Flexible $CuGaSe_2$ solar cell for indoor photovoltaic application: prospects for the SIPHON project

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The purpose of this communication is to present the objectives and the preliminary results of the SIPHON (stable inorganic thin film photovoltaic devices for a sustainable Internet of Things) ANR JCJC project, starting in 2024.

Objectives: the project aims to provide a power generation solution for Internet of Things devices from ambient artificial light using thin-film solar cells based on a stable inorganic chalcopyrite $CuGaSe_2$ semiconductor (CGS). The 1.7eV bandgap of the absorber can theoretically lead to power conversion efficiency (PCE) close to 50% under white LED spectrum[1]. The development of metal halide assisted low-temperature syntheses of this semiconductor will be necessary in order to be able to fabricate the solar cells on a flexible polyimide substrate. The use of heavy alkali based post-treatments will allow the improvement of both the absorber and junction quality and thereby the photovoltaic (PV) conversion efficiency. Finally, the material consumption will be optimized by reducing the thickness of the layers constituting the cell stack and the toxic CdS buffer layer will be replaced by an alternative buffer layer based on non-toxic and earth-abundant materials.

Preliminary results: we performed in-house measurement of 0.5 cm² CGS cells under 1600 lux white LED spectrum. The photovoltaic parameters of our best device, as shown Figure 1, give a 10.8 % PCE, already better than the state of the art for $Cu(In,Ga)Se_2$ (CIGS) based solar cell under 1600lux white LED illumination [1]. Note that there is room for improvement since the buffer layer used was CdS and no heavy alkali PDT was performed. As far as low-temperature synthesis are concerned, we demonstrated 13.3% and 11.7% PCE under standard test conditions for devices based on 550nm thick CIGS absorbers co-evaporated following a bi-thermal 350-400°C process, using an AgBr in-situ treatment and based on chemical bath deposited CdS and Zn(O,S), respectively.

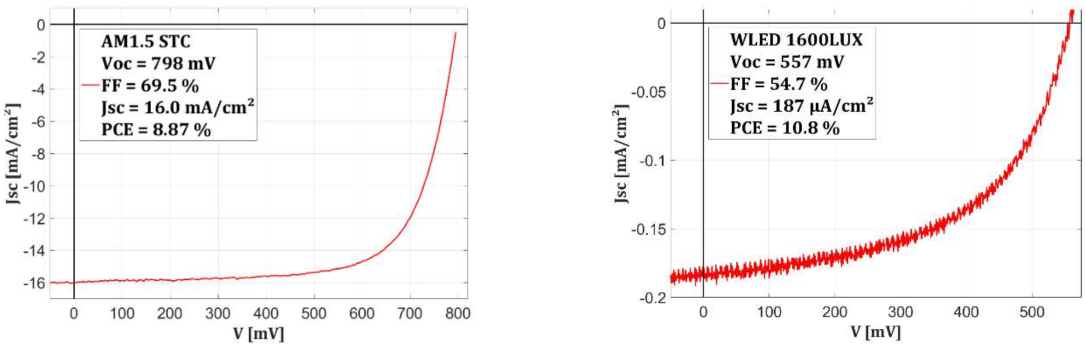

***Figure 1:** JV curves of CGS device under AM1.5 STC (left) and 1600 lux white LED (right) spectra*

1. Freunek, M., Freunek, M. & Reindl, L. M. Maximum efficiencies of indoor photovoltaic devices. *IEEE J. Photovolt.* 3, 59–64 (2013).
2. Biswas, S. & Kim, H. Solar Cells for Indoor Applications: Progress and Development. *Polymers* 12, 1338 (2020).

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