NANOPHOTONICS

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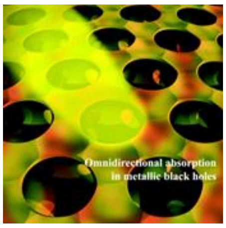
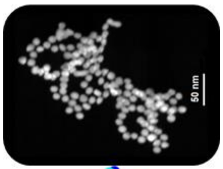
<u>NanoOptics</u>: Our centres in NanoOptics to NanoChemistry, Soft NanoPhotonics and Light-controlled Nano-assembly make unusual sorts of nano-materials which combine novel optical properties built from structuring components on the nanometre scale, to investigating single molecules, with the (literal) flexibility of using soft materials. The physics of combining electromagnetism and quantum mechanics produces emergent surprises in new and useful properties. Our collaborations with Scherman (polymer), Keyser (soft matter) groups involve many research disciplines around the University including Chemistry, Chemical Eng., Physics of Medicine, Institute for Manufacturing, with Hess (Imperial), Aizpurua (Spain) and other international leaders.
To get an idea of current projects, check out recent papers (http://www.np.phy.cam.ac.uk/publications/)



<u>Ultrafast nonlinear spectroscopy of single nano-structures</u>: Our group has pioneered ways to trap light inside gold metallic nanostructures producing enormous concentration of the optical fields down to 1nm^3. Light coupling to dipoles inside our nanostructures, enhance coupling by up to 10 orders of magnitude. This project involves ultrashort laser pulses to disturb the electrons inside such nanostructures, and observe the ultrashort dynamics of individual atoms and molecules trapped in these nanocavities. The aim is to produce the lowest energy optoelectronic switches ever created, down to zepto-joules.



<u>The Intelligent Toilet</u>: We have pioneered the assembly of nanostructure with sub-1nm gaps between the optically-active plasmonic components of Au and Ag. In collaboration with the Scherman group in Chemistry, we use CB molecules as the glue to control this assembly, which allows ultrahigh resolution sensing. This project looks at building integrated low-cost optics with microfluidic nano-assembly for detection of neurotransmitters in urine at clinical levels, and more generally how to leverage nanoassembly for personalised healthcare.

<u>Light-driven DNA nanomachines</u>: We have been using DNA origami to build exquisite nanosctructures that combine active plasmonics nanoparticles and other functional elements such as semiconductor quantum dots. Our aim is to build a new generation of realistic nanomachinery capable of selective action and locomotion, which has so far held back development of anything that can move on surfaces or solutions at ambient conditions. This project would combine the design and assembly of nanostructures with optically-triggered and detected dynamics.

<u>Optically-interrogated memristors</u>: One of the most promising contenders for ultralow-energy electronic devices is resistive switching memory (RRAM), capable of reducing energy consumption in IT by >50%. Understanding the nanoscale kinetics of the switching mechanisms is needed to unlock their integration into fast, low-energy, logic-in-memory architectures. Using the ultra-concentration of light we recently achieved, this project will develop innovative fast ways to study real-time movement of individual atoms inside these nano-devices, thus overcoming the limitations of traditional techniques and opening new routes to sustainable future IT.

Active plasmonics nanodevices: We lead the world in the robust nano-assembly of individual metallic nano-architectures which trap light to the nm-scale, allowing us to study excitations such as electron-hole pairs or individual molecular bonds. This project will explore the use of active photo-responsive polymers in switching these optical devices on the sub-ns scale, opening access to dynamics of indivdual atoms, molecules and electrons, and their dynamics and control, as well as accessing quantum properties which we can exploit.

In all projects for a PhD in NanoPhotonics, you will develop new construction techniques combining self-assembly and soft polymer materials to create and then spectroscopically measure these nanomaterials. This will thus involve a large number of different techniques in Nano-science, before you build advanced optics rigs to create adaptively-controllable materials and devices. The new applications for such materials are widespread and you would get involved in considering how novel physics can impact different areas. We work with collaborators around the world, for instance in theory, and you would visit and interact with a number of key people.