MARIE SKŁODOWSKA-CURIE POSTDOCTORAL FELLOWSHIPS 2022

EXPRESSION OF INTEREST FOR HOSTING MARIE CURIE FELLOWS

HOST INSTITUTION

NOVA.ID.FCT via CENIMAT-i3N

RESEARCH GROUP AND URL

Photonics and Photovoltaics team of MEON group
https://www.cenimat.fct.unl.pt/people/manuel-joao-de-moura-dias-mendes

SUPERVISOR (NAME AND E-MAIL)

Prof. Manuel J. Mendes (mj.mendes@fct.unl.pt)

SHORT CV OF THE SUPERVISOR

Prof. Manuel J. Mendes was born in Lisbon, Portugal, in 1982. He received the Engineering licenciatura degree in Physics in 2005 from Instituto Superior Técnico, Univ. de Lisboa (IST-UL). In 2008 he completed a Master of Science degree from Rice University (Houston, USA), working in Carbon Nanotubes technology for Energy Harvesting, at the group of the Nobel Laureate Richard Smalley who is considered one of the founding fathers of Nanotechnology. In 2012 he completed the Ph.D. in Photovoltaic Solar Energy in 2012 from Instituto de Energía Solar (Madrid, Spain) on the novel topic of Nanophotonics for Intermediate-Band Photovoltaics. At this point, he was already inventor of 2 U.S. Patents - the first distinguished with an award from NASA Inventions & Contributions Board, and the second opened a new research line in Plasmonic Intermediate-band Solar Cells. This was followed by 2 Post-Docs in IMM-CNR (Italy, 2012-4) and CENIMAT (Portugal, 2014-6), funded by 2 prestigious Marie-Curie Fellowships, in Photonic-enhanced Thin-film Photovoltaics.
He is now Assistant Professor at the Department of Materials Science of Faculdade de Ciências e Tecnologia of Univ. Nova de Lisboa (FCT-NOVA), and Senior Researcher at the R&D center CENIMAT|i3N, associated with FCT-NOVA, where he leads the team of light management for photovoltaics. Here, he has been supervisor of 35 Master students (17 as co-sup.), 5 PhDs (2 as co-sup.) and 5 Post-Docs. His main scientific interests are in the domain of photovoltaic (PV) physics, and in the research of innovative photonic concepts that allow enhancing light capturing and, consequently, the sunlight-to-electricity conversion efficiency of solar cells. He has been involved in 29 scientific projects (19 national, 10 European) in energy-related areas while working in USA (2005-08), Spain (2008-12), Italy (2012-14) and Portugal (2014-present). His research in Portugal has been performed at FCT-NOVA where he has been PI of 4 projects (2 national, 2 European), such as the ENLIGTHEN Marie-Curie action (H2020-MSCA-IF-2019) aimed at developing perovskite-based intermediate-band solar cells. He has also been institution responsible (WP leader) for 5 projects (4 national, 1 European), related with photonic-enhanced thin-film solar cells, quantum-structured semiconductors and solar fuels, such as the national project FlexSolar, developing all-thin-film perovskite-on-silicon tandem solar cells, and the EU project APOLO (H2020-LCE-2017-RES-RIA) developing flexible perovskite solar cells improved with light-trapping for building-integration.
Overall, he attracted a total funding of ~1.5 million Euros to FCT-NOVA via projects that he scientifically coordinate(d) and (co-)authored in the past 5 years. He is author of 60 publications in peer-reviewed scientific journals (H-index=28) and conference proceedings, as well as 3 book chapters. He was also awarded with 9 prestigious scientific honours, being the most recent the 2021 IN3+ Award of Imprensa Nacional Casa da Moeda (INCM), which is the highest national prize for individual innovation projects. This prize was given to his nanophotonics project HIGHLIGHT, delivered in a ceremony with the presence of the President and Prime Minister of Portugal which was broadcasted in major national news channels and websites. The project received a research grant to develop the idea, patent it, and bring it to a commercial reality. He acts as regular reviewer for 32 scientific journals, and was co-editor of the journal Frontiers in Materials (Nature Publishing Group). Finally, Prof. Mendes is member of two prestigious national scientific societies: "Academica das Ciências de Lisboa" and "Sociedade Portuguesa de Materials".

5 SELECTED PUBLICATIONS

1. *Light management with quantum nanostructured dots-in-host semiconductors.*
M. Alexandre, H. Águas, E. Fortunato, R. Martins, M. J. Mendes
Light: Science & Applications*,* 10, article # 231 (2021)

2. *Light trapping in solar cells: simple design rules to maximize absorption.*
K. Li, S. Haque, A. Martins, E. Fortunato, R. Martins, M. J. Mendes, C. S. Schuster
Optica*,* 7, 1377-1384 (2020)

3. *Photonic-structured TiO2 for high-efficiency, flexible and stable Perovskite solar cells.*
S. Haque, M. J. Mendes, O. S. Sobrado, H. Águas, E. Fortunato, R. Martins
Nano Energy, 59, 91–101 (2019)

4. *Wave-optical front structures on Silicon and Perovskite thin-film solar cells.*
M. J. Mendes, O. Sobrado, S. Haque, T. Mateus, H. Águas, E. Fortunato, R. Martins.
Solar Cells and Light Management: Materials, Strategies and Sustainability, Elsevier Book Chapter, ISBN: 9780081027622 (2019).

5. *Design of optimized wave-optical spheroidal nanostructures for photonic-enhanced solar cells.*
M. J. Mendes, A. Araújo, A. Vicente, H. Águas, I. Ferreira, E. Fortunato, R. Martins.
Nano Energy, 26, 286-296 (2016)

PROJECT TITLE AND SHORT DESCRIPTION

Possible title: Photonic Nano-structuring for Improved Sunlight Harvesting

Short description:

Thin film (TF) photovoltaic (PV) devices have stimulated enormous interest as a low-cost alternative to bulk crystalline Silicon cells. However, TF PV technology is not yet sufficiently developed to be competitive with 1st generation bulk (wafer-based) solar cells, mainly due to the incomplete absorption of sunlight in their thin semiconductor material. Light trapping methods (such as surface texturing, diffraction gratings or resonant plasmonic structures) are nowadays regarded as the most promising strategies to increase the optical density of TF PV materials while keeping their reduced physical thickness (thereby also enabling mechanical flexibility).

This project aims to theoretically and experimentally develop a novel light trapping approach that presents several advantages relative to the aforementioned ones.[1] The method uses the light scattering and anti-reflection properties of arrays of nanostructured features patterned on the front of silicon and perovskite-based solar cells. Such photonic features should have a semi-spheroidal shape and dimensions comparable to the wavelength of incident light in order to act as an effective optical solution. A highly-scalable nano/micro-fabrication method will be developed in this project to engineer the desired photonic structures, employing an industrial-attractive soft-lithography approach[2]; all guided by advanced optoelectronic simulation and optimization using a top mesh-based solver (Lumerical Solutions).

The project will develop light trapping (LT) schemes for TF PV, namely for perovskite and silicon-based solar cells, under the expertise of the host center, looking for the optimal cells structure that provides maximum efficiency with minimal absorber layer thickness (to allow high flexibility). Such optimal thickness is strongly correlated with the material quality and LT capability. The host team has been exploring high refractive-index dielectric features with wavelength-scale sizes that are nowadays considered the preferential photonic elements to attain maximum LT in TF PV without deteriorating the cells' electrical performance. We have already demonstrated that up to ~50% photocurrent enhancement can be attained in TF Si cells, relative to optimized anti-reflection coatings.[1] Such type of structures, operating in the wave-optics regime, will be fabricated by colloidal-lithography (CL), under the expertise of the team,[2] which allows forming nano/micro-scale structures with any material and is compatible with the PV industry scalability requirements.

References:

[1] Wave-optical front structures on Silicon and Perovskite thin-film solar cells. M. J. Mendes, O. Sobrado, S. Haque, T. Mateus, H. Águas, E. Fortunato, R. Martins. Solar Cells and Light Management: Materials, Strategies and Sustainability, Elsevier Book Chapter, ISBN: 9780081027622 (2019).

[2] Colloidal Lithography for Photovoltaics: An Attractive Route for Light Management. R. D. Oliveira, A. Mouquinho, P. Centeno, M. Alexandre, S. Haque, R. Martins, E. Fortunato, H. Águas, M. J. Mendes. Nanomaterials 11, pp. 1665 (2021).

SCIENTIFIC AREA WHERE THE PROJECT FITS BEST*

Information Science and Engineering (ENG)

***Scientific Area where the project fits best** – Please select/indicate the scientific area according to the panel evaluation areas: Chemistry (CHE) • Social Sciences and Humanities (SOC) • Economic Sciences (ECO) • Information Science and Engineering (ENG) • Environment and Geosciences (ENV) • Life Sciences (LIF) • Mathematics (MAT) • Physics (PHY)