Development of spin-coating deposition of new wide band gap perovskite $MAPb_{0.75}Sn_{0.25}(I_{0.4}Br_{0.6})_3$ and extracting layers for tandem application

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$MASn_xPb_{1-x}(I_yBr_{1-y})_3$ perovskite is a material with remarkable electric properties and direct tunable band gap. In addition it can be deposited using low-cost spin-coating technique. In case of PSK/Silicon 4T tandem, Shockley Queisser limit calculation predicts over 40% Power Conversion Efficiency (PCE) when perovskite's band gap is of 1.7 eV (Figure 1.a) [1]. Perovskite's band gap can vary from 1.6 eV (for $MAPbI_3$) to 2.3 eV (for $MAPbBr_3$) by changing the iodine/bromide ratio and from 1.14 eV (for $MASnI_3$) to 1.6 eV (for $MAPbI_3$) by changing the tin/lead metal ratio. Thus, one can tune perovskite composition to desired band gap value. This work aims to widen the 1.58 eV band gap of the massively used $(FA_{0.84}MA_{0.16})_{0.95}Cs_{0.05}Pb(I_{0.84}Br_{0.16})_3$ to a targeted value of 1.7 eV by adding tin.
By changing elements ratios in perovskite solution, one has to be aware that perovskite crystallization – therefore resulting film– is highly related to chosen precursors and their ratios. For example, PbI_2 and $PbBr_2$ do not have the same structure and are not equally soluble in solvents; SnI_2 crystallizes faster than PbI_2 with MAI. Consequently, widening the band gap of triple cation perovskite will necessarily result in spin-coating engineering process.
New $MAPb_{0.75}Sn_{0.25}(I_{0.4}Br_{0.6})_3$ 1.7 eV wide band gap perovskite (PSK) was successfully synthesized. The resulting layer shows 300 to 400 nm grains and no pinhole (Fig.1.b). To prevent facile oxidation of lead-tin based perovskite by traditional spiro-OMeTAD additives, it has been decided to switch from n-i-p FTO/c-TiO_2/m-TiO_2/PSK/spiro-OMeTAD/Au standard configuration to p-i-n ITO/PEDOT:PSS/PSK/PCBM/BCP/Au stack (Fig. 1.c). Herein we present a proof of concept (Fig. 1.d) for a not yet optimized stack but showing encouraging V_{OC} and FF values of 0.25 V and 26.9% resp.. Future work will mainly focus on extracting layers optimization.

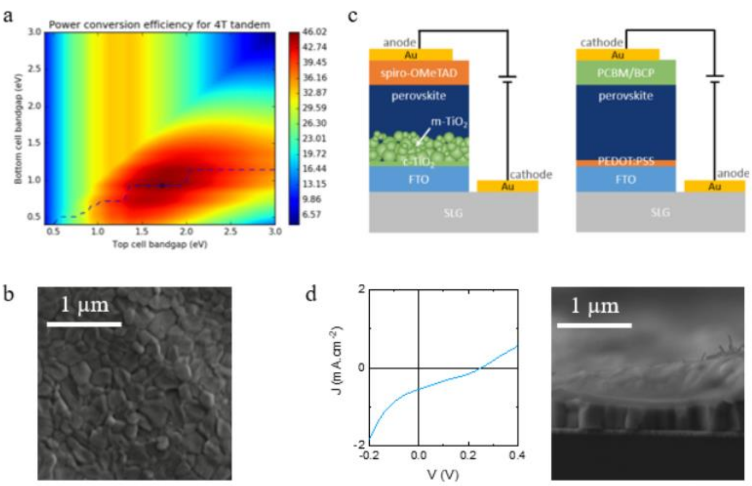

Figure 1 : a- Combined tandem power conversion efficiency in 4T configuration following the Shockley Queisser limit. From [1]. b- Micrograph of pin-hole free $MAPb_{0.75}Sn_{0.25}(I_{0.4}Br_{0.6})_3$ layer. c- p-i-n and n-i-p PSC stacks. d- J(V) diagram of PSC and micrograph cross section.

Reference:
[1] M. T. Hörantner and H. J. Snaith, *Energy Environ. Sci.* **2017**, 10, 1983 - 1993