

Double-Mesoscopic HTM-Free Perovskite Solar Cells: Overcoming Charge Transport Limitation by sputtered 40 nm Al_2O_3 isolating layer

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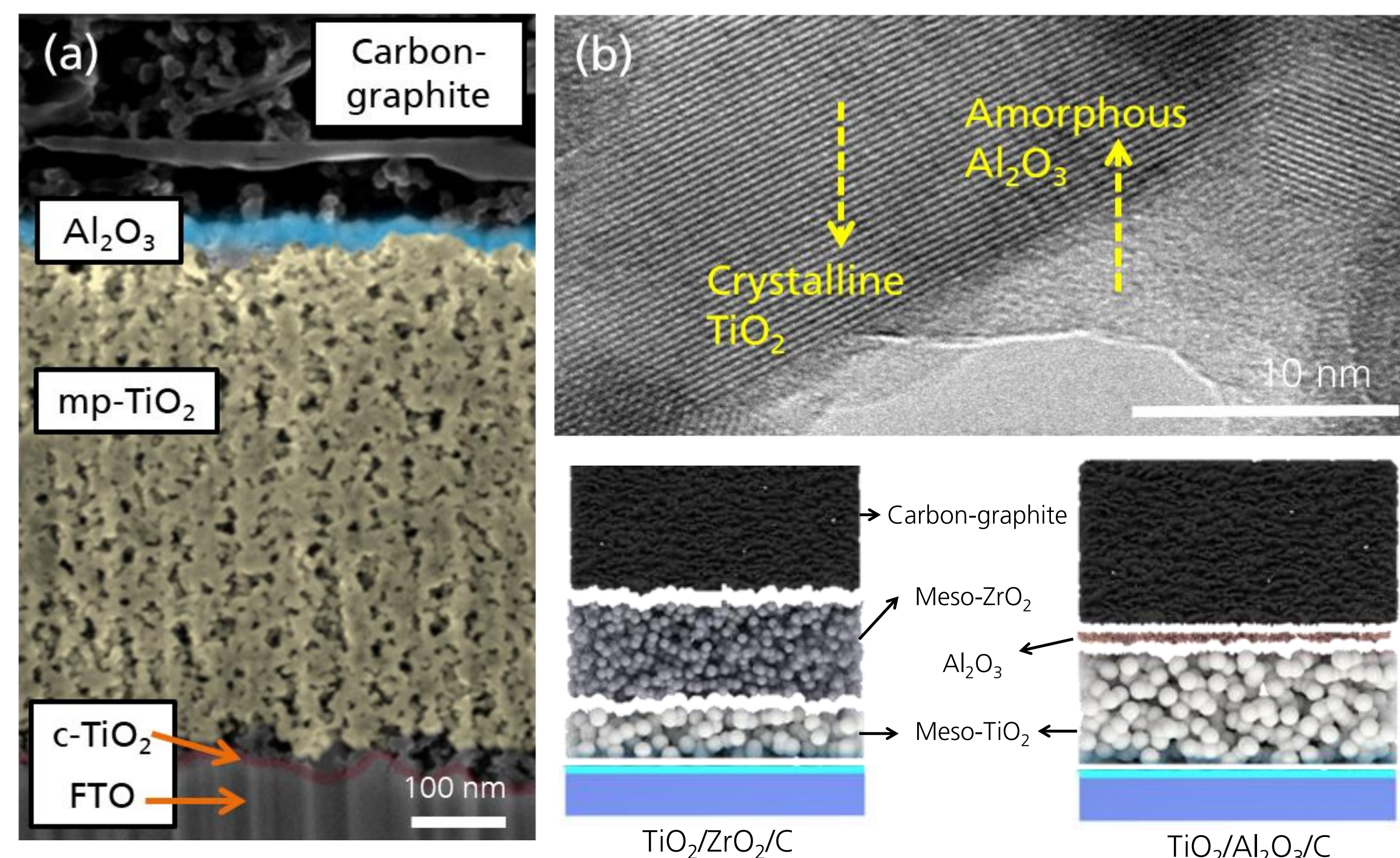
INTRODUCTION

CARBON-GRAPHITE BASED PEROVSKITE SOLAR CELLS (C-PSCs) ¹:

- In C-PSCs the space layer is fundamental in order to:
 - Prevent direct shunts between the mesoporous TiO_2 (mp- TiO_2) electron transport layer and the carbon-graphite interface
 - Prevent electron recombination at the TiO_2 /carbon-graphite interface

IN THIS WORK:

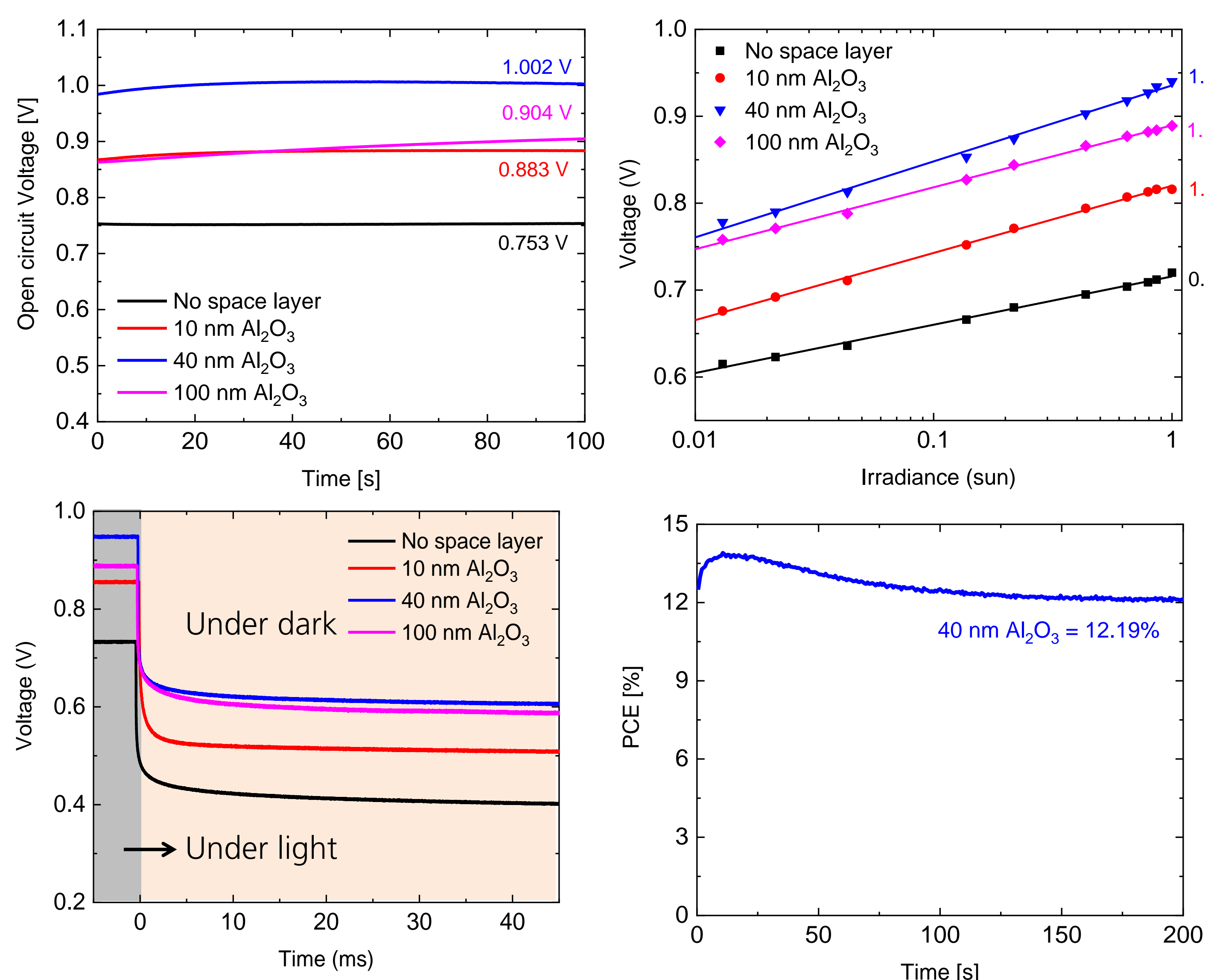
- Crystalline TiO_2 conformally covered by amorphous sputtered Al_2O_3 creating pseudo-porosity



FIB-SEM and TEM images of double mesoscopic carbon-graphite based perovskite solar cells (C-PSCs)

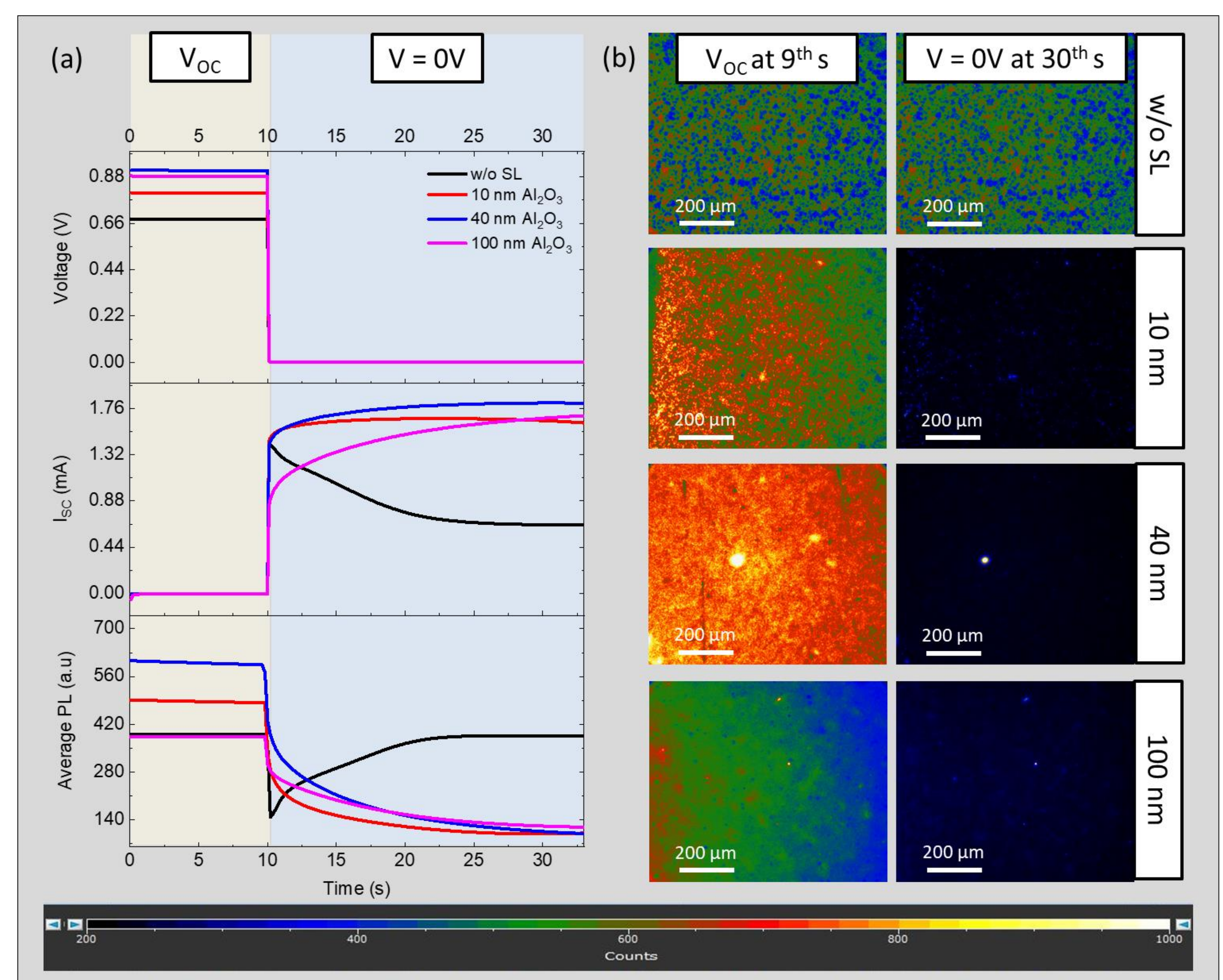
STABLE VOLTAGE, V_{OC} DECAY & LOW SUN INTENSITY MEASUREMENT

- Recombination of trapped e^- in mp- TiO_2 with carbon is efficiently blocked by the 40 nm thin Al_2O_3 → long living secondary charges at higher voltage
- Voltage > 0.75 V at low sun intensity → shunt-free, pinhole-free
- High n factor → mono- & bi-molecular recombination



SPACE-RESOLVED PHOTOLUMINESCENCE (PL)

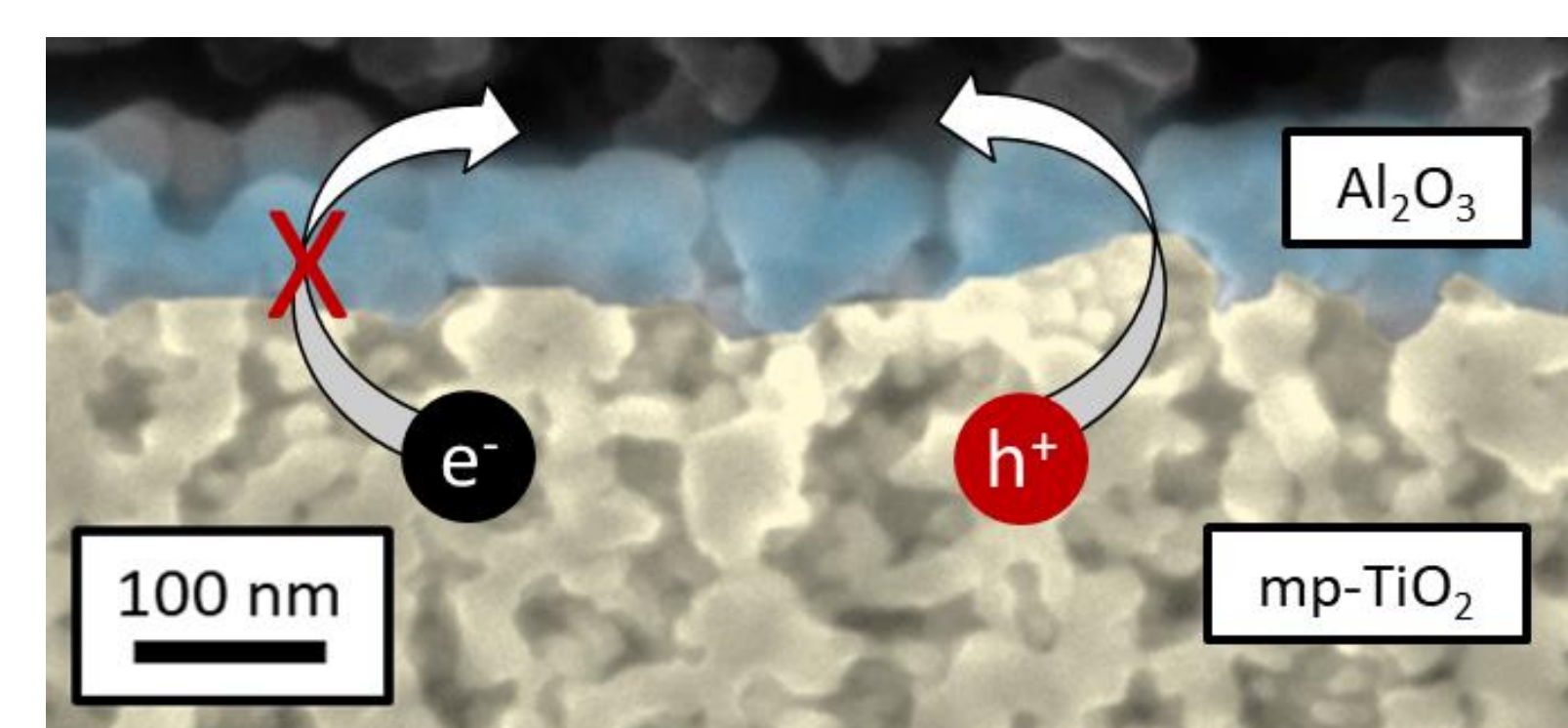
- At open circuit → PL contributed by primary charge carrier recombination
- At short circuit → complete extraction of charges leads to zero PL (ideal case)
- PL quenching → to measure charge transport efficiency
- The addition of Al_2O_3 space layer:
 - Stable quenched PL and charge extraction
 - 40 nm Al_2O_3 thickness shows efficient charge extraction



(a) Voltage, current and PL measured simultaneously while switching between open circuit (OC) and short circuit (SC) conditions (b) PL images at 9th and 30th s of measurement (9th s in OC; 30th s in SC)

CONCLUSION

- Shunt-free pinhole-free 40 nm Al_2O_3
- e^- in mp- TiO_2 are blocked from reaching the carbon-graphite interface: Stable voltage of 1 V reached
- Stable quenched PL → Efficient charge extraction
- Pseudo-porous Al_2O_3 → Allows good pore filling
- Stable PCE of 12.1% achieved ²



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¹ L.Wagner et al. ACS Energy Lett. 2018,3, 1122-1127

² G.Mathiazhagan et al. – ACS Applied nano materials. Manuscript under revision

