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ACCELERATED PUBLICATION

# Solar cell efficiency tables (version 42)

Martin A. Green[1]*, Keith Emery[2], Yoshihiro Hishikawa[3], Wilhelm Warta[4] and Ewan D. Dunlop[5]

[1] Australian Centre for Advanced Photovoltaics, University of New South Wales, Sydney, 2052, Australia
[2] National Renewable Energy Laboratory, 15013 Denver West Parkway, Golden, CO, 80401, USA
[3] National Institute of Advanced Industrial Science and Technology (AIST), Research Center for Photovoltaics (RCPV), Central 2, Umezono 1-1-1, Tsukuba, Ibaraki 305-8568, Japan
[4] Fraunhofer Institute for Solar Energy Systems, Solar Cells—Materials and Technology Department, Heidenhofstr. 2, D-79110 Freiburg, Germany
[5] European Commission—Joint Research Centre, Renewable Energy Unit, Institute for Energy, Via E. Fermi 2749, IT-21027 Ispra, (VA), Italy

## ABSTRACT

Consolidated tables showing an extensive listing of the highest independently confirmed efficiencies for solar cells and modules are presented. Guidelines for inclusion of results into these tables are outlined, and new entries since January 2013 are reviewed. Copyright © 2013 John Wiley & Sons, Ltd.

**KEYWORDS**
solar cell efficiency; photovoltaic efficiency; energy conversion efficiency

***Correspondence**
Martin A. Green, Australian Centre for Advanced Photovoltaics, University of New South Wales, Sydney, 2052, Australia.
E-mail: m.green@unsw.edu.au

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## 1. INTRODUCTION

Since January 1993, 'Progress in Photovoltaics' has published six monthly listings of the highest confirmed efficiencies for a range of photovoltaic cell and module technologies [1–3]. By providing guidelines for the inclusion of results into these tables, this not only allows an authoritative summary of the current state of the art but also encourages researchers to seek independent confirmation of results and to report results on a standardised basis. In version 33 of these tables [2], results were updated to the new internationally accepted reference spectrum (IEC 60904-3, Ed. 2, 2008), where this was possible.

The most important criterion for inclusion of results into the tables is that they must have been independently measured by a recognised test centre listed elsewhere [1]. A distinction is made between three different eligible definitions of cell area: total area, aperture area and designated illumination area, as also defined elsewhere [1]. 'Active area' efficiencies are not included. There are also certain minimum values of the area sought for the different device types (above 0.05 $cm^2$ for a concentrator cell, 1 $cm^2$ for a one-sun cell and 800 $cm^2$ for a module).

Results are reported for cells and modules made from different semiconductors and for subcategories within each semiconductor grouping (e.g. crystalline, polycrystalline and thin film). From version 36 onwards, spectral response information is included when available in the form of a plot of the external quantum efficiency (EQE) versus wavelength, either as absolute values or normalised to the peak measured value. Current–voltage (I–V) curves have also been included where possible from version 38 onwards.

## 2. NEW RESULTS

Highest confirmed 'one-sun' cell and module results are reported in Tables I and II. Any changes in the tables from those previously published [3] are set in bold type. In most cases, a literature reference is provided that describes either the result reported or a similar result (readers identifying improved references are welcome to submit to the lead author). Table I summarises the best measurements for cells and submodules, whereas Table II shows the best results for modules. Table III contains what might be

 

**Table I.** Confirmed terrestrial cell and submodule efficiencies measured under the global AM1.5 spectrum (1000 W/m$^2$) at 25 °C (IEC 60904-3: 2008, ASTM G-173-03 global).

| Classification[a] | Efficiency (%) | Area[b] (cm$^2$) | $V_{oc}$ (V) | $J_{sc}$ (mA/cm$^2$) | Fill factor (%) | Test centre[c] (date) | Description |
|---|---|---|---|---|---|---|---|
| Silicon | | | | | | | |
| Crystalline | 25.0 ± 0.5 | 4.00 (da) | 0.706 | 42.7[d] | 82.8 | Sandia (3/99)[e] | UNSW PERL [18] |
| Multicrystalline | 20.4 ± 0.5 | 1.002 (ap) | 0.664 | 38.0 | 80.9 | NREL (5/04)[e] | FhG-ISE [19] |
| Thin-film transfer | 20.1 ± 0.4 | 242.6 (ap) | 0.682 | 38.14[f] | 77.4 | NREL (10/12) | Solexel (43-μm thick) [20] |
| Thin-film submodule | 10.5 ± 0.3 | 94.0 (ap) | 0.492[g] | 29.7[g] | 72.1 | FhG-ISE (8/07)[e] | CSG Solar (1–2 μm on glass; 20 cells) [21] |
| III–V cells | | | | | | | |
| GaAs (thin-film) | 28.8 ± 0.9 | 0.9927 (ap) | 1.122 | 29.68[h] | 86.5 | NREL (5/12) | Alta Devices [22] |
| GaAs (multicrystalline) | 18.4 ± 0.5 | 4.011 (t) | 0.994 | 23.2 | 79.7 | NREL (11/95)[e] | RTI, Ge substrate [23] |
| InP (crystalline) | 22.1 ± 0.7 | 4.02 (t) | 0.878 | 29.5 | 85.4 | NREL (4/90)[e] | Spire, epitaxial [24] |
| Thin-film chalcogenide | | | | | | | |
| CIGS (cell) | 19.6 ± 0.6[i] | 0.996 (ap) | 0.713 | 34.8[j] | 79.2 | NREL (4/09) | NREL, on glass [25] |
| CIGS (submodule) | 17.4 ± 0.5 | 15.993 (da) | 0.6815[g] | 33.84[g] | 75.5 | FhG-ISE (10/11) | Solibro, four serial cells [26] |
| **CdTe (cell)** | **19.6 ± 0.4** | **1.0055 (ap)** | **0.8573** | **28.59**[k] | **80.0** | **Newport (6/13)** | **GE Global Research** [4] |
| Amorphous/nanocrystalline Si | | | | | | | |
| Si (amorphous) | 10.1 ± 0.3[l] | 1.036 (ap) | 0.886 | 16.75[d] | 67.8 | NREL (7/09) | Oerlikon Solar Lab, Neuchatel [27] |
| **Si (nanocrystalline)** | **10.7 ± 0.2** | **1.044 (da)** | **0.549** | **26.55**[k] | **73.3** | **FhG-ISE (12/12)** | **EPFL, Neuchatel (1.8 μm on glass)** [5] |
| Photochemical | | | | | | | |
| Dye sensitised | 11.9 ± 0.4[m] | 1.005 (da) | 0.744 | 22.47[f] | 71.2 | AIST (9/12) | Sharp [28] |
| Dye sensitised (submodule) | 9.9 ± 0.4[m] | 17.11 (ap) | 0.719[g] | 19.4[g,k] | 71.4 | AIST (8/10) | Sony, eight parallel cells [29] |
| Organic | | | | | | | |
| Organic thin-film | 10.7 ± 0.3[m] | 1.013 (da) | 0.872 | 17.75[f] | 68.9 | AIST (10/12) | Mitsubishi Chemical (4.4 × 23.0 mm)[30] |
| **Organic (submodule)** | **8.2 ± 0.3**[m] | **24.99 (da)** | **0.797**[g] | **15.17**[g,k] | **67.6** | **AIST (1/13)** | **Toshiba, four serial cells** [6] |
| Multijunction devices | | | | | | | |
| **InGaP/GaAs/InGaAs** | **37.9 ± 1.2** | **1.047 (ap)** | **3.065** | **14.27**[l] | **86.7** | **AIST (2/13)** | **Sharp** [8] |
| a-Si/nc-Si/nc-Si (thin-film) | 13.4 ± 0.4[n] | 1.006 (ap) | 1.963 | 9.52[f] | 71.9 | NREL (7/12) | LG Electronics [31] |
| a-Si/nc-Si (thin-film cell) | 12.3 ± 0.3[o] | 0.962(ap) | 1.365 | 12.93[p] | 69.4 | AIST (7/11) | Kaneka [32] |
| a-Si/nc-Si (thin-film submodule) | 11.7 ± 0.4[q,r] | 14.23 (ap) | 5.462 | 2.99 | 71.3 | AIST (9/04) | Kaneka [33] |

UNSW, University of New South Wales; EPFL, École Polytechnique Fédérale de Lausanne.

[a]CIGS, CuInGaSe2; a-Si, amorphous silicon/hydrogen alloy; nc-Si, nanocrystalline or microcrystalline silicon.

described as 'notable exceptions'. Although not conforming to the requirements to be recognised as a class record, the cells and modules in this table have notable characteristics that will be of interest to sections of the photovoltaic community, with entries based on their significance and timeliness.

To encourage discrimination, Table III is limited to nominally 10 entries with the present authors having voted for their preferences for inclusion. Readers who have suggestions of results for inclusion into this table are welcome to contact any of the authors with full details. Suggestions conforming to the guidelines will be included on the voting list for a future issue.

Table IV shows the best results for concentrator cells and concentrator modules (a smaller number of 'notable exceptions' for concentrator cells and modules additionally are included in Table IV).

Thirteen new results are reported in the present version of these tables. The first new result in Table I is a very recent result, the demonstration of 19.6% efficiency for a 1-cm$^2$ CdTe cell fabricated by GE Global Research [4] and measured by the Newport Technology and Application Center. This is a significant improvement upon the previous best efficiency of 18.3% for a CdTe cell of this size and equals the outright record for any polycrystalline thin-film cell. This remains the most efficient CdTe cell above the minimum area (1 cm$^2$) deemed reasonable for inter-technology comparisons.

The second new cell result in Table I is an improvement in the performance of a 1-cm$^2$ nanocrystalline (sometimes called microcrystalline) silicon solar cell to 10.7%, significantly improving upon one of the oldest results in these tables. The cell was fabricated by École Polytechnique Fédérale de Lausanne (EPFL) [5] and measured at the Fraunhofer Institute for Solar Energy Systems (FhG-ISE).

A third new result in Table I is an improvement in efficiency to 8.2% for a 25-cm$^2$ organic cell submodule fabricated by Toshiba [6] and measured by the Japanese National Institute of Advanced Industrial Science and Technology (AIST). Along with other emerging technology devices, the stability of this device was not investigated, although the stability of earlier devices is reviewed elsewhere [7]. This improves upon the 6.8% result for a much larger submodule (396 cm$^2$) also reported by Toshiba in the previous issue of these tables [3].

A fourth major new result in Table I is a new record for energy conversion efficiency for any photovoltaic converter that does not use sunlight concentration. An efficiency of 37.9% is reported for a 1-cm$^2$ InGaP/GaAs/InGaAs monolithic multijunction cell fabricated by Sharp [8] and again measured at AIST.

The first new result in Table II is a new record for a large area silicon module. An efficiency of 22.4% is reported for a 1.6-m$^2$ silicon module fabricated by SunPower [9] and measured by NREL. A SunPower representative described this as a standard commercial module that "would be on someone's roof" if it had not been sent to NREL for calibration.

[b] (ap), aperture area; (t), total area; (da), designated illumination area.
[c] FhG-ISE, Fraunhofer Institut für Solare Energiesysteme; AIST, Japanese National Institute of Advanced Industrial Science and Technology; NREL, National Renewable Energy Laboratory.
[d] Spectral response reported in version 36 of these tables.
[e] Recalibrated from original measurement.
[f] Spectral response and current–voltage curve reported in version 41 of these tables.
[g] Reported on a 'per cell' basis.
[h] Spectral response and current–voltage curve reported in version 40 of these tables.
[i] Not measured at an external laboratory.
[j] Spectral response reported in version 37 of these tables.
[k] Spectral response and current–voltage curve reported in the present version of these tables.
[l] Light soaked at Oerlikon prior to testing at NREL (1000 h, one sun, 50 °C).
[m] Stability not investigated. References 7, 34 and 35 review the stability of similar devices.
[n] Light soaked under 100 mW/cm$^2$, white light at 50 °C for over 1000 h.
[o] Stabilised by manufacturer.
[p] Spectral response and current–voltage curve reported in version 39 of these tables.
[q] Stabilised by 174 h, one-sun illumination after 20 h, five-sun illumination at a sample temperature of 50 °C.
[r] Measured under IEC 60904-3 Ed. 1: 1989 reference spectrum.

**Table II.** Confirmed terrestrial module efficiencies measured under the global AM1.5 spectrum (1000 W/m2) at a cell temperature of 25 °C (IEC 60904-3: 2008, ASTM G-173-03 global).

| Classification[a] | Efficiency (%) | Area[b] ($cm^2$) | $V_{oc}$ (V) | $I_{sc}$ (A) | Fill factor (%) | Test centre (date) | Description |
|---|---|---|---|---|---|---|---|
| Si (crystalline) | 22.9 ± 0.6 | 778 (da) | 5.60 | 3.97 | 80.3 | Sandia (9/96)[c] | UNSW/Gochermann [36] |
| **Si (large crystalline)** | **22.4 ± 0.6** | **15 775 (ap)** | **69.57** | **6.341**[d] | **80.1** | **NREL (8/12)** | **SunPower** [9] |
| Si (multicrystalline) | 18.5 ± 0.4 | 14 661 (ap) | 38.97 | 9.149[e] | 76.2 | FhG-ISE (1/12) | Q-Cells (60 serial cells) [37] |
| Si (thin-film polycrystalline) | 8.2 ± 0.2 | 661(ap) | 25.0 | 0.320 | 68.0 | Sandia (7/02)[c] | Pacific Solar (1–2 μm on glass) [38] |
| | | | | | | | |
| GaAs (thin-film) | 24.1 ± 1.0 | 858.5 (ap) | 10.89 | 2.255[f] | 84.2 | NREL (11/12) | Alta Devices [39] |
| **CdTe (thin-film)** | **16.1 ± 0.5** | **7200 (t)** | **68.68** | **2.252**[d] | **74.8** | **NREL (2/13)** | **First Solar, monolithic** [10] |
| CIGS (thin-film) | 15.7 ± 0.5 | 9703 (ap) | 28.24 | 7.254[g] | 72.5 | NREL (11/10) | Miasole [40] |
| CIGSS (Cd-free) | 13.5 ± 0.7 | 3459 (ap) | 31.2 | 2.18 | 68.9 | NREL (8/02)[c] | Showa Shell [41] |
| a-Si/a-SiGe/nc-Si (tandem) | 10.5 ± 0.4[h] | 14 316 (t) | 224.3 | 0.991 | 67.9 | AIST (9/12)[e] | LG Electronics [31] |

NREL, National Renewable Energy Laboratory; FhG-ISE, Fraunhofer Institut für Solare Energiesysteme; AIST, Japanese National Institute of Advanced Industrial Science and Technology; UNSW, University of New South Wales.

[a]CIGSS, CuInGaSSe; a-Si, amorphous silicon/hydrogen alloy; a-SiGe, amorphous silicon/germanium/hydrogen alloy; nc-Si, nanocrystalline or microcrystalline silicon.

[b](t), total area; (ap), aperture area; (da), designated illumination area.

[c]Recalibrated from original measurement.

[d]Spectral response and current–voltage curve reported in the present version of these tables.

[e]Spectral response and/or current–voltage curve reported in version 40 of these tables.

[f]Spectral response and current–voltage curve reported in version 41 of these tables.

[g]Spectral response reported in version 37 of these tables.

[h]Stabilised at the manufacturer under the light-soaking conditions of IEC61646.

**Table III.** 'Notable exceptions': 'top ten' confirmed cell and module results, not class records measured under the global AM1.5 spectrum (1000 W/m$^{-2}$) at 25 °C (IEC 60904-3: 2008, ASTM G-173-03 global).

| Classification[a] | Efficiency (%) | Area[b] (cm$^2$) | $V_{oc}$ (V) | $J_{sc}$ (mA/cm$^2$) | Fill factor (%) | Test centre (date) | Description |
|---|---|---|---|---|---|---|---|
| Cells (silicon) | | | | | | | |
| **Si (large crystalline)** | **24.7 ± 0.5** | **101.8 (t)** | **0.750** | **39.5**[c] | **83.2** | **AIST (12/12)** | **Panasonic HIT, n-type** [11] |
| Si (large crystalline) | 24.2 ± 0.7 | 155.1 (t) | 0.721 | 40.5[d] | 82.9 | NREL (5/10) | Sunpower n-type CZ substrate [42] |
| Si (large multicrystalline) | 19.5 ± 0.4 | 242.7 (t) | 0.652 | 39.0[d] | 76.7 | FhG-ISE (3/11) | Q-Cells, laser fired contacts [43] |
| Cells (other) | | | | | | | |
| **GaInP** | **20.8 ± 0.6** | **0.2491 (ap)** | **1.4550** | **16.04**[c] | **89.3** | **NREL (5/13)** | **NREL, high bandgap** [12] |
| **CIGS (thin-film)** | **20.4 ± 0.6** | **0.5203 (ap)** | **0.7363** | **35.08** | **78.9** | **FhG-ISE (9/12)** | **EMPA, flexible CIGS on polymide** |
| **CIGSS (Cd-free)** | **19.7 ± 0.5** | **0.496 (da)** | **0.683** | **37.06**[c] | **77.8** | **AIST (11/12)** | **Showa Shell/Tokyo U. of Science** [13] |
| CZTSS (thin-film) | 11.1 ± 0.3 | 0.4496 (ap) | 0.4598 | 34.54[e] | 69.8 | Newport (2/12) | IBM solution grown [44] |
| **CZTS (thin-film)** | **8.5 ± 0.2**[f] | **0.2382 (da)** | **0.708** | **16.83**[c] | **70.9** | **AIST (1/13)** | **Toyota Central R&D Laboratories** [15] |
| **Perovskite (thin-film)** | **14.1 ± 0.3** | **0.2090 (ap)** | **1.007** | **21.34**[c] | **65.7** | **Newport (5/13)** | **EPFL**[16,45] |
| Organic (thin-film) | 11.1 ± 0.3[f] | 0.159 (ap) | 0.867 | 17.81[g] | 72.2 | AIST (10/12) | Mitsubishi Chemical [30] |
| Luminescent submodule | 7.1 ± 0.2 | 25(ap) | 1.008 | 8.84[d] | 79.5 | ESTI (9/08) | ECN Petten, GaAs cells [46] |

AIST, Japanese National Institute of Advanced Industrial Science and Technology; NREL, National Renewable Energy Laboratory; FhG-ISE, Fraunhofer Institut für Solare Energiesysteme; ESTI, European Solar Test Installation.

[a]CIGSS, CuInGaSSe; CZTSS, $Cu_2ZnSnS_{4-y}Se_y$; CZTS, $Cu_2ZnSnS_4$

[b](ap), aperture area; (t), total area; (da), designated illumination area.

[c]Spectral response and current–voltage curves reported in the present version of these tables.

[d]Spectral response reported in version 37 of these tables.

[e]Spectral response and current–voltage curves reported in version 39 of these tables.

[f]Stability not investigated.

[g]Spectral response and current–voltage curves reported in version 41 of these tables.

**Table IV.** Terrestrial concentrator cell and module efficiencies measured under the ASTM G-173-03 direct beam AM1.5 spectrum at a cell temperature of 25 °C.

| Classification | Efficiency (%) | Area[a] ($cm^2$) | Intensity[b] (suns) | Test centre (date) | Description |
|---|---|---|---|---|---|
| Single cells | | | | | |
| GaAs | 29.1 ± 1.3[c,d] | 0.0505 (da) | 117 | FhG-ISE (3/10) | FhG-ISE |
| Si | 27.6 ± 1.0[e] | 1.00 (da) | 92 | FhG-ISE (11/04) | Amonix back-contact [47] |
| Multijunction cells (monolithic) | | | | | |
| **InGaP/GaAs/InGaAs** | **44.4 ± 2.6**[f] | **0.1652 (da)** | **302** | **FhG-ISE (4/13)** | **Sharp, inverted metamorphic** [17] |
| Submodule | | | | | |
| GaInP/GaAs; GaInAsP/GaInAs | 38.5 ± 1.9[g] | 0.202 (ap) | 20 | NREL (8/08) | DuPont *et al.*, split spectrum [48] |
| Modules | | | | | |
| Si | 20.5 ± 0.8[c] | 1875 (ap) | 79 | Sandia (4/89)[h] | Sandia/UNSW/ENTECH (12 cells) [49] |
| Triple junction | 33.5 ± 0.5[i] | 10 674.8 (ap) | N/A | NREL (5/12) | Amonix [50] |
| 'Notable exceptions' | | | | | |
| Si (large area) | 21.7 ± 0.7 | 20.0 (da) | 11 | Sandia (9/90)[h] | UNSW laser grooved [51] |

FhG-ISE, Fraunhofer Institut für Solare Energiesysteme; NREL, National Renewable Energy Laboratory; UNSW, University of New South Wales.

[a](da), designated illumination area; (ap), aperture area.

[b]One sun corresponds to direct irradiance of 1000 $W/m^{-2}$.

[c]Not measured at an external laboratory.

[d]Spectral response reported in version 36 of these tables.

[e]Measured under a low aerosol optical depth spectrum similar to ASTM G-173-03 direct[52].

[f]Spectral response and current–voltage curve reported in present version of these tables.

[g]Spectral response reported in version 37 of these tables.

[h]Recalibrated from original measurement.

[i]Based on ASTM E2527 rating, May 2012 (850 $W/m^2$ direct irradiance, 20 °C ambient, 4 m/s wind speed).



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The second new result reported in Table II is a record for any polycrystalline thin-film module, with 16.1% total area efficiency reported for a 0.72-m$^2$ CdTe module fabricated by First Solar [10] and again measured at NREL. Notable features of this result are that the efficiency is reported on a total area basis (includes the largely inactive isolation area around the edge of the module) and that the module is monolithic (some thin-film approaches allow pre-selection of the cells included in the module, which somewhat reduces the challenge in producing high-efficiency modules).

Several new ‘notable exceptions’ are reported in Table III. The first is a new efficiency record for a large-area silicon cell with 24.7% efficiency reported for a 102-cm$^2$ HIT cell (Heterojunction with Intrinsic Thin-layer cell) fabricated on an n-type silicon wafer substrate by Panasonic [11] and measured by AIST.

The second new result in Table III is 20.8% efficiency for a small area (0.25 cm$^2$) crystalline GaInP cell fabricated and measured by NREL. The notable feature of this cell is the high efficiency for such a high-bandgap material (1.80 eV), evidence for a high radiative efficiency [12].

The third new result is 20.4% efficiency for a small area (0.52 cm$^2$) flexible $CuIn_xGa_{1-x}Se_2$ (CIGS) cell developed by EMPA, the Swiss Federal Laboratory for Materials Science and Technology, and measured at FhG-ISE. This is the highest confirmed efficiency for any CIGS cell, although the cell area is too small for consideration as an outright record.

A fourth new result in Table III is 19.7% efficiency for a small area (0.5 cm$^2$) $CuIn_xGa_{1-x}S_ySe_{2-y}$ cell fabricated by Showa Shell Sekiyu K.K. and the Tokyo University of Science [13] and measured by AIST. The notable feature of this result is that the cell is Cd-free, allowing it to comply with legislation such as the European Restriction on Hazardous Substances [14].

The fifth new result in Table III relates to an efficiency increase to 8.5% for a small area (0.24 cm$^2$) pure sulphide CZTS (copper tin zinc sulphide) solar cell fabricated by

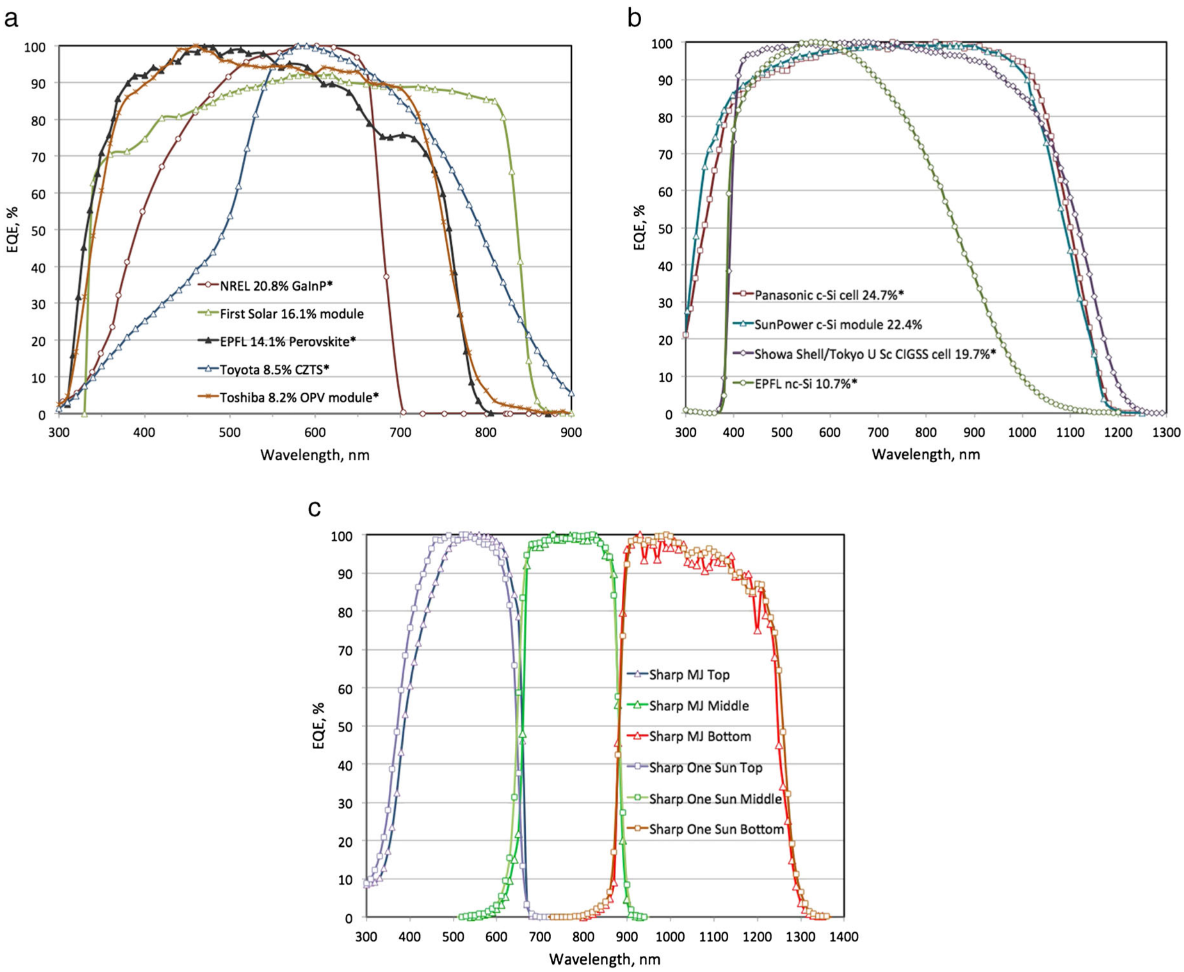


**Figure 1.** (a) External quantum efficiency (EQE) for the new GaInP, CdTe, CZTS and perovskite cell as well as for the CdTe module and the organic submodule results in this issue, (b) EQE for the new silicon cell and module entries in this issue, as well as for the new CIGSS cell result, and (c) EQE for two new III–V multijunction cells in this issue (* indicates normalised value; other values are absolute values).

Toyota Central R&D Laboratories [15] and measured at AIST. This cell is also much smaller than the 1-$cm^2$ size required for consideration as an outright record.

The final new result in Table III introduces a new cell type into these Tables, the perovskite cell which has evolved from research into dye-sensitised cells. Recent good results have been reported using the perovskite methylammonium triiodideplumbate ($CH_3NH_3PbI_3$) as the absorber and transport layer [16]. An efficiency of 14.1% has subsequently been confirmed for a small area cell (0.2-$cm^2$) fabricated by EPFL and measured at the Newport Technology and Application Center, again too small to be classified as an outright record. The rapid rate of increase in performance over recent months for this device suggests that the full efficiency potential remains untapped. The high Pb content of the above-mentioned perovskite (33%) means that devices based on this material would not comply with legislation such as the European ROHS [14] without an exemption or exclusion, such as presently does exist for photovoltaic systems.

Table IV reports one new result for concentrator cells. A new record of 44.4% for the conversion of sunlight by any means is reported for a 0.165-$cm^2$ multijunction cell operating at a concentration of 302 suns (direct irradiance of 302 $kW/m^2$). The cell is an InGaP/GaAs/InGaAs triple junction device fabricated by Sharp [17] and measured at FhG-ISE.

The EQE for the new CZTS, GaInP and perovskite cell, the new CdTe module as well as for the organic submodule results are shown in Figure 1(a). Figure 1(b) shows the EQE for the new silicon cell and module results reported in the present issue of these tables. Figure 1(c) shows the EQE for two of the new III–V multijunction cell results.

Figure 2 shows the current density–voltage (J–V) curves for the corresponding devices. For the case of

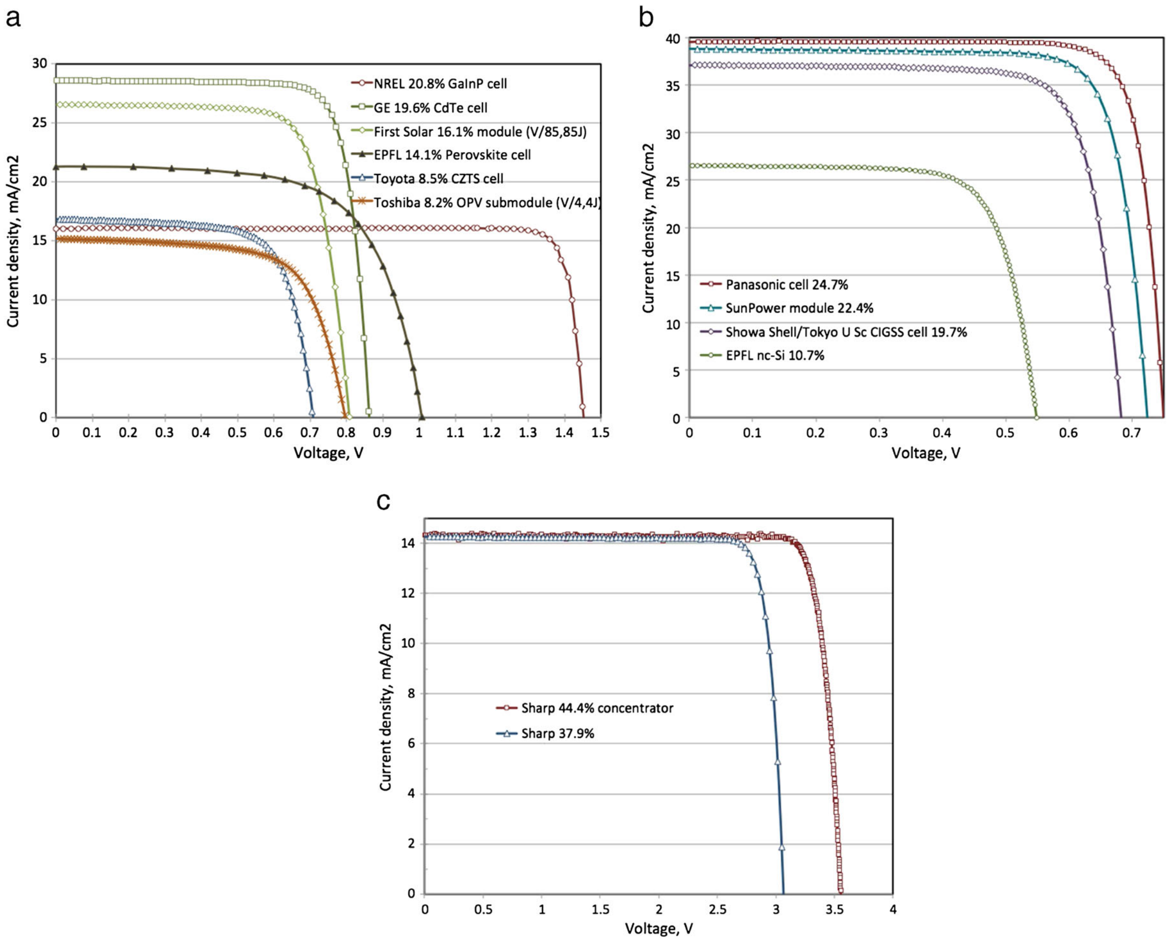


**Figure 2.** (a) Current density–voltage (J–V) curve for the new GaInP, CdTe, CZTS and perovskite cells and CdTe module results, as well as for the organic submodule results in this issue, (b) J–V curves for the new silicon and module entries in this issue, as well as for the new CIGSS cell result, and (c) J–V curves for the new multijunction cell results in this issue (for the concentrator cell, the current density is normalised to an irradiance of 1 $kW/m^2$).

modules, the measured current–voltage data has been reported on a ‘per cell’ basis (measured voltage has been divided by the known or estimated number of cells in series, whereas measured current has been multiplied by this quantity and divided by the module area). For the concentrator cell, the current density has been normalised by the sunlight concentration ratio.

## 3. DISCLAIMER

Although the information provided in the tables is provided in good faith, the authors, editors and publishers cannot accept direct responsibility for any errors or omissions.

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