Supporting Information

Ge-Alloyed Kesterite Thin-Film Solar Cells: Previous Investigations and Current Status - a Comprehensive Review

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Reference	x= Ge/(Ge+Sn)	y= S/(S+Se)	η [%]	V_{oc} ($V_{oc,def}^{SQ}$) [mV]	J_{sc} ($J_{sc,def}^{SQ}$) [mA/cm^2]	FF (FF$_{def}^{SQ}$) [%]	E_g [eV]
Zhang 2020 [95]	0.002	0.00	10.5	424 (371)	37.2 (8.5)	66.9 (19.1)	1.05
Neuschitzer 2018 [66]	0.01	0.00	8.6	460 (344)	29.3 (15.9)	64.1 (22.1)	1.06
Deng 2021 [112]	0.01	0.03	11.5	490 (323)	34.8 (10.0)	67.2 (19.1)	1.07
Liu 2021 [72]	0.02	0.00	10.3	440 (383)	34.7 (9.9)	67.6 (18.8)	1.08
S. Lee 2019 [123]	0.03	0.00	8.3	442 (353)	31.7 (14.0)	59.0 (27.0)	1.05
Giraldo 2018 [63]	0.04	0.00	11.0	463 (332)	36.0 (9.7)	66.3 (19.7)	1.05
Wang 2022 [30]	0.06	0.03	13.1	550 (292)	34.3 (9.9)	70.0 (16.6)	1.10
Andres 2018 [71]	0.07	0.00	7.5	445 (340)	31.0 (15.1)	54.7 (31.2)	1.04
Y. Sun 2017 [109]	0.08	0.10	9.1	410 (478)	34.3 (8.14)	64.7 (22.5)	1.15
Khadka 2016 [83]	0.10	0.10	6.1	440 (430)	32.3 (11.1)	43.4 (43.6)	1.13
Sanchez 2019 [79]	0.03	1.00	7.0	660 (555)	18.7 (10.3)	57.6 (32.3)	1.50
Sun 2020 [101]	0.09	1.00	3.4	620 (670)	12.4 (13.8)	43.8 (46.6)	1.58
Lim 2019 [78]	0.10	1.00	4.5	590 (541)	15.5 (17.0)	49.0 (40.3)	1.41
Saini 2021 [77]	0.11	1.00	3.0	600 (690)	11.7 (14.5)	42.4 (48)	1.59
Saini 2021 [77]	0.25	1.00	3.0	580 (776)	10.1 (14.0)	53.0 (37.7)	1.65
Kim 2014 [100]	0.71	1.00	6.0	520 (920)	23.3 (-1.9)	49.6 (41.6)	1.74
J. Li 2017 [80]	0.05	0.38	2.0	270 (739)	22.4 (13.9)	33.3 (55.1)	1.28
L. Sun 2019 [81]	0.12	0.26	3.3	290 (691)	26.4 (11.2)	42.1 (46.0)	1.25
Lokhande 2017 [86]	0.12	0.46	3.8	430 (495)	18.3 (22.2)	47.0 (40.6)	1.21
Fu 2020 [111]	0.13	0.15	12.3	490 (295)	37.1 (9.0)	67.5 (18.4)	1.04

	x	y	η	V_{OC}	J_{SC}	FF	E_g
Lee 2021 [84]	0.15	0.10	7.9	450 (401)	33.8 (10.3)	52.0 (34.7)	1.11
Du 2018 [85]	0.14	0.02	8.1	400 (479)	32.7 (10.2)	62.5 (24.6)	1.14
S. Kim 2016 [126]	0.22	0.00	12.3	530 (321)	32.2 (11.9)	72.7 (14.0)	1.11
Collord 2016 [106]	0.25	0.00	11.0	583 (296)	33.6 (9.3)	55.9 (31.2)	1.14
Nowak 2022 [73]	0.32	0.00	10.4	540 (413)	36.0 (3.0)	54.0 (33.8)	1.22
Gao 2018 [110]	0.37	0.07	7.0	450 (420)	29.3 (14.1)	64.0 (23.0)	1.13
S. Kim 2016 [37]	0.39	0.00	10.0	540 (385)	29.5 (11.0)	62.7 (24.9)	1.19
Bag 2012 [94]	0.40	0.00	9.1	480 (408)	31.8 (10.6)	60.4 (26.8)	1.15
Guo 2012 [103]	0.17	0.50	8.3	470 (362)	29.0 (15.4)	61.8 (24.7)	1.09
Lv 2020 [113]	0.20	0.22	5.4	350 (650)	34.6 (2.1)	38.0 (50.3)	1.27
Zhao 2016 [108]	0.30	0.16	4.8	390 (600)	29.3 (7.8)	42.0 (46.2)	1.26
Hages 2015 [104]	0.30	0.50	9.4	460 (465)	31.9 (8.6)	63.8 (23.8)	1.19
Punathil 2022 [114]	0.46	0.26	7.1	390 (741)	33.0 (-0.5)	55.0 (34.3)	1.41
Ruiz-Perona 2020 [41]	0.52	0.00	6.4	510 (499)	22.4 (13.9)	56.3 (32.1)	1.28
Ruiz-Perona 2020 [42]	0.61	0.00	5.6	500 (509)	21.0 (15.3)	53.2 (35.2)	1.28
Ford 2011 [29]	0.70	0.54	6.8	640 (482)	21.5 (11.4)	49.0 (40.3)	1.40
Choubrac 2020 [49]	1.00	0.00	8.5	625 (469)	24.4 (9.6)	55.7 (33.4)	1.37
Schnabel 2017 [93]	1.00	0.27	2.2	670 (723)	9.5 (13.2)	39.0 (51.9)	1.69
Schnabel 2017 [92]	1.00	0.31	6.0	620 (567)	15.0 (14.6)	52.0 (37.7)	1.47
Ruiz-Perona 2021 [43]	1.00	0.39	2.8	790 (734)	6.2 (12.6)	56.3 (35.2)	1.83
Ruiz-Perona 2021 [44]	1.00	0.65	2.7	820 (844)	6.4 (8.6)	51.0 (41.1)	1.98
Saini 2022 [58]	1.00	1.00	1.3	920 (950)	3.2 (7.4)	45.0 (47.8)	2.20

Table S1. Measured x=Ge/(Ge+Sn), y=S/(S+Se), solar cell performance figures-of-merit and bandgap for the reported champion devices per composition point. This table is used to generate the composition maps of efficiency and Shockley-Queisser (SQ) deficits in Figure 8, using the same colors as the symbols of the 4 different composition groups (Group 1 Ge-doping and Se-rich in blue, Group 2 Ge-doping and S-rich in purple, Group 3 Ge-moderate and Se-rich in white and Group 4 Pure-Ge in orange). The first column is the author-year and reference number as used in the main text. The SQ deficits are indicated between brackets, the minus sign meaning a measured figure-of-merit greater than the corresponding SQ limit and thus not shown on the maps in Figure 8.