

Environmental Ageing of $\text{CaZrO}_{3-x}\text{S}_x$ Oxychalcogenide Perovskite Thin Films

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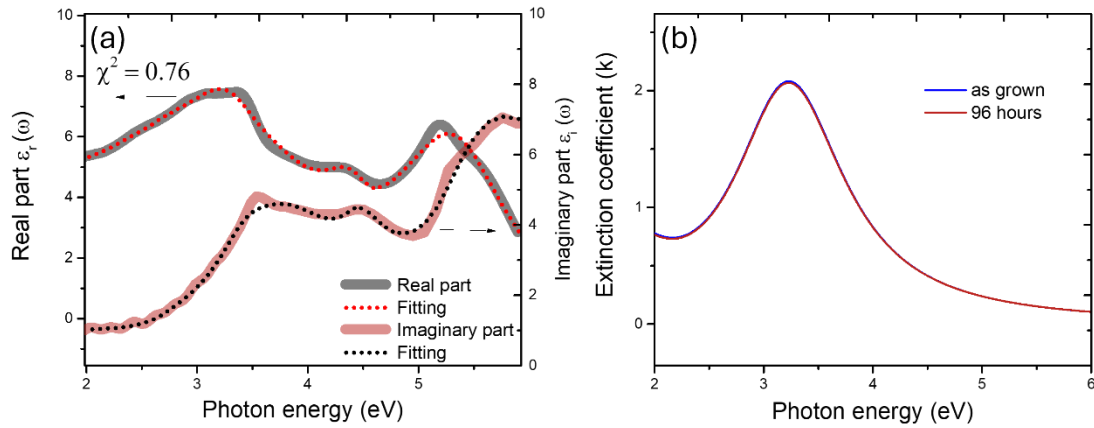


Fig. S1. (a) Experimental and fitted real and imaginary dielectric constant spectra, determined by spectroscopic ellipsometry (SE). (b) the extracted extinction coefficient (k), of CZOS thin film under humidity test within the time period 0-96 hours.

Table S1. The fitting parameters of CZOS thin film extracted from SE. Phase 1 and 2 refer to sulfur-rich and oxide-rich phases, respectively.

Phase 1		Phase 2	
Tauc Lorentz 3		Tauc Lorentz 2	
E_g	1.000000	E_g	4.0690112
ϵ^∞	101.6708984	ϵ^∞	0.5018587
A_1	23.6741829	A_1	48.9445877
E_1	1.7374042	E_1	5.1016116
C_1	0.8306053	C_1	1.2592200
A_2	69.1529312	A_2	93.0644913
E_2	3.2110596	E_2	4.3876185
C_2	1.1930536	C_2	0.4222689
A_3	7.1874418	-	-
E_3	0.1125293	-	-
C_3	7.2834630	-	-

Table S2. Summary of the CZOS thin films used in the different ageing experiments, including the test condition, film thickness extracted vis ellipsometry, and as-grown optical bandgap.

Test condition	Thickness (nm)	As-grown bandgap (eV)
80% RH	48.8	3.2
80% RH at 80 °C	46.3	3.2
Annealing up to 600 °C	42.7	3.1
1 sun illumination	46.6	3.2
Ambient condition	33.8	3.2

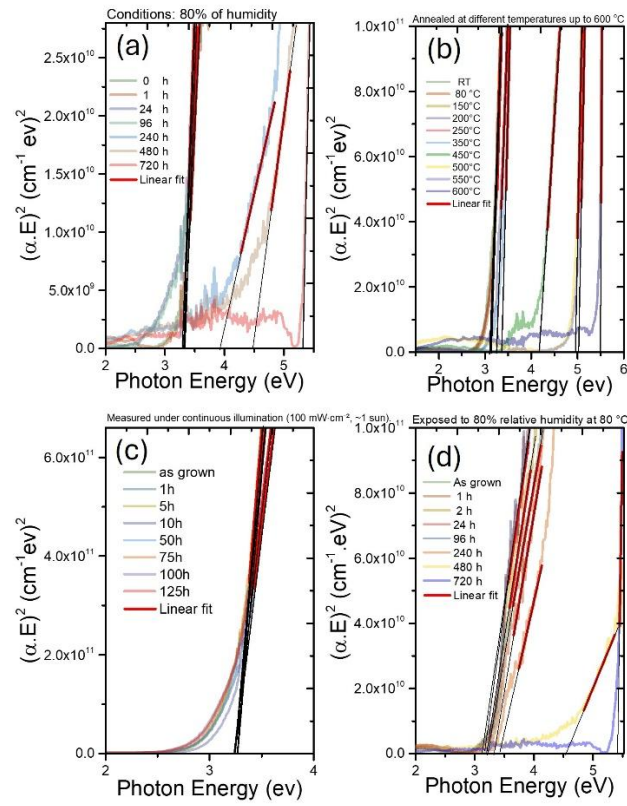


Fig. S2. The bandgap estimated from Tauc plot under (a) Humidity 80% RH, (b) temperature, (c) illumination, and (d) combined humidity-temperature. The bold linear segments show the fitting windows used for bandgap extraction.

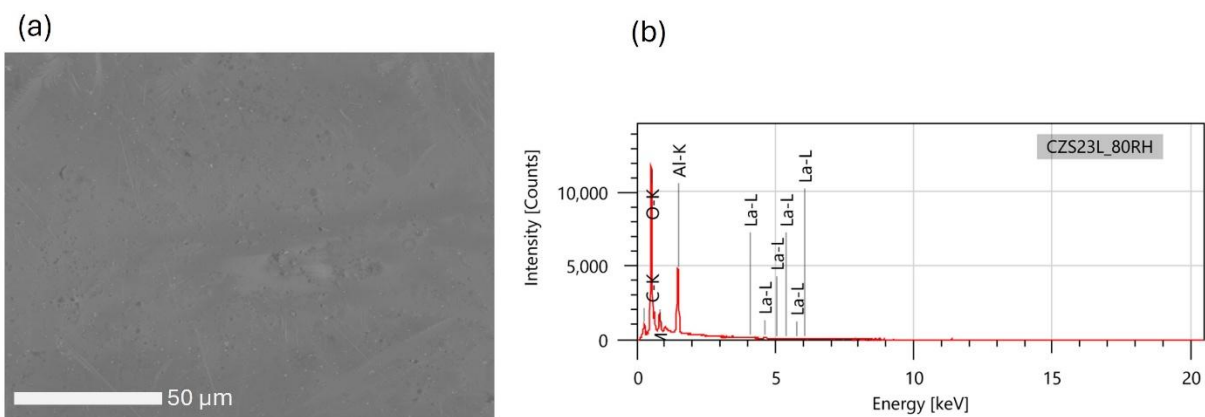


Fig. S3. (a) SEM scan of CZOS thin film after 30 days under humidity test. (b) corresponding EDS analysis.

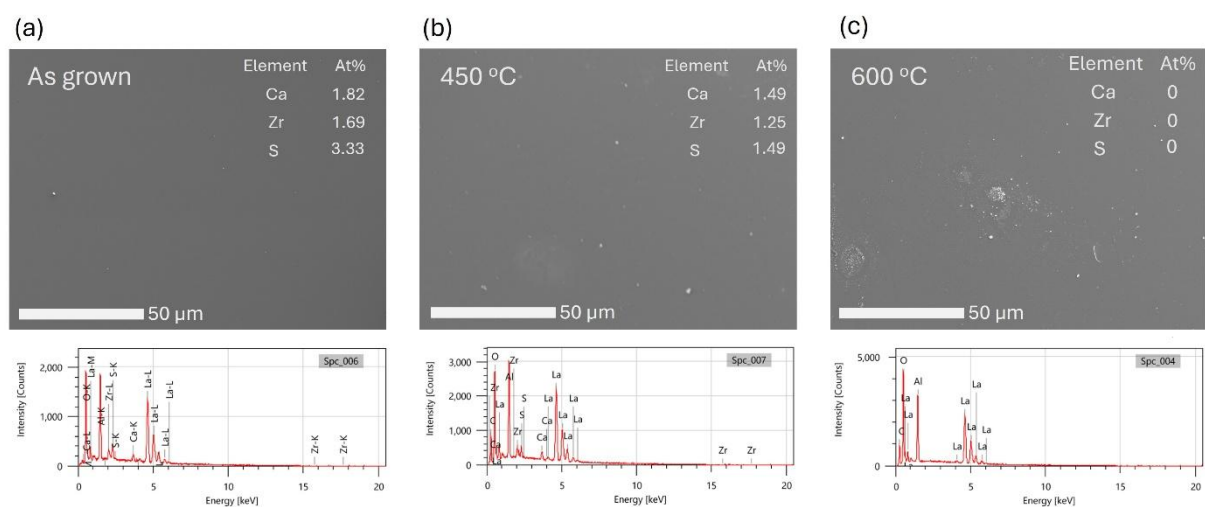


Fig. S4. SEM scans and corresponding EDS of CZOS film under temperature stress (a) as-grown (b) 450 °C (c) 600 °C.

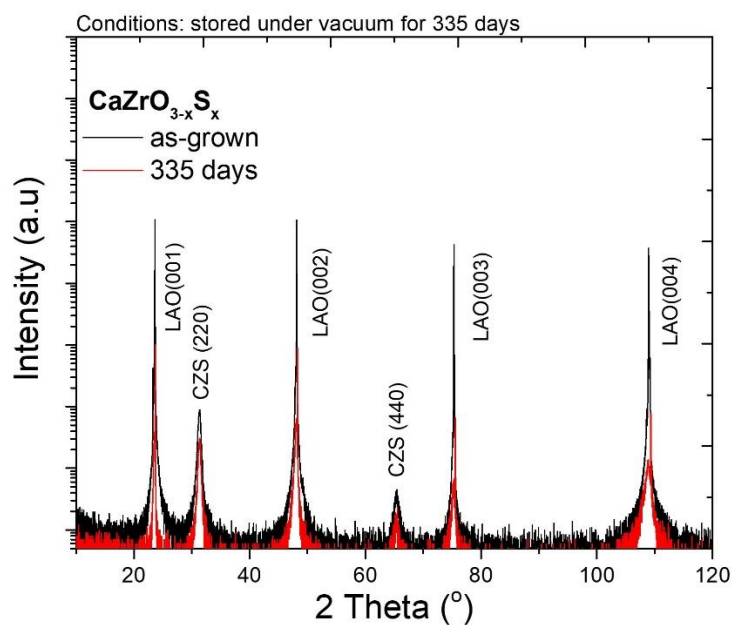


Fig. S5. Room temperature XRD of CZOS stored in vacuum for 335 days.

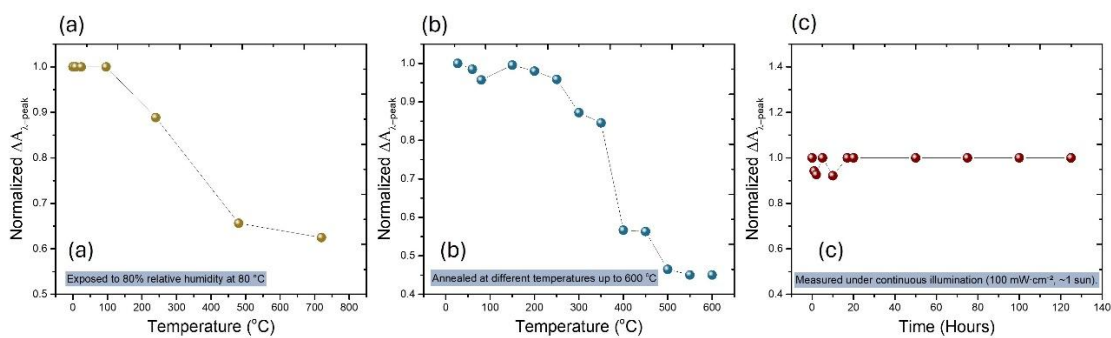


Fig. S6. Time-dependent evolution of the normalized peak absorbance of CZOS film under (a) combined humidity-temperature, (b) temperature, (c) illumination.