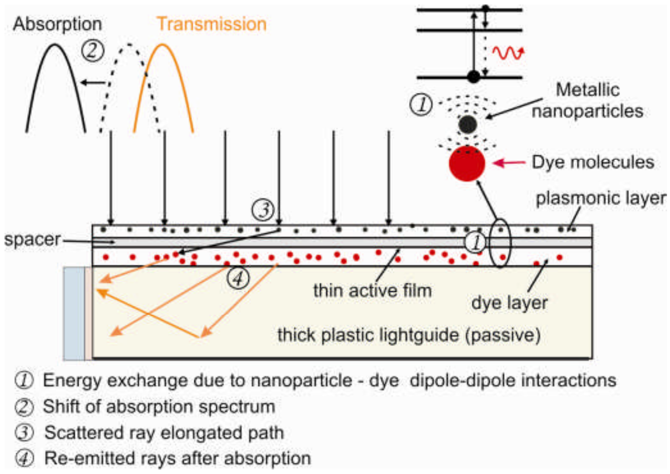
“Maximizing the Efficiency of Solar Energy Harvesting in Luminescent Solar Concentrators by Implanting Resonant Plasmonic Nanostructures”



The main objective of the PhD project is to reduce the cost of harvesting solar energy in Luminescent Solar Concentrators (LSCs) by exploiting advanced nanophotonic concepts and by doing so, to contribute to the global efforts for economically viable - carbon free energy generation from sustainable and renewable resources. The work to be undertaken is highly multidisciplinary, crossing the boundaries between electrodynamics modelling, material science and nanotechnology fabrication and will be carried out in close collaboration with the London Centre of Nanotechology (LCN) and UCL’s Department of Chemistry.

Luminescent solar concentrators are non-tracking solar devices designed to collect both diffuse and direct light with minimum requirement for expensive semiconductor material. LSCs consist of a thin, transparent lightguide typically doped with fluorescent dyes whose wide facet is oriented towards the sun, while semiconductor solar cells are attached to some or all of its thin edges. Solar photons reaching the LSC are first absorbed by the fluorescent molecules (fluorophores) before they are re-emitted isotropically due to the Stokes effect. A fraction of the re-emitted light is trapped in the lightguide by means of total internal reflection (TIR), where it propagates until being converted into electricity by the edge solar cells. The semiconductor material budget in the LSC is significantly reduced in comparison to a direct solar cell by an amount that depends on the ratio of its illuminated facet over its edge areas and which is termed the geometrical gain. LSCs’ aesthetically pleasant colours make them attractive in modern architecture where they can be integrated into buildings as active semi-transparent surfaces. In spite of their great potential, LSCs find limited commercial applications currently, since they typically exhibit very low energy conversion efficiency which results in their deployment being uneconomical.

The ultimate aim of the project is to significantly improve the energy conversion efficiency of typical monolayer LSC systems by harnessing the interplay phenomena between fluorescence and localized surface Plasmon resonances emanating when light interacts with metallic nanoparticles. By fine tuning the interaction mechanisms between plasmonics and fluorophores, heat dissipation and escape cone losses, which combined account for more than 75% of the light being lost in typical baseline devices, can be reduced considerably, thereby potentially doubling the efficiency of the LSC.

The project will be divided into four development phases giving the opportunity for the PhD student to be involved in a wide range of multilateral tasks:

Phase A: The first phase will focus on the theoretical understanding of the fundamental energy exchanging mechanisms occurring between plasmons and fluorophores and its output will be the derivation of a design rule set for metallic nanoparticles tailored to LSC applications.

Phase B: A generic simulation platform that combines nanoscale with macroscale modelling will be developed during this phase to allow for rapid prototype performance assessment before proceeding to expensive fabrication.

Phase C: During Phase C, fabrication of a highly efficient prototype plasmonic-LSC will be carried out. *Phase D:* The last phase of the project will be open for the research student to explore completely new research avenues that can bring about radical improvements to LSC efficiency.

Essential requirements: We are looking for enthusiastic, self-driven and hard-working applicants with desire to contribute to reversing climate change. Applicants must have a strong background in Electromagnetism and Maths and we would expect our candidates to have obtained an undergraduate degree in Electronic Engineering, Physics or Maths. Students with a degree in Chemistry and background in Quantum Chemistry are also strongly encouraged to apply.

Desirable requirements: Experience in any of the following areas is not mandatory but will be counted positively:

Programming: C++, Matlab or Python

Optical simulation methods: Ray-tracing, Finite-Difference-Time-Domain (FDTD) or Finite Element Method (FEM)

Fabrication and diagnostics: Photolithography, Electron Beam (EBeam) Lithography, Focused Ion Beam (FIB), Spectrometry, Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM)

Interested students should email their CV and a brief letter of intend to i.papakonstantinou@ee.ucl.ac.uk