www.sciencemag.org/content/352/6283/aad4424/suppl/DC1

Supplementary Materials for

Photovoltaic materials: Present efficiencies and future challenges

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Published 15 April 2016, *Science* **352**, aad4424 (2016)
DOI: 10.1126/science.aad4424

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Table S1

References

Material	tf/w	Lab/company	Eff.	J_{sc}	*Voc*	*FF*	*j*	*v*	*f*	E_g	Ref.	
			(%)	($mAcm^{-2}$)	(mV)		J_{sc}/J_{SQ}	V_{oc} / V_{SQ}	FF / FF_{SQ}	(eV)	Cell	E_g
GaAs	tf	Alta Devices	28.8	29.7	1.122	0.865	0.92	0.97	0.97	1.42	(*16*)	(*51*)
Si SHJ/IBC	w	Panasonic	25.6	41.8	0.740	0.827	0.96	0.84	0.95	1.12	(*12*)	(*52*)
Si IBC	w	SunPower	25.0	41.5	0.726	0.828	0.95	0.83	0.95	1.12	(*10*)	(*52*)
Si TOPCon	w	Fraunhofer	25.1	42.1	0.718	0.832	0.96	0.82	0.96	1.12	(*7*)	(*52*)
GaInP	w	NREL	20.8	16.0	1.455	0.893	0.82	0.96	0.98	1.81	(*19*)	(*19*)
InP	w	Spire	22.1	29.5	0.878	0.854	0.85	0.81	0.96	1.35	(*18*)	(*53*)
CuInGaSe/S	tf	ZSW Stuttgart	21.7	36.5	0.748	0.794	0.84	0.84	0.91	1.13	(*20*)	(*20*)
multicryst. Si	w	Trina Solar	21.3	39.8	0.668	0.803	0.91	0.76	0.92	1.12	(*11, 54*)	(*52*)
CdTe	tf	First Solar	21.0	30.3	0.876	0.794	0.96	0.75	0.89	1.43	(*22*)	(*9*)*
perovskite	tf	KRICT	20.1	22.5	1.100	0.732	0.88	0.83	0.81	1.60	(*24*)	(*24*)*
CuZnSnSe/S	tf	IBM	12.6	35.2	0.513	0.698	0.81	0.58	0.80	1.13	(*26*)	(*26*)
dye/TiO_2	tf	Sharp	11.9	22.5	0.744	0.712	0.78	0.60	0.79	1.50	(*27*)	(*55*)*
nanocryst. Si	tf	AIST	11.4	29.1	0.535	0.731	0.67	0.61	0.84	1.12	(*32*)	(*52*)
organic	tf	Toshiba	11.0	19.4	0.793	0.714	0.82	0.57	0.79	1.66	(*30*)	(*9*)
amorphous Si	tf	AIST	10.2	16.4	0.896	0.698	0.78	0.61	0.76	1.76	(*33*)	(*9*)*
quantum dots	tf	U Toronto	9.9	21.6	0.635	0.719	0.66	0.56	0.80	1.40	(*35*)	(*35*)

Table S1 | Performance parameters for record solar cells. Cells are grouped by the fraction of the S-Q detailed-balance efficiency limit achieved: >75% (blue), 50-75% (green), and <50% (red). tf=thin-film, w=wafer-based solar cell. *j, v,* and *f* are the short-circuit current, open-circuit voltage and fill factors normalized to maximum values according to the S-Q model: , $j=J_{sc}/J_{SQ}$, $v=V_{oc}/V_{SQ}$, $f=FF/FF_{SQ}$ using the listed band gap energies. Record efficiencies were all taken from Refs. (*9, 11*) except for dye/TiO_2 (ref. (*55*)) and quantum dots (Ref. (*35*)). Details on each record cell are given in the references under Ref.-Cell; references for the band gaps E_g used in the S-Q analysis are given under Ref.-E_g. *Indicates that E_g was derived from external quantum efficiency data in that reference using the method in Ref. (*56*); the fitting process yields an uncertainty on the order of ±10 meV. While new certified records have been reported for CdTe (21.5%, First Solar) (*21*), perovskite (21.0% EPFL (*9*)) and organic solar cells (11.5%, Hong Kong University), they are not analyzed here because detailed data are not yet available. Record cell efficiencies were measured for cells with an area >1 cm^2, with the exception of GaInP, CIGS, CZTS and perovskite (*9*). For updated values, see: http://lmpv.amolf.nl/SQ.

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