Lead-free double perovskite materials for photovoltaic application

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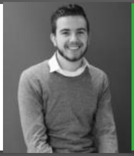
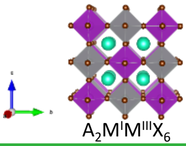
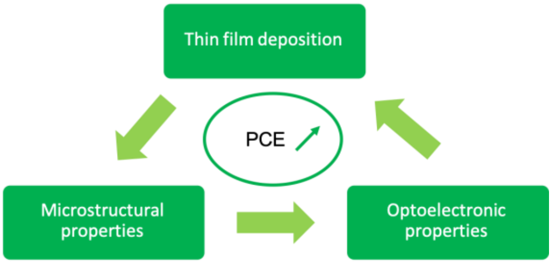


Introduction

The most efficient perovskite compounds for PV application contain lead, which is toxic to humans and environment. A major challenge is therefore to replace lead with a less toxic element while maintaining high conversion efficiency. The **double perovskite** structures have only been considered very recently for PV application and have shown very high stability under ambient conditions (air, moisture, temperature) compared to lead-based perovskite compounds. For now, only **$Cs_2AgBiBr_6$** compound has been assembled in PV cell [1-3] with maximum efficiency close to **2.5%.** In order to increase the PV efficiency of the cells, the scientific community agrees on the need to better control the **film morphology** (uniformity, coverage rate, crystallite size, grain boundaries, thickness...).

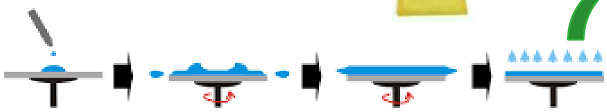


Objective

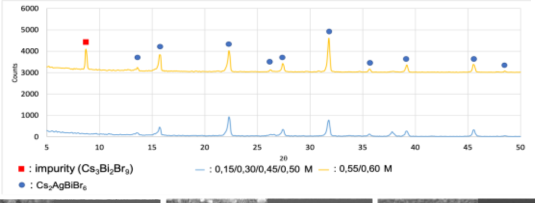


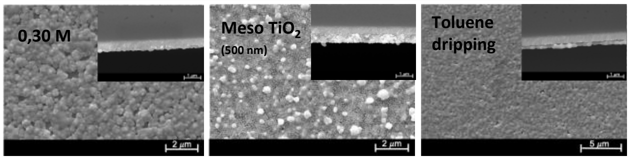
$Cs_2AgBiBr_6$ films

Spin-coating



Concentration	Mesoporous TiO_2	Anti-solvent smoothing
- 0.15M - 0.30M - 0.45M - 0.50M - 0.55M - 0.60M	- 200 nm - 500 n - 1 µm	- Chlorobenzene - Isopropanol - Toluene
✓ 0.30M (250 nm)	✓ 500 nm	✓ Toluene

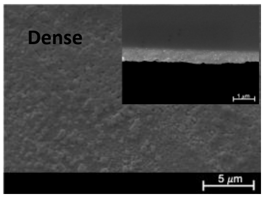


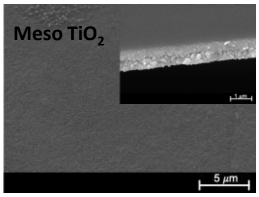


✓ No major effect of relative humidity and thermal treatment on the film morphology

Process scale-up

Ultrasonic spray pyrolysis (USP)

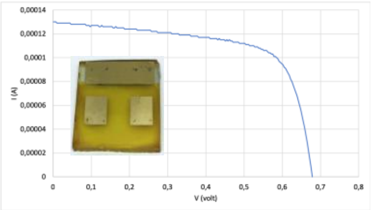




✓ Transfer of the best spin-coating settings to USP
✓ Promising results with uniform and covering films
⧗ Assembly of USP made cells in the coming weeks

Power conversion efficiencies

Thermal treatment	Samples	V_{OC} (V)	J_{sc} (mA/cm²)	FF	PCE (%)
Preheating: 75°C Heating: 285°C (5 min)	0.30 M (without mesoporous TiO_2)	0,763	0,5	56	0,3
	0.30 M + toluene dripping	0,700	0,5	30	0,2
	0.30 M + 500 nm mesoporous TiO_2 + toluene dripping	0,726	1,7	63	0,8
	0.30 M + 500 nm mesoporous TiO_2	0,720	2,5	67	1,2
Preheating: 85°C Heating: 300°C (5 min)	**0.30 M + 500 nm mesoporous TiO_2**	**0,679**	**3,7**	**67**	**1,7**



I-V curve of our best cell

Acknowledgements

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References

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3. Pantaler, M., *ACS Energy Letters*, 1–14.