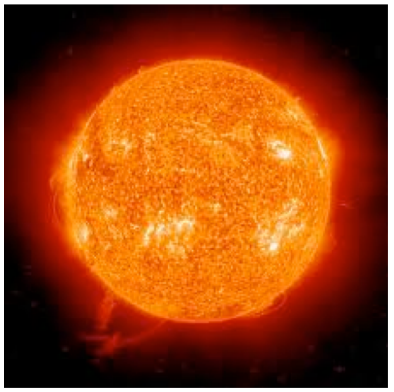
The Energy Solution: SunCell®

- Continuous power source, developed with proprietary technology
- Non-polluting: by-product is harmless lower energy state of hydrogen called Hydrino®, lighter than air, vents to space
- System is sealed with H_2O fuel injected with recirculated silver or gallium, absolutely safe materials and operation
- Capital cost estimated at $50 per kW at production power & scale, versus $3,463 for solar
- No Metering: Electricity sold at about $0.05 per kWh via a per diem lease fee.
- Low operating cost, only consumable is minimal amounts of water
- Scalable from 10kW to 10 MWs
- Initially heating applications, stationary electric, developing to motive



SunCell Economics

- Current Annual Gross Earning Capacity of Any Electrical Generator:
  - $1/W
- Capital Cost:
  - $60/kW
- Life Span:
  - 20 years
- Capital Cost Annually:
  - $3/kW
- Solar Capital Cost (2013):
  - $3,463/kW[a]
- Maintenance Cost:
  - $1.20/kW
- Generation Cost:
  - $0.001/kWh

[a] http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html

SunCell® CPV Cost Drops Dramatically with Scale

- For SunCell units of ~>100 kW, the cost per kW is essentially that of the PV converter component.
- At a volume of ~100 MW/yr, the SunCell® CPV converter is estimated to cost less than $75 per kW (2000 Suns concentration, 30% efficiency) and less than $20 per kW (10,000 Suns concentration)
- At 10 GW annual production which is equivalent to the global annual deployment of c-Si solar, the cost of SunCell® CPV converter is estimated to cost less than $32 per kW (2000 Suns concentration) and less than $6 per kW (10,000 Suns concentration)

(Kelsey Horowitz, "A Bottom-up Cost Analysis of a High Concentration PV Module", CPV-11, 2015; NREL/PR-6A20-63947)

Solar Power

Solar cells have been optimized over five decades at a cost of more than one trillion dollars to convert sunlight into electricity. The capital cost of solar power is high due to the low power density of sunlight at the Earth's surface. Acres of land need be covered by panels to harvest a meaningful amount of power; thus, the appropriate namesake: "solar farm".

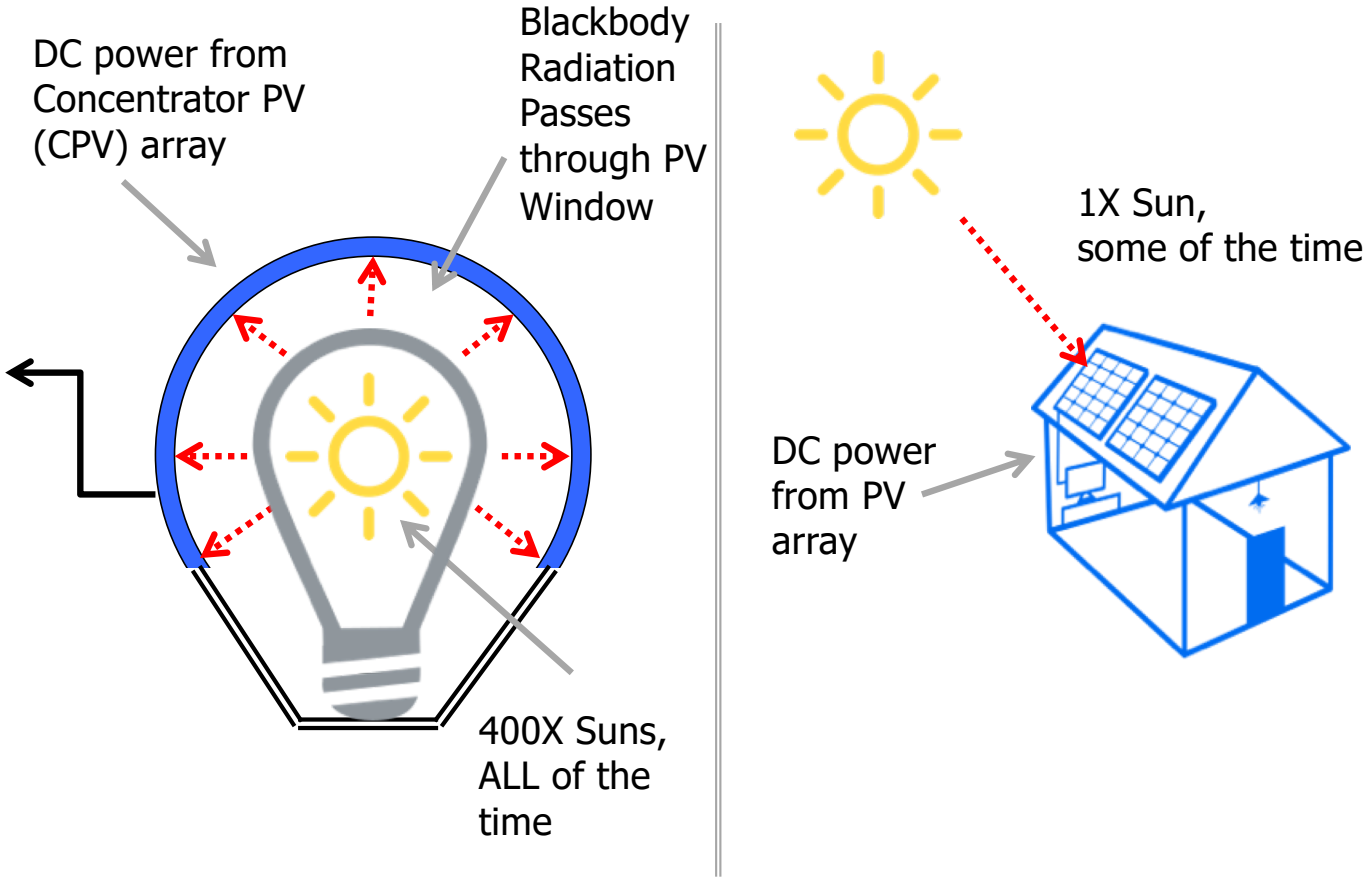
Jasper Power Project, South Africa's Northern Cape
96 MW on 247 acres (about 1 million m^2)

Solar Power

To reduce costs by reducing the solar panel coverage area, less-expensive sunlight concentrators are employed to increase the sunlight intensity to a thousand times natural intensity. Concentrator solar cells typically comprise three layers or junctions engineered to be responsive to a selected wavelength region of the Sun's spectral emission such that the triplet set covers a substantial portion of the total emission, and the conversion efficiency is greater with higher concentration.

Due to the same low incident light concentration from the Sun, the typical scale is 100 MW on 250 acres (about 1 million m^2)

SunCell® vs Solar PV

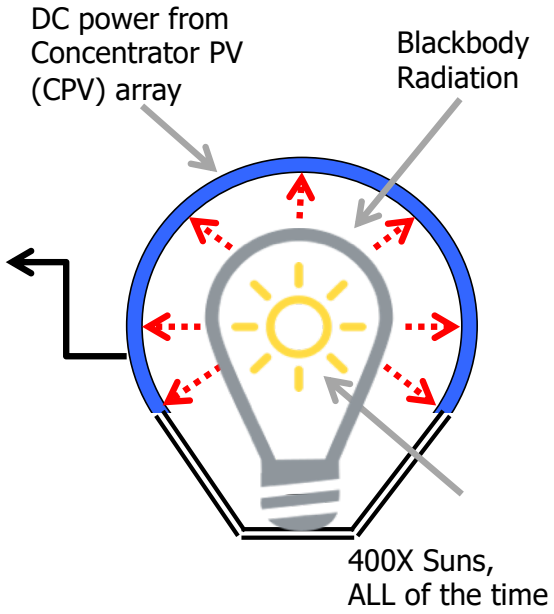


Product Development Foundation

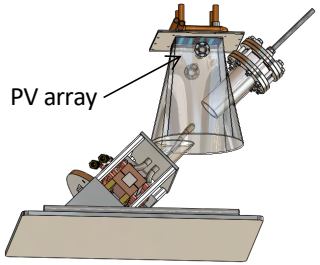
- SunCell blackbody radiation resembles the emission of the Sun
- Blackbody temperature is adjusted to more closely match the response spectrum of commercial PV
- Rapid, low cost development approach

Established Foundation

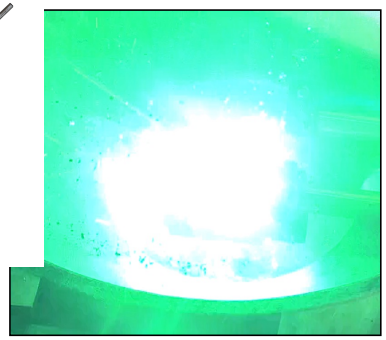
- Theory solved, IP filings
- Light source demonstrated
  - Internally certified
  - Externally certified
- Advanced thermophotovoltaic (CPV)
  - Suppliers selected
  - CPV cell design
  - Dense receiver array design
- SunCell radiator design
- Costed bill of materials
- Continuous Llght source prototypes



Spectral Emission in the High Energy Region Only

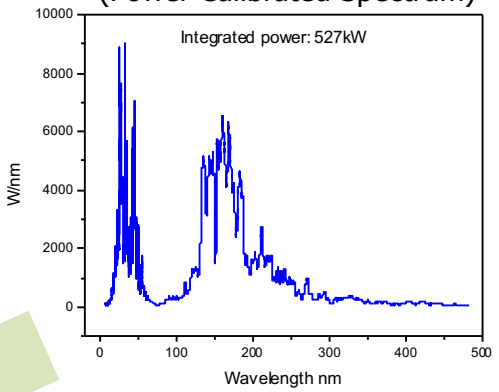


Plasma Ignition

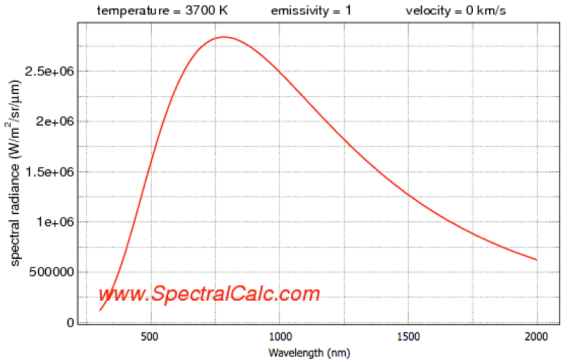


Measurement

Plasma Emission
(Power Calibrated Spectrum)



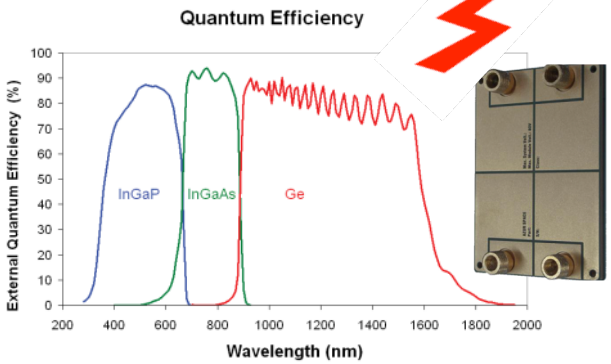
Cell gas absorb to BB



SunCell Blackbody Radiation

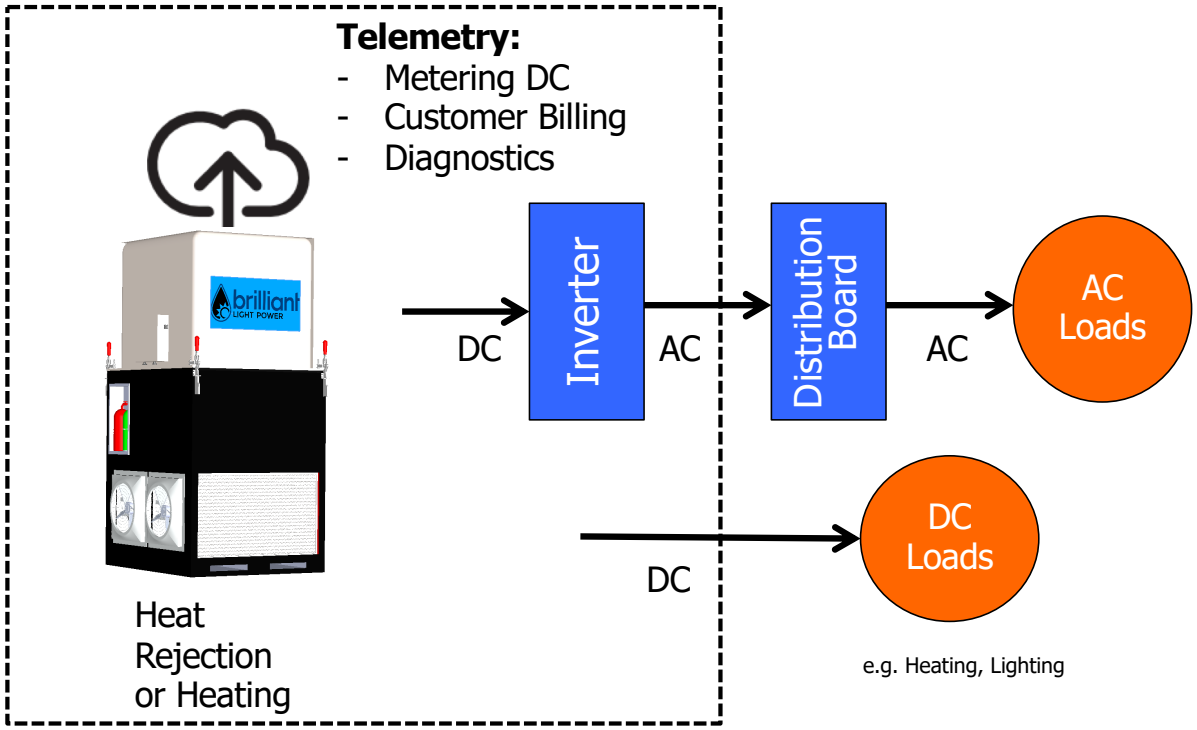
Re-emit to CPV

DC Power



Concentrator PV
Power Conversion Spectrum

SunCell Turnkey System (Basic)



The SunCell® can support either direct DC loads or AC loads with the addition of standard inverter technology as used by the solar industry today.

SunCell® vs Solar PV

An autonomous SunCell operating at up to 10,000 Suns requires 75,000 times less area and complexity than a matched conventional solar power station.

SunCell

11 MW

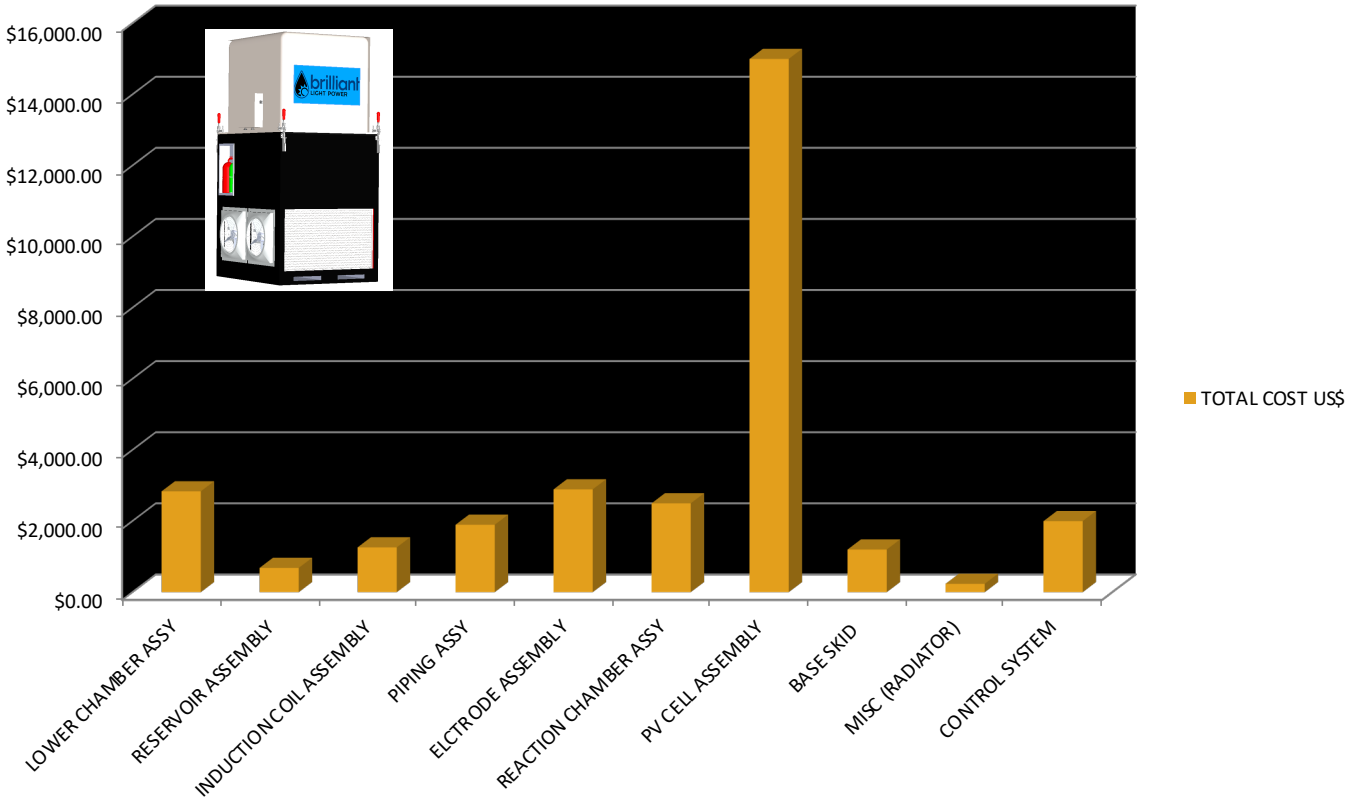
1 m^2

Planta Solar 10, Sevilla, Spain

11 MW

75,000 m^2 (nrel.gov)

250 kW COST ANALYSIS FOR EACH ASSEMBLY



COST ANALYSIS FOR FIRST OF A KIND 250KW (2000 Suns)

DESCRIPTION	TOTAL COST US$
LOWER CHAMBER ASSY	$2,837.60
RESERVOIR ASSEMBLY	$684.17
INDUCTION COIL ASSEMBLY	$1,261.00
PIPING ASSY	$1,897.00
ELCTRODE ASSEMBLY	$2,893.00
REACTION CHAMBER ASSY	$2,500.00
PV CELL ASSEMBLY	$15,000.00
BASE SKID	$1,200.00
MISC (RADIATOR)	$236.00
CONTROL SYSTEM	$2,000.00
TOTAL COST	**$30,508.77**

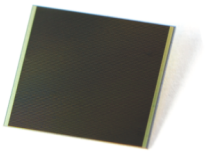
Triple Junction CPV Cell

DRAFT - NOT FOR RELEASE

Solar Junction

DATA SHEET
SJ3 CPV CELL

SOLAR JUNCTION High Performance CPV Cells with 42.0% Mean Production Efficiency provide the highest efficiency solution for CPV systems. Solar Junction's single crystal structure, made with our proprietary material technology, ensures reliable superior performance throughout the lifetime of the CPV system. Specific system needs can be addressed on request through custom modifications designed by Solar Junction's in-house engineering and manufacturing teams.



FEATURES AND CHARACTERISTICS

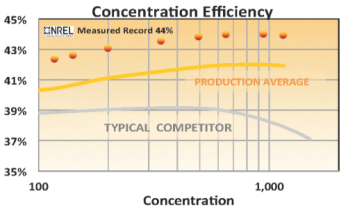
- Sustained efficiency at very high concentrations
- Fully lattice matched single crystal structure for reliable operation
- Silver metallization with gold finish front and back contacts
- Anti-reflective coating (ARC) matched to glass
- Rapid custom design available to meet your needs - all engineering in-house
- 100% flash testing available

SJ3-55 AVERAGE VALUES

100W/cm², 25° C, ASTM G173-03
AM1.5D DNI + Circumsolar Spectrum

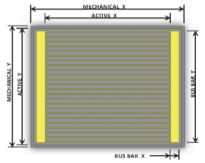
Parameter	Typical Value
Eff.	42.0 %
Eff. Sigma	0.5%
P_{max}	13.1 W
I_{sc}	4.35 A
V_{oc}	3.50V
FF	86 %

Parameter	Thermal Coefficient
Eff.	-0.055% abs./°C
V_{oc}	-4.5mV/°C



FORM FACTORS

Standard Prod. Type	Aperture (mm)	Active Area (mm²)	Mechanical (mm)	Busbar (mm)
SJ3-55	5.5 x 5.5	30.25	6.17 x 5.62	0.25 x 5.46
Other sizes available on request				



Solar Junction Corporation
401 Charcot Avenue, San Jose CA 95131 www.sj-solar.com TEL: 1.408.503.7000
Rev: Oct., 2012

Triple Junction CPV Dense Array

AZURSPACE SOLAR POWER GMBH

Advanced Dense Array Module (ADAM)
Product Type: Concentrator Triple Junction Solar Cell Module – 3C30M
Application: Concentrating Photovoltaic (CPV) Sytem for Dish Application

General

AZUR SPACE's **A**dvanced **D**ense **A**rray **M**odule (ADAM) is intended to be used in HCPV receivers with reflective optics, e.g. parabolic mirrors. It consists of a two-dimensional array of high efficiency solar cells mounted on a cooling element. Electrical protection of solar cells against reverse voltage is provided by bypass diodes. The solar cells and diodes within ADAM are completely interconnected and only electrical connection to the external circuitry and connection to cooling system shall be provided by system integrator. For requested thermal management of the module, an active liquid cooling system is necessary. The ADAM module has to be protected against all environmental influences (e.g. water, humidity, dust, pollution, etc.).

Design and Mechanical Data

Base Solar Cell Material	GaInP/GaAs/Ge on Ge substrate
Base Cooler Material	Copper and AlN Ceramic
AR Coating Solar Cell	TiO_x/Al_2O_x
Module Size	17,8 cm x 12,7 cm
Module Active Area	11,77 cm x 12,1 cm = 142,417 cm²
Cooler Thickness without fittings	ca. 0,9 cm
Cooler Thickness with fittings	ca. 2,9 cm
Total module thickness	ca. 3,4 cm
Electrical plus contact	suitable for clamp process
Electrical minus contact	suitable for clamp process

Typical Electrical Data

(Measurement condition: 1.5 AMd – 1000 W/m² (ASTM G 173-03), T = 25° C)

Sun concentration	I_{SC} [A]	V_{OC} [V]	I_{MPP} [A]	V_{MPP} [V]	P_{MPP} [kW_{MPP}]	FF [%]	η [%]
x 700	53	76	50	64	3,20	79,5	32,0

Values are valid for homogeneous illumination only!

Bypass diode protection is provided for each segment.
Inhomogeneous illumination, a lower light intensity or higher temperatures will reduce the power output.

Typical Temperature Coefficients of Solar Cell (@ 500 suns)

Temperature range (25 – 80°C)

Parameter	$(\Delta I_{sc} / I_{sc(25°C)}) / \Delta T$	$(\Delta V_{oc} / V_{oc(25°C)}) / \Delta T$	$(\Delta P_{mpp} / P_{mpp(25°C)}) / \Delta T$
value	0,074 %/°K	- 0,137 %/°K	- 0,106 %/°K

3C30M

Triple Junction CPV Dense Array Cont'd

AZURSPACE SOLAR POWER GMBH

Recommended Cooling Unit

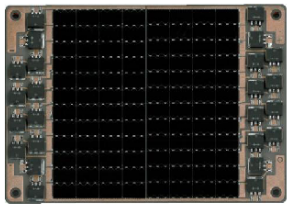
Wafer connection:	2 inlet and 2 outlet fittings on the rear side
Wafer flow rate:	14 – 18 l/min
Pressure drop:	0,3 bar @ 15 l/min
Max. water inlet temperature:	60° C
Max. system peak preassure:	3 bar

Failure of cooling unit or interruption of cooling flow has to be avoided, otherwise damage will result within seconds.

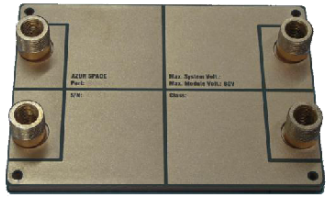
Thermal Power Output

At 700 sun concentration approximately ~ 6 kW

Picture of Front Side



Picture of Rear Side



Water Inlets Water Outlets

Order information

ADAM fittings	picture	SAP-Material number for order
with thread connector outer thread: M20 inner thread: G 1/4 height: 2 cm		80563
with hose connector (20 mm outer tube diameter)		80420

3C30M

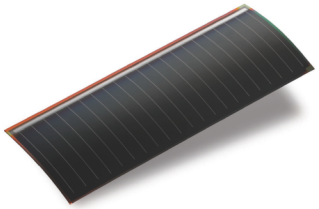
GaAs Solar Cells

ALTADEVICES

TECHNOLOGY BRIEF
Single Solar Cell

Alta Devices produces the highest performance single junction solar cells available on the market.

- The gallium arsenide based cells are thin, flexible, and lightweight, enabling a broad range of mobile power applications
- World-record cell and module efficiencies
- Low temperature coefficients and high sensitivity to low light generate unsurpassed real world performance



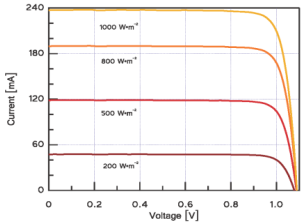
Mechanical Data and Design

Format	[mm]	50 x 19.6 ± 0.5
Thickness	[µm]	110 ± 10
Weight	[mg]	180
Front	[-]	1.0 mm bus bar, AR coating
Back	[+]	Polymer carrier film, vias for electrical contact

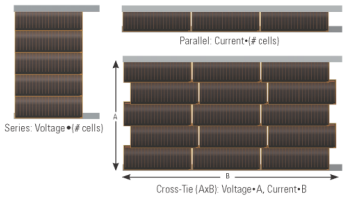
Temperature Coefficients

Voltage	[%/ °C]	-0.187
Current	[%/ °C]	+0.084
Power	[%/ °C]	-0.095

Electrical Performance



Architecture Options



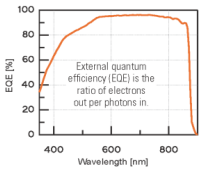
Electrical Specifications

Performance at STC of a 24.2% efficient cell

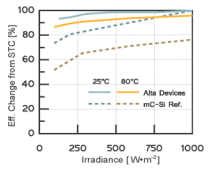
Eff.	[%]	24.2 (shingle area)
Eff.	[%]	26.0 (active area)
P_{mp}	[mW]	220
V_{mp}	[V]	0.96
I_{mp}	[mA]	230
FF	[%]	84.2
V_{oc}	[V]	1.09
I_{sc}	[mA]	239

Standard Testing Conditions [STC]: 1000W•m⁻², AM1.5, 25°C

External Quantum Efficiency



Low Light / High Temperature Performance

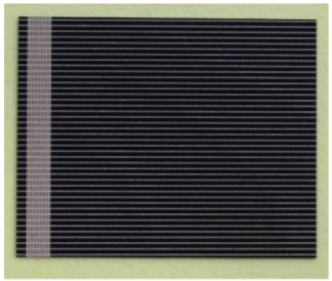


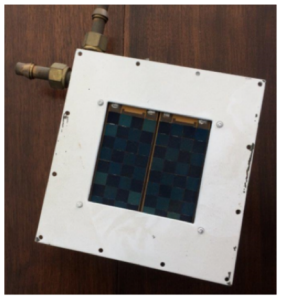
Alta Devices | 545 Oakmead Parkway, Sunnyvale, CA 94085 | www.altadevices.com

Rev: 2013.v1.3_ENG-04-03

Silicon Concentrator Cells and DRAs

- Initial Products:
  - Commercially available cells
  - Concentration- 500 Suns
  - Lower Efficiency – 30% versus 45%
  - Better fit with SunCell Generator System Requirements
    - Less demanding cold plate solutions
    - Higher operating temperature (smaller and less costly cooling equipment)
    - Lower cost
    - Existing Si cell manufacturing capacity





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