ADVANCED MATERIALS INTERFACES
www.advmatinterfaces.de

Perovskite Metal–Oxide–Semiconductor Structures for Interface Characterization

José M. V. Cunha, M. Alexandra Barreiros, Marco A. Curado, Tomás S. Lopes, Kevin Oliveira, António J. N. Oliveira, João R. S. Barbosa, António Vilanova, Maria João Brites, João Mascarenhas, Denis Flandre, Ana G. Silva, Paulo A. Fernandes, and Pedro M. P. Salomé*

Perovskite solar cells (PSCs) are one of the most promising photovoltaic technologies. Amongst several challenges, developing and optimizing efficient electron transport layers that can be up-scaled still remains a massive task. Admittance measurements on metal–oxide–semiconductor (MOS) devices allow to better understand the optoelectronic properties of the interface between perovskite and the charge carrier transport layer. This work discloses a new pathway for a fundamental characterization of the oxide/semiconductor interface in PSCs. Inverted MOS structures, that is, glass/fluorine-doped tin oxide/tin oxide (SnO_2)/perovskite are fabricated and characterized allowing to perform a comparative study on the optoelectronic characteristics of the interface between the perovskite and sputtered SnO_2. Admittance measurements allow to assess the interface fixed oxide charges (Q_f) and interface traps density (D_{it}), which are extremely relevant parameters that define interface properties of extraction layers. It is concluded that a 30 nm thick SnO_2 layer without annealing presents an additional recombination mechanism compared to the other studied layers, and a 20 nm thick SnO_2 layer without annealing presents the highest positive Q_f values. Thus, an effective method is shown for the characterization of the charge carrier transport layer/perovskite interface using the analysis performed on perovskite-based inverted MOS devices.

1. Introduction

Perovskite solar cells (PSCs) have accomplished a remarkable evolution in the field of photovoltaics since its first publication in 2009,[1] currently reaching a light to power conversion efficiency (PCE) value of 25.5%, which is close to the 26.7% PCE value presented by single-crystalline silicon.[2,3] The rapid performance evolution by PSCs results from the intensive interdisciplinary research efforts in film crystal growth control, interface and device engineering, and in adapting feedback from both optical and electrical characterizations.[4] A PSC works as an n-i-p or p-i-n solar cell, where the perovskite is, theoretically, an intrinsic semiconductor sandwiched between two carrier selective contacts: one for holes and another for electrons.[5–7] For the fabrication of a high-quality perovskite, the production of the PSC charge extraction layers requires special care concerning material properties and interfaces. A typical n-i-p (regular)

J. M. V. Cunha, M. A. Curado, T. S. Lopes, K. Oliveira, A. J. N. Oliveira, J. R. S. Barbosa, A. Vilanova, P. A. Fernandes, P. M. P. Salomé
INL–International Iberian Nanotechnology Laboratory
Avenida Mestre José Veiga
Braga 4715-330, Portugal
E-mail: jose.cunha@inl.int

J. M. V. Cunha, A. J. N. Oliveira, P. A. Fernandes, P. M. P. Salomé
Departamento de Física and i3N
Universidade de Aveiro
Campus Universitário de Santiago
Aveiro 3810-193, Portugal

M. A. Barreiros, M. J. Brites, J. Mascarenhas
Laboratório Nacional de Energia e Geologia
LNEG
Estrada do Paço do Lumiar, 22, Lisboa 1649-038, Portugal

The ORCID identification number(s) for the author(s) of this article can be found under https://doi.org/10.1002/admi.202101004.

DOI: 10.1002/admi.202101004

M. A. Curado
CFisUC
Department of Physics
University of Coimbra
Coimbra P-3004-516, Portugal

T. S. Lopes
Institute for Material Research (IMO)
Hasselt University (partner in Solliance)
Agoralaangebouw H, Diepenbeek 3590, Belgium

T. S. Lopes
Imec division IMOMEC (partner in Solliance)
Wetenschapspark 1, Diepenbeek 3590, Belgium

T. S. Lopes
EnergyVille
Thorpark, Poort Genk 8310 & 8320, Genk 3600, Belgium

D. Flandre
UCLouvain
ICTEAM institute
Place du Levant 3, Louvain-la-Neuve 1348, Belgium

