chemical self-assembly using DNA for example, or via directed assembly using external forces to position particles. In this talk, we will present the first work demonstrating quantitative self-assembly and patterning of single nanocrystals from the nanometre lengthscale to the centimetre lengthscale. We will discuss several methods including capillary force assembly, chemical assembly and electrophoretic assembly. The third of these is particularly flexible. A polymer coated substrate is patterned using EBL, photolithography or nano-imprint lithography to generate a template. The substrate must be conducting. Particles are deposited either anodically or cathodically depending on their charge. We demonstrate that a wide range of particle types, particle shapes and particle sizes can be deposited. We present the first optical image created from

single nanoparticles. Up to 10^{10} particles may be put down over a square centimetre substrate with fidelity > 95%.

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