

# Spécialité de Master « Optique, Matière, Paris »

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

## Proposition de stage (ne pas dépasser 1 page)

Date de la proposition : 27 décembre 2016

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| <b>Responsable du stage / internship supervisor:</b>                                       |   |                      |                             |
| Nom / name:  | Collin                                    | Prénom/ first name : | Stéphane                    |
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| Courriel / mail:   | Stephane.Collin@lpn.cnrs.fr               |                      |                             |
| <b>Nom du Laboratoire / laboratory name:</b> Centre de Nanosciences et de Nanotechnologies |   |                      |                             |
| Code d'identification :  | UMR 9001                                  | Organisme :          | CNRS / Université Paris Sud |
| Site Internet / web site:  | http://www.c2n.universite-paris-saclay.fr |                      |                             |
| Adresse / address:   | Route de Nozay, 91460 Marcoussis          |                      |                             |
| Lieu du stage / internship place:  | Route de Nozay, 91460 Marcoussis          |                      |                             |

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| <b>Titre du stage / internship title:</b> <b>Ultrathin Nanostructured Solar Cells: towards record efficiencies</b>  |
| <p>Reducing the absorber thickness is a major issue for most photovoltaic technologies because of material scarcity, material cost and/or process cost. Moreover, it results in an increase of the photogenerated charge density, which is also a key step towards high-efficiency solar cells based on advanced concepts like hot carrier solar cells. However, novel light-trapping schemes are required to compensate for the low single-pass absorption of very thin films. Nanophotonics and nanofabrication techniques provide new tools to go in this direction.</p> <p>In this context, we have developed a new light-trapping strategy based on multi-resonant absorption<sup>1</sup>, and we are currently developing ultra-thin solar cells based on various materials including III-V semiconductors (GaAs, InP), crystalline silicon (c-Si) and CIGS. We have recently proposed novel light-trapping architectures based on nanostructured back mirrors. We have also developed original techniques for low-cost and large-area nanofabrication of solar cells applied to GaAs and c-Si solar cells. This work has resulted in the recent demonstration of state-of-the-art ultrathin solar cells with record short-circuit currents (GaAs, c-Si), confirming the relevance of this approach<sup>2,3</sup>.</p> <p><b>The short-term objective of this work is to optimize the conception (both optically and electronically) and the fabrication process of ultrathin solar cells (thickness ~200 nm) in order to reach record conversion efficiencies (<math>\eta \rightarrow 20\%</math>).</b></p> <p>The first task of this internship project will be to integrate improved architectures and novel methods in the fabrication process (high aspect-ratio nanostructures, point contacts, novel heterostructures, lift-off for reusable substrates, ALD passivation,...). The candidate will be involved in the fabrication of the solar cells (clean room facility). He will be in charge of the full characterization of the devices (home-made setups) through spectral and optoelectronic measurements (reflectivity, EQE, dark IV and IV under 1-sun illumination). The performances will be analyzed with the optical and electrical modeling tools available in our team. This project will be carried out at C2N, site de Marcoussis, in close collaboration with several partner labs of the "Fédération de Recherche Photovoltaïque d'Ile-de-France" and in the new "Institut photovoltaïque d'Ile-de-France" (IPVF). We plan to offer opportunities for PhD grants on novel concepts for high-efficiency, nanoscale solar cells.</p> |

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| <b>Ce stage pourra-t-il se prolonger en thèse ? Possibility of a PhD ? : OUI</b>         |
| <b>Si oui, financement de thèse envisagé/ financial support for the PhD: ANR/U. PSud</b> |

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|--------------------------------|------------|--------------------------|------------|
| Lumière, Matière, Interactions | <b>OUI</b> | Lasers, Optique, Matière | <b>OUI</b> |
|--------------------------------|------------|--------------------------|------------|

1 *Metal nanogrid for broadband multi-resonant light-harvesting in ultrathin GaAs layers*, I. Massiot et al., ACS Photonics **1**, 878-884, 2014. See also a review on *Nanostructure arrays in free-space: optical properties and applications*, S. Collin, Reports on Progress in Physics **77**, 126402 (2014).

2 *Ultrathin GaAs solar cells with a silver back mirror*, N. Vandamme et al., IEEE Journal of Photovoltaics **5**, 565 - 570 (2015). *Ultrathin GaAs solar cells with a nanostructured silver back mirror*, to be published.

3 *Ultrathin epitaxial silicon solar cells with inverted nanopillar arrays for efficient light trapping*, A. Gaucher et al., Nano Letters **16**, 5358-5364 (2016).