Spécialité de Master « Optique, Matière, Plasmas »

Stage de recherche (4 mois minimum, à partir de début mars)

Proposition de stage (ne pas dépasser 1 page)

Date de la proposition :

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Localized Surface Plasmon Resonance of $Cu_{2-x}S$ Nanocrystals and Their Applications in Photovoltaics

Colloidal nanocrystals (NCs) have been fascinating since their discovery in the 1980s due to their unique size/morphology-tunable optical and electronic properties in the quantum confinement regime. Highly monodispersed samples of II-VI and IV-VI semiconducting NCs can now be prepared with precise synthetic control. Combining advantages of tunable absorption/emission and the ease of solution-processing, semiconducting NCs are highly attractive for their applications in large-area and low-cost optoelectronics, such as solar cells, light-emitting diodes, and field-effect transistors.

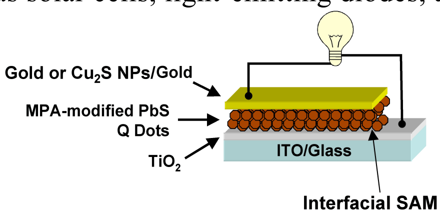

Figure 1. Device schematic of a solar cell based on PbS quantum dots.

As one of the emerging colloidal systems, non-stoichiometric Copper-based chacogenides NCs have aroused extensive interest recently due to their environmental benign and earth-abundant compositions and their well-defined **localized surface plasmon resonance** (LSPR) effect in the near-infrared (NIR). A few recent studies reported size/morphology-tunable synthetic protocols yielding $Cu_{2-x}S$ NCs, heavily self-*p*-doped by cation vacancies, via direct synthesis.[1] By applying different surface ligands or post-synthesis chemical doping, $Cu_{2-x}S$ NCs of different amounts of cation vacancy (and thus different free hole density) and different LSPR absorption have been achieved.[2,3] This LSPR effect is particularly promising for NIR optoelectronics because it can concentrate the local electromagnetic field and enhance absorption/emission processes in their vicinity. Yet up to now no studies have been done to apply this LSPR effect of $Cu_{2-x}S$ NCs in optoelectronic devices.

In this master project, we aim to explore the synthesis of $Cu_{2-x}S$ NCs and their applications to enhance the NIR absorption in the PbS-quantum-dot-based solar cells currently developed in our research team. Practically, the student shall accomplish: (1) Reproduce the current synthetic protocols in the literature[1-3] for high quality and LSPR-tunable $Cu_{2-x}S$ NCs; (2) Incorporate $Cu_{2-x}S$ NCs into NIR absorbing PbS-quantum-dot solar cells and experiment different device structures; (3) Evaluate the device characteristics of solar cells with and without plasmonic $Cu_{2-x}S$ NCs and for different device configurations to quantify the absorption and efficiency enhancements.

Reference: [1] J. M. Luther *et al.* Nat. Mater., 10, 361-366 (2011); [2] I. Kriegel *et al.* JACS, 134, 1583-1590 (2012); [3] X. Liu *et al.* Adv. Funct. Mater, (2012) DOI: 10.1002/adfm.201202061

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : Yes**

Si oui, financement de thèse envisagé/ *financial support for the PhD***:** 50% from Marie-Curie CIG grant; another 50% from other sources, such as the IDF region, or DGA, or CIFRE.

Lasers et matière	X	Lumière, Matière : Mesures Extrêmes	X
Optique de la science à la technologie	X	Plasmas : de l'espace au laboratoire	