

Electronic Supplementary Information (ESI)

Fabrication of a $\text{Cu}_2\text{ZnSn}(\text{S},\text{Se})_4$ photovoltaic devices with 10% efficiency by optimizing the annealing temperature of precursor films

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Table S1. Performance of $\text{Cu}_2\text{ZnSn}(\text{S},\text{Se})_4$ (CZTSSe) solar cells with different annealing temperatures for precursor films

300 °C annealing temperature									
	J_{sc} ($\text{mA}\cdot\text{cm}^{-2}$)	V_{oc} (mV)	FF	Efficiency (%)		J_{sc} ($\text{mA}\cdot\text{cm}^{-2}$)	V_{oc} (mV)	FF	Efficiency (%)
A1	30.18	420	0.58	7.31	A2	29.84	409	0.46	5.59
A3	28.05	387.09	0.46	5.00	A4	27.43	255.11	0.32	2.25
A5	28.27	222.12	0.31	1.92	A6	30.13	409.23	0.53	6.53
A7	29.68	409.14	0.54	6.51	A8	28.78	403.73	0.55	6.41
A9	30.54	381.66	0.53	6.18	A10	30.98	409.24	0.53	6.68
A11	30.71	381.67	0.43	5.06	A12	29.35	403.73	0.56	6.65
A13	29.79	398.17	0.52	6.15	A14	28.38	409.24	0.54	6.22
A15	31.23	420.20	0.55	7.24	A16	27.83	194.75	0.31	1.68
A17	30.05	425.70	0.56	7.18	A18	27.88	365.24	0.42	4.23
A19	30.32	409.21	0.56	6.96	A20	28.60	354.23	0.40	4.01
A21	30.03	425.71	0.55	6.98	A22	31.32	343.25	0.38	4.11
A23	27.40	205.70	0.28	1.60	A24	29.65	398.25	0.55	6.49
A25	29.08	288.20	0.32	2.67	A26	29.99	392.75	0.55	6.43
A27	29.67	409.22	0.50	6.08	A28	31.23	376.26	0.28	3.33
A29	29.84	288.21	0.32	2.73	A30	29.61	321.26	0.32	3.03
350 °C annealing temperature									
A1	33.73	453.25	0.63	9.64	A2	34.02	453.26	0.62	9.60
A3	33.78	447.75	0.64	9.65	A4	30.62	458.76	0.61	8.62
A5	33.15	436.74	0.63	9.15	A6	32.91	436.75	0.62	8.89
A7	31.03	436.74	0.62	8.46	A8	33.12	425.75	0.61	8.61
A9	31.30	442.25	0.62	8.59	A10	31.83	453.25	0.62	8.96
A11	32.39	431.24	0.61	8.59	A12	31.58	436.74	0.61	8.44
A13	33.33	447.75	0.63	9.41	A14	30.74	442.25	0.62	8.48
A15	31.99	447.75	0.61	8.71	A16	31.11	442.25	0.62	8.56
A17	31.38	447.75	0.62	8.78	A18	31.59	420.26	0.62	8.26
A19	32.15	442.25	0.62	8.82	A20	32.20	442.25	0.63	8.99
A21	33.10	442.25	0.61	9.00	A22	32.06	442.24	0.62	8.82
A23	32.43	442.25	0.62	8.86	A24	32.31	436.74	0.61	8.60
A25	32.31	431.24	0.60	8.38	A26	30.92	442.25	0.62	8.49
A27	31.37	453.26	0.63	8.98	A28	31.19	442.25	0.61	8.44
A29	31.66	431.24	0.61	8.27	A30	32.16	436.75	0.62	8.74
380 °C annealing temperature									

A1	31.96	480.71	0.62	9.49	A2	31.42	469.73	0.61	9.03
A3	32.04	480.70	0.63	9.70	A4	32.50	469.72	0.62	9.45
A5	32.10	475.25	0.63	9.54	A6	31.77	469.72	0.59	8.82
A7	33.46	475.24	0.62	9.92	A8	32.47	464.26	0.60	9.01
A9	33.50	481.00	0.62	10.04	A10	31.93	464.26	0.61	9.06
A11	33.57	475.24	0.61	9.77	A12	32.92	464.25	0.60	9.10
A13	33.50	475.24	0.61	9.68	A14	32.30	464.25	0.62	9.27
A15	32.47	475.23	0.62	9.57	A16	33.00	464.25	0.62	9.54
A17	32.72	469.75	0.62	9.50	A18	30.90	464.25	0.61	8.75
A19	32.48	469.75	0.63	9.56	A20	34.71	464.25	0.60	9.69
A21	32.57	469.75	0.63	9.65	A22	32.15	464.24	0.61	9.18
A23	32.73	469.74	0.61	9.41	A24	32.50	464.24	0.61	9.25
A25	32.21	469.74	0.62	9.43	A26	33.02	464.23	0.61	9.37
A27	32.39	469.74	0.64	9.66	A28	32.39	464.23	0.60	8.96
A29	32.11	469.74	0.62	9.37	A30	32.07	464.23	0.62	9.20
400 °C annealing temperature									
A1	33.51	442.05	0.63	9.39	A2	32.15	442.20	0.63	9.00
A3	31.58	442.07	0.62	8.70	A4	32.98	420.22	0.59	8.14
A5	31.94	436.58	0.63	8.79	A6	31.48	442.22	0.62	8.61
A7	29.46	447.61	0.64	8.40	A8	31.36	431.21	0.60	8.08
A9	29.58	447.63	0.64	8.42	A10	32.06	420.24	0.59	8.02
A11	29.61	453.14	0.64	8.58	A12	31.37	431.23	0.62	8.35
A13	31.39	442.15	0.63	8.81	A14	31.63	431.23	0.62	8.48
A15	32.57	436.65	0.64	9.15	A16	32.47	436.74	0.63	8.89
A17	31.10	442.16	0.64	8.74	A18	31.06	431.23	0.61	8.18
A19	30.06	436.67	0.64	8.34	A20	31.88	425.75	0.60	8.16
A21	32.25	442.18	0.62	8.89	A22	31.58	431.24	0.60	8.18
A23	31.56	442.19	0.62	8.63	A24	31.06	431.24	0.62	8.25
A25	31.42	431.18	0.59	7.96	A26	31.88	436.75	0.60	8.37
A27	30.48	436.70	0.60	8.00	A28	30.40	436.76	0.60	7.98
A29	30.53	442.20	0.61	8.29	A30	31.91	431.25	0.62	8.47
450°C annealing temperature									
A1	31.25	420.28	0.57	7.53	A2	31.86	425.76	0.60	8.09
A3	30.13	420.28	0.59	7.47	A4	27.35	425.77	0.49	5.68
A5	30.10	414.78	0.57	7.08	A6	30.64	420.27	0.60	7.67
A7	29.28	414.78	0.56	6.85	A8	33.73	387.25	0.58	7.59
A9	28.84	414.78	0.56	6.74	A10	32.86	403.75	0.58	7.71

A11	29.93	409.28	0.55	6.71	A12	32.46	387.26	0.56	7.07
A13	31.58	409.27	0.58	7.54	A14	32.34	387.25	0.56	7.06
A15	30.42	414.78	0.58	7.36	A16	32.75	398.25	0.58	7.56
A17	29.98	409.28	0.58	7.16	A18	34.18	381.76	0.57	7.46
A19	32.44	431.26	0.63	8.77	A20	34.28	381.76	0.57	7.40
A21	31.64	431.26	0.62	8.52	A22	32.05	381.76	0.58	7.11
A23	31.37	425.77	0.62	8.27	A24	32.58	376.26	0.57	7.01
A25	30.11	425.77	0.62	7.91	A26	30.44	425.75	0.57	7.33
A27	29.24	431.25	0.62	7.79	A28	30.85	425.76	0.58	7.64
A29	30.16	425.76	0.62	8.00	A30	27.91	409.25	0.57	6.53

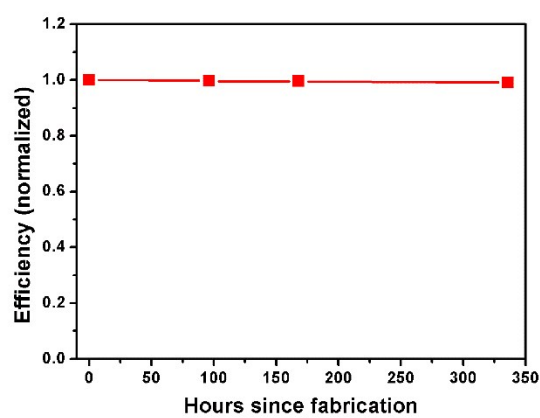


Fig. S1 Efficiency of CZTSSe solar cells kept in an ambient environment as a function of storage time

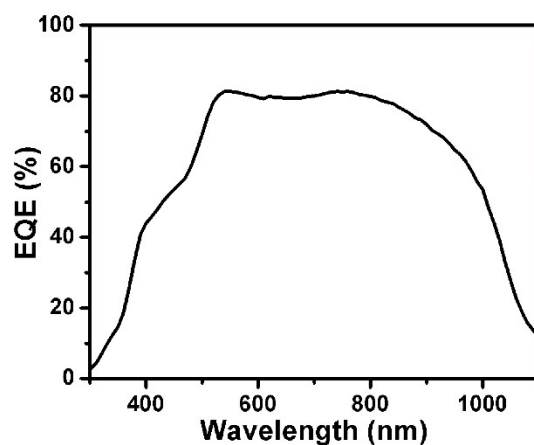


Fig. S2 EQE of the champion CZTSSe solar cell