Metal oxide layers for perovskite solar cells

Introduction: A new type of solar cells based on perovskite absorber have rapidly developed, starting from 3.8% efficiency in 2009 and reaching almost 26% in 2023 surpassing established photovoltaic technologies such as CIGS and CdTe. Perovskite materials are compatible with low-temperature processing and flexible substrates, allowing for a wide range of inexpensive processing techniques and potentially lower cost of solar cells. Moreover, perovskite solar cells can be integrated in potentially highly efficient tandem solar cells, *e.g.*, with silicon or CIGS. To reach good efficiency, it's necessary to design and optimize various components in the solar cells, in particular, this project focuses on charge transport layers, and tunnel recombination junction (TRJ), which is necessary to monolithically connect two subcells.

The configuration of perovskite single junction cell employing charge transport layers (e.g. NiO as hole transport layer, and SnO_2 as electron transport layer) is shown in (**Fig.1**). Atomic layer deposition (ALD) is a technique that has been successfully employed for the growth of these metal oxide layers in perovskite solar cells.[1] ALD metal oxide films have demonstrated excellent electrical and optical properties. In addition, when deposited on the top of the cell as one of the interlayers, they also show excellent chemical robustness to protect the bottom cell from damages caused by subsequent layer deposition.

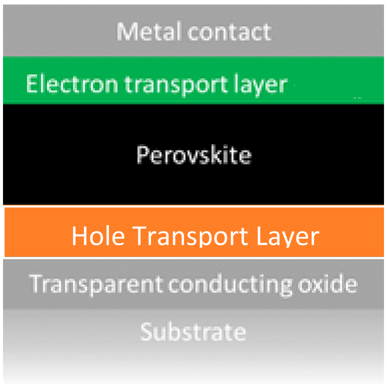

***Figure 1:** Perovskite solar cell structure*

Project description: ALD of various metal oxides for application in perovskite-based solar cells is currently being developed within our research group. Following our publication,[2] we have gained knowledge about the combination between NiO and self-assembled monolayer (SAM) used in perovskite single junction solar cells. The student will work with us to further optimize the interface of HTL/perovskite using different SAMs to improve the cells' performance based on established processes in the research group.[3, 4] This will be applied in both single junction and tandem solar cells. On the ETL side, the student will optimize the SnO_2 to be an effective buffer layer to protect the perovskite underneath from damage of subsequent layer deposition. The metal oxide and its interfaces with other layers will be analyzed using X-ray diffraction, X-ray photoelectron spectroscopy, IR spectroscopy and spectroscopic ellipsometry together with electrical solar cell measurements to study the properties and performance of the transport layers in perovskite solar cells.

References:

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2. Phung, *et al.*, ACS Appl. Mater. Interfaces **2022**, 14, 1, 2166–2176
3. Koushik, *et al.*, J. Mater. Chem. C **2019**, 7, 12532-12543
4. Phung, *et al.*, IEEE J. of Photovoltaics **2022**, 12(6), 1377-1385.

For further information please contact

MSc. Kousumi Mukherjee	**Flux 3.096**	**k.mukherjee@tue.nl**
Dr. Nga Phung	**Flux 3.116**	**t.t.n.phung@tue.nl**
Prof. Dr. Adriana Creatore	**Flux 3.107**	**m.creatore@tue.nl**