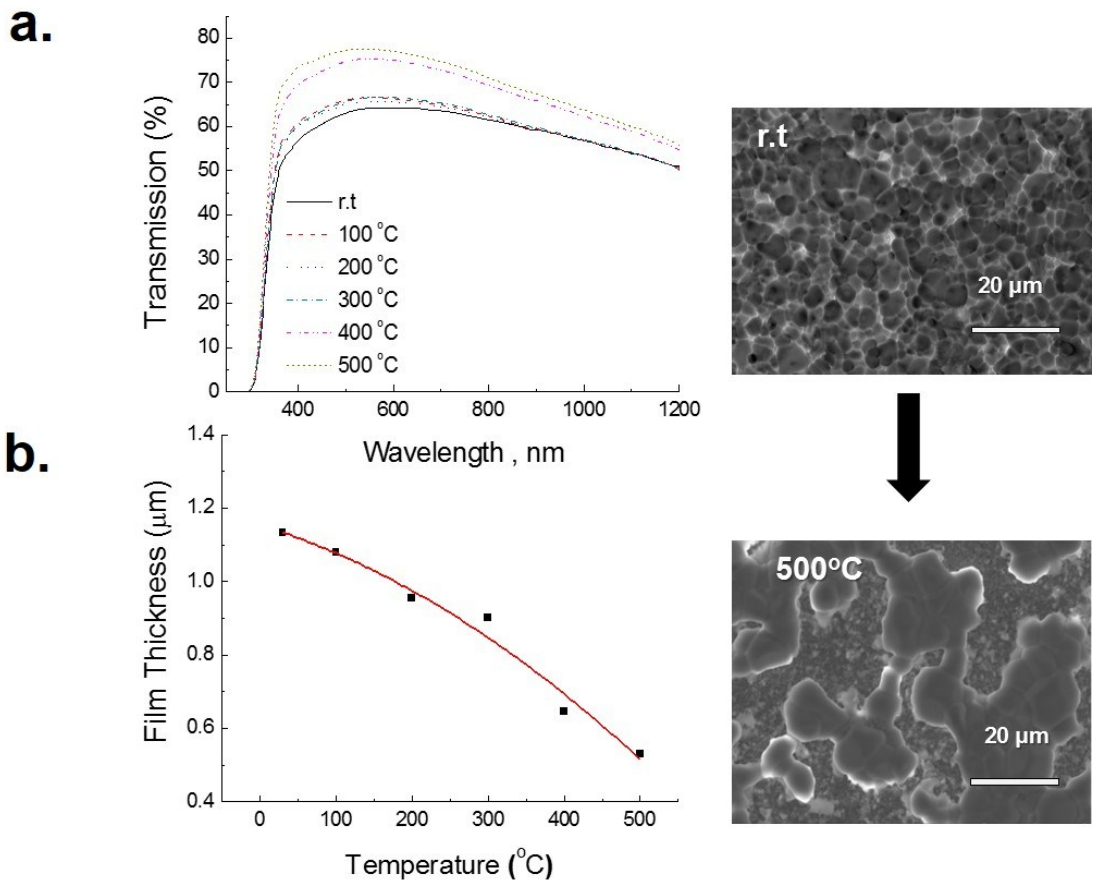
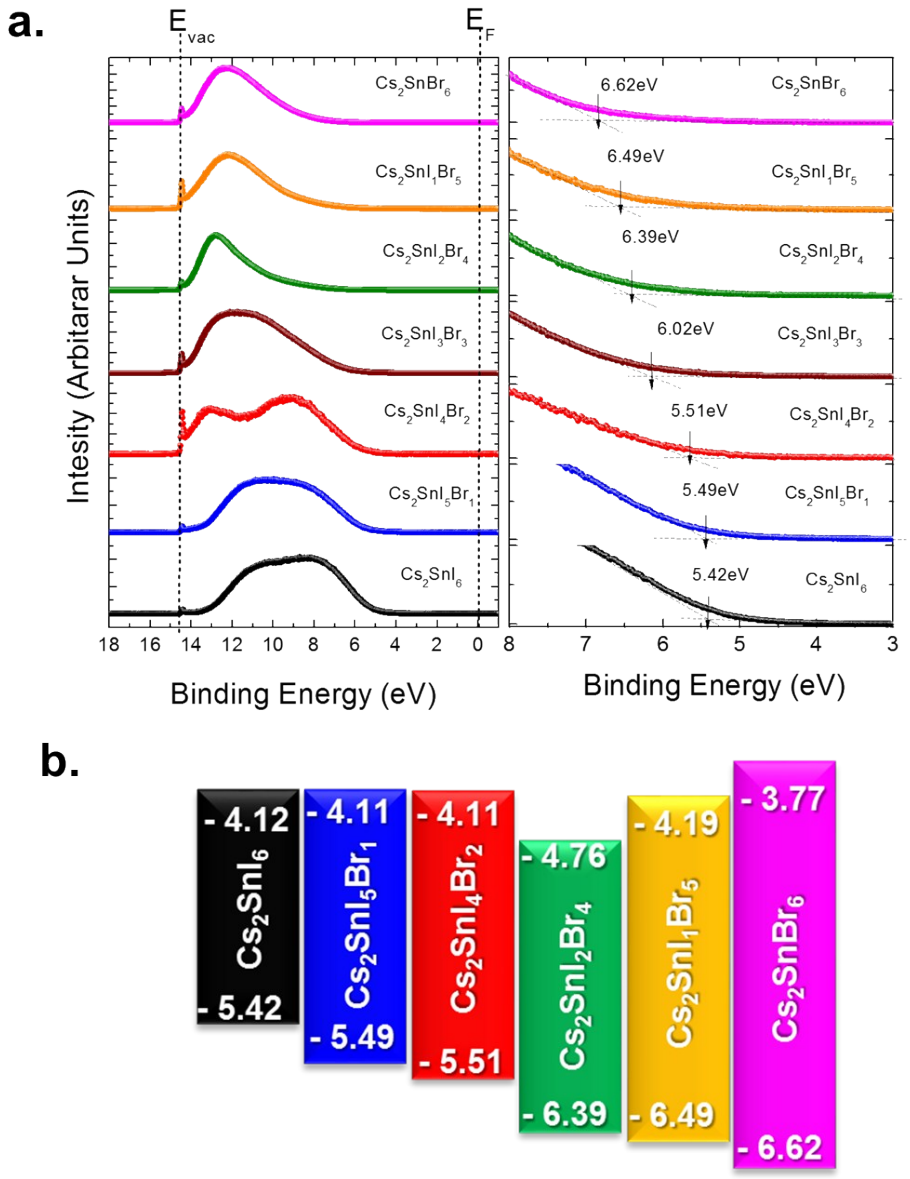
Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Supporting Information

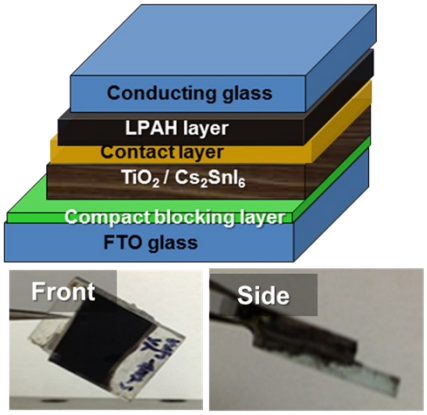


Supporting Information 1. **a.** Transmission graph (The inset shows the coverage of CsI film by SEM at low and high temperatures) **b.** Plot of the film thickness of CsI film as a function of temperature

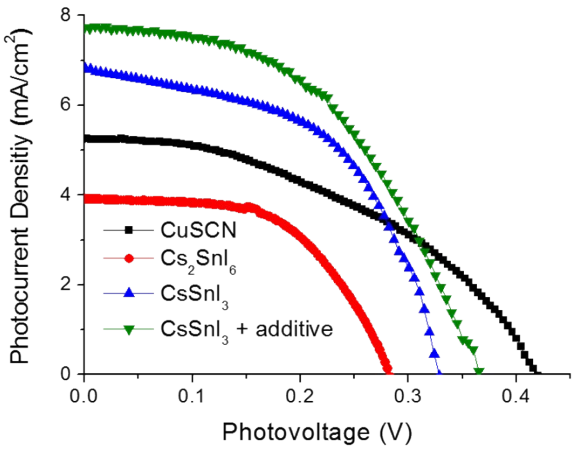


Supporting Information 2. Characteristics of the different composition of $Cs_2SnI_{6-x}Br_x$: a. UPS analysis of various $Cs_2SnI_{6-x}Br_x$ compositions prepared by Two-Step solution process **b.** the corresponding energy diagram

a.



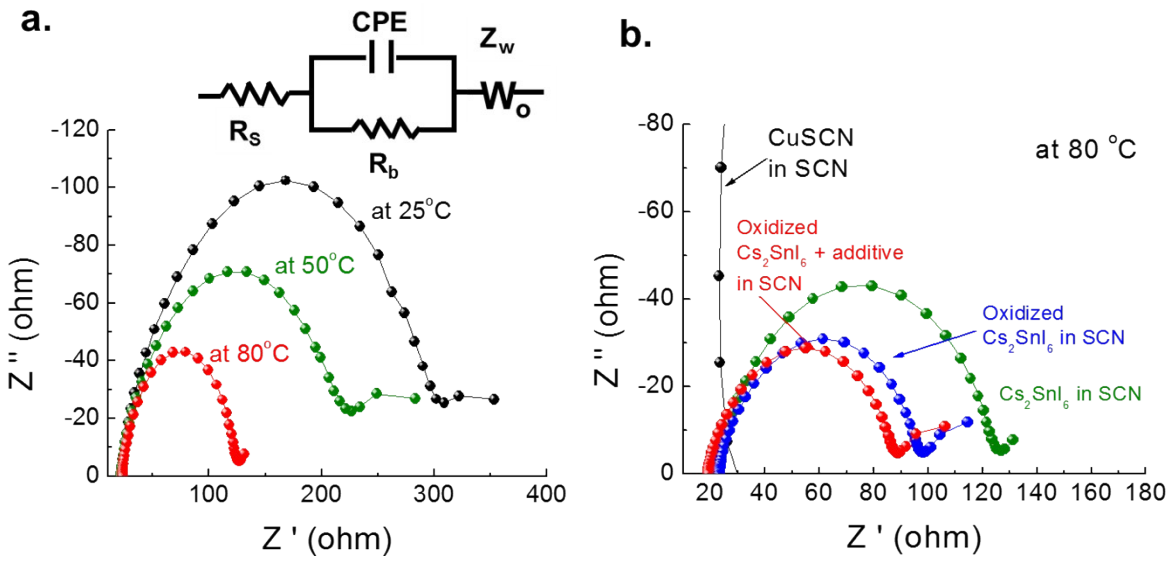
b.



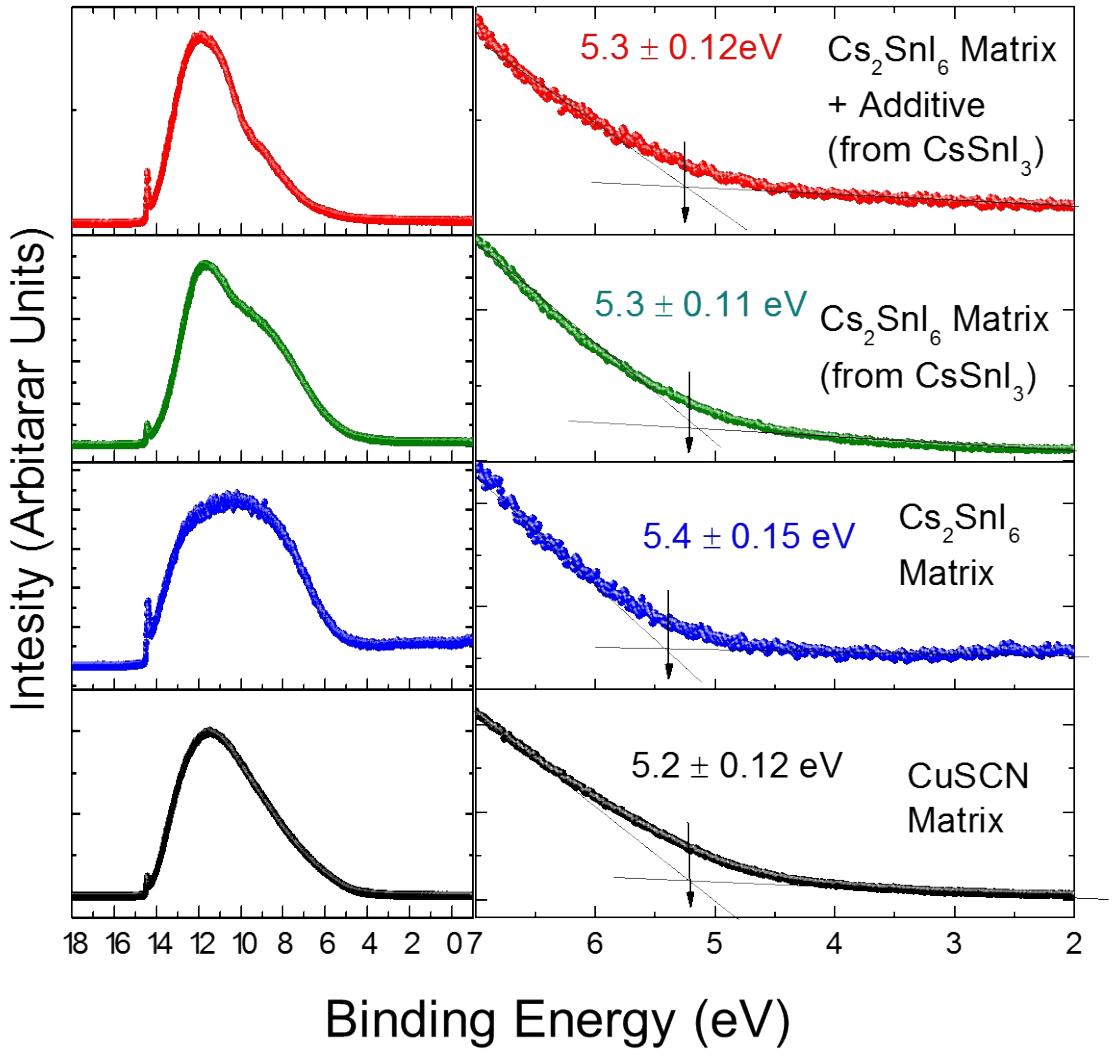
c.

Structures	Ionic conductivity (σ, S cm^{-1})		Activation Energy	JV characteristics			
	rt	75°C	(E_a ,eV)	V_{OC} (V)	J_{sc} (mA/cm^2)	FF (%)	EFF (%)
CuSCN	9.14×10^{-7}	2.06×10^{-6}	0.278	0.419	5.255	43.3	0.955
Cs_2SnI_6	1.26×10^{-5}	1.22×10^{-4}	0.390	0.282	3.929	55.8	0.619
* $Cs2SnI_6$	1.63×10^{-4}	8.34×10^{-4}	0.243	0.349	6.799	53.8	1.280
$CsSnI_3$ + additive	5.67×10^{-4}	2.44×10^{-3}	0.197	0.367	7.732	48.8	1.412

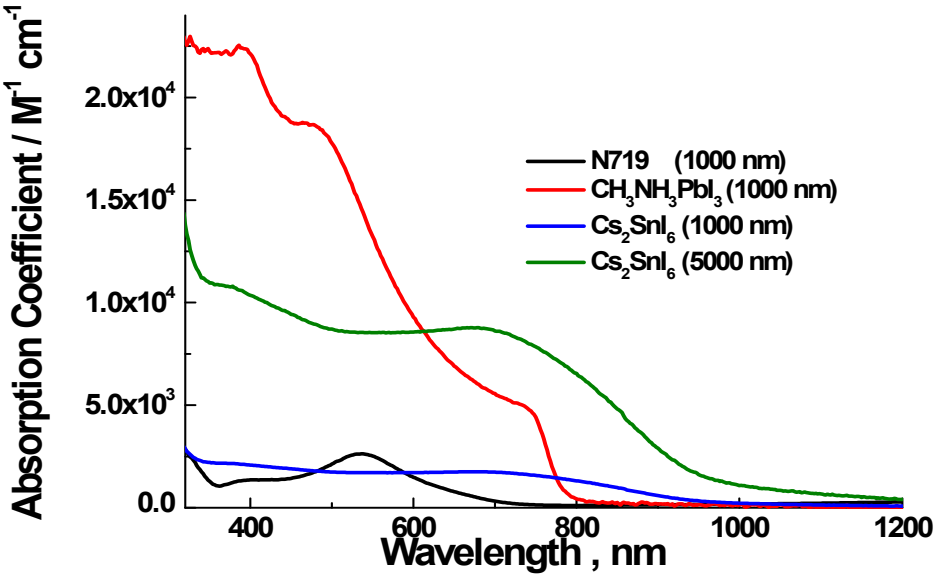
Supporting Information 3. Ionic conductivity and Solar cell properties of the different solid state ionic conductors as HTM layers **a.** the cell configuration of a sandwich typed device (top and side) and photo images for the real device **b.** JV characteristic of the Cs2SnI6 film using the different mixture of blend **c.** table summarizing ionic conductivity, activation energy, and solar cell performance



Supporting Information 4. Electrical properties of the different solid state ionic conductor as a HTM layer a. 10wt% Cs_2SnI_6 in SCN at different temperatures, and the equivalent circuit. In the equivalent circuit, R_b is the bulk resistance of the solid state electrolytes and CPE is the constant phase element to fit bulk capacitance. The straight line at the lower frequencies is due to an ion diffusion-limited process contributing to an impedance response (Warburg impedance Zw) **b.** Experimental and fitted impedance spectra at 80°C

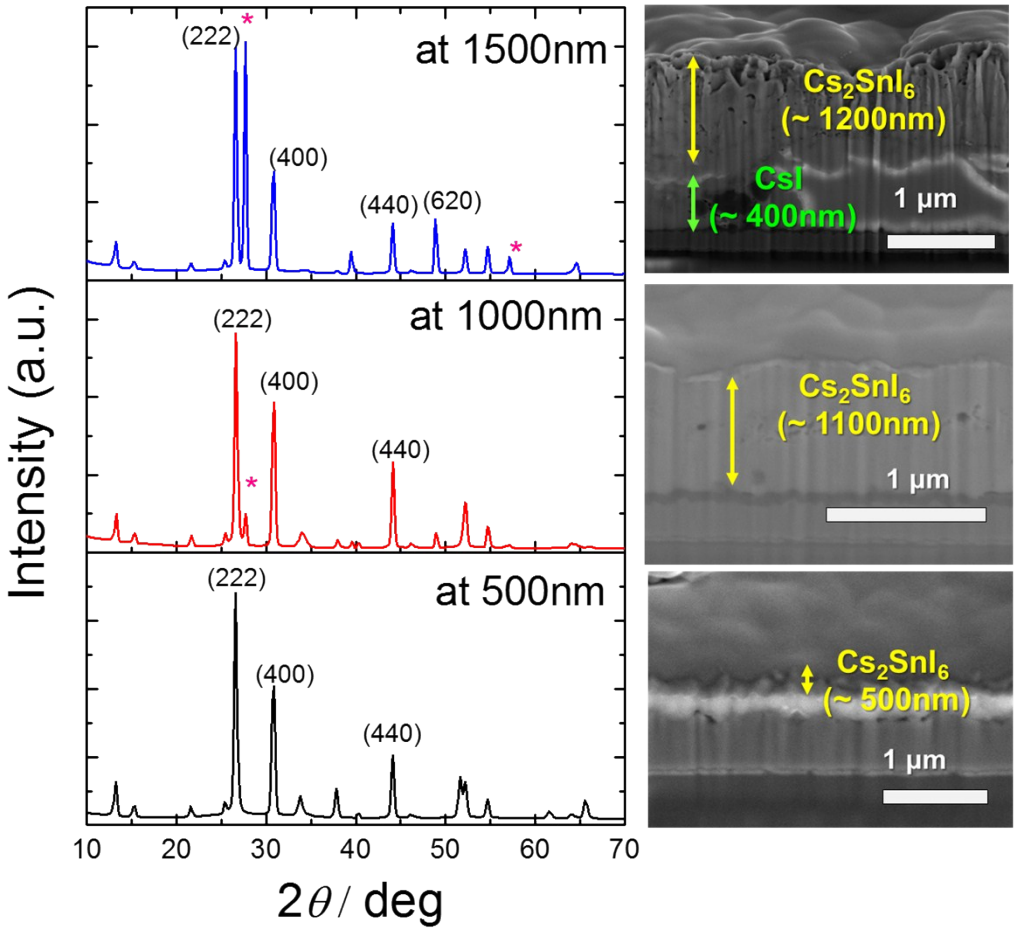


Supporting Information 5. UPS analysis of the different solid state ionic conductor as a HTM layer



	Thickness (nm)	E_g (eV)	Absorption coefficient (α, cm^{-1})	
			at 550nm	at 680nm
N719		2.32	2.52×10^3	0.484×10^3
$CH_3NH_3PbI_3$	~ 400	1.5	1.32×10^4	6.01×10^3
	~ 1000		1.5×10^4	5.0×10^3
Cs_2SnI_6	~ 1000	1.3	1.70×10^3	1.75×10^3
	~ 5000		8.5×10^3	8.77×10^3

Supporting Information 6. Absorption properties of the different sensitizer materials



Supporting Information 7. XRD analysis for the different film thickness and morphological study from SEM and TEM analysis for