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**SANYO**

## Amorphous Silicon Solar Cells / Amorphous Photosensors

2007-11



**SANYO Semiconductor Co., Ltd.**

***Amorton***

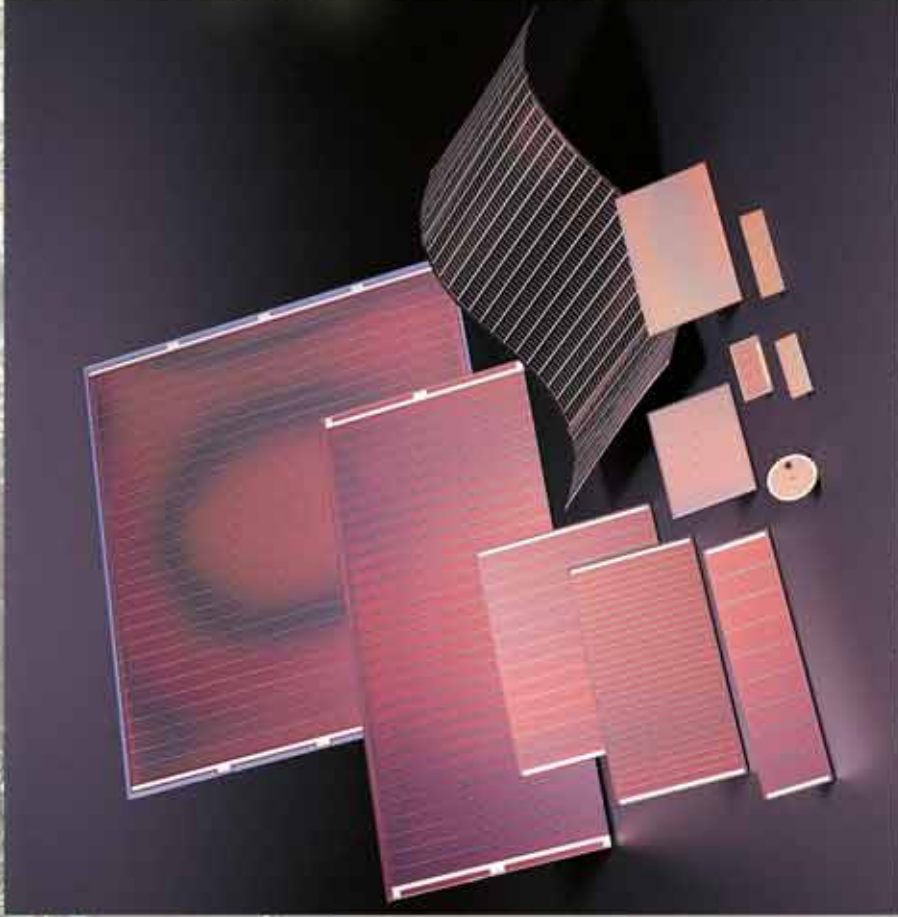
## The Concept

Solar cell power is generated by semiconductors. When light of suitable intensity, a positive hole are generated between photons and silicon. At a p/n junction between electrons are diffused into electrodes respectively, and are scattered in the p-type electrodes respectively, and electrodes respectively, and electrodes respectively.

When an external load is connected, an external load is connected. In this way, an external load is connected. In this way, an external load is connected. In this way, an external load is connected.

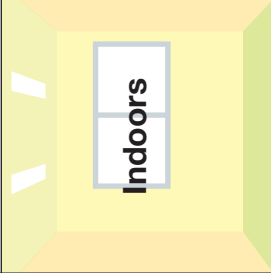








## Amorphous Silicon

Solar cells are classified into monocrystalline silicon and compound semiconductors. Amorphous silicon is defined as non-crystalline silicon. Unlike crystalline silicon, amorphous silicon has an irregular atomic arrangement. As a result, the recipient of amorphous silicon is thin amorphous silicon utilizing metal or plastic substrate. Amorphous silicon is an integrate of silicon and hydrogen. Amorphous silicon uses silane (SiH<sub>4</sub>) as a raw material. Three amorphous silicon junctions are formed on a substrate. This p-i-n junction formation, this junction formation, in series on a substrate, in series on a substrate, desired voltage to be desired voltage to be equipment operation.



*The development of the solar cell is progressing with rapid speed. As a new energy tool which can effectively harness the amazing power of sunlight, solar cells have the potential to replace fossil fuels as our main means of power generation. Solar energy is both a clean and inexhaustible resource, and it can be used to produce electricity wherever and whenever sunlight is available. Of these technologies, amorphous silicon solar cells have many strengths that surpass those of the earlier crystalline silicon solar cells. In addition, they require little energy to manufacture and use less raw materials, and thus are truly environmentally friendly devices. This technology also allows larger area cells to be manufactured*

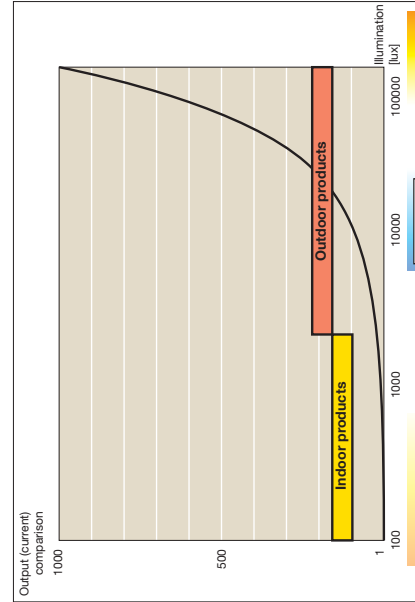
## Features of Amorton

Place used	Substrate	Feature	Reference
 <p><b>Indoors</b></p>	 <p><b>Glass</b></p>	Low price (basic substrate)	Page 5
	 <p><b>Stainless steel</b></p>	Thin, light weight, unbreakable, can easily be formed in arbitrary shapes, highly precise dimensions	Contact your SANYO representative.
	 <p><b>Film</b></p>	Thin, light weight, unbreakable, bendable, can easily be formed in arbitrary shapes	Contact your SANYO representative.
 <p><b>Outdoors</b></p>	 <p><b>Glass</b></p>	Low price (basic substrate)	Page 5
	 <p><b>Stainless steel</b></p>	Thin, light weight, unbreakable, can easily be formed in arbitrary shapes, highly precise dimensions	Contact your SANYO representative.
	 <p><b>Film</b></p>	Thin, light weight, unbreakable, bendable, can easily be formed in arbitrary shapes	Page 6
 <p><b>Visible light sensor</b></p>		Support designs with arbitrary sizes and patterns as required by the application	Page 9

Contact: The person in charge of Amorton products TEL.03-3837-6306

### Relationship between illumination level and output

The figure shows the relationship between illumination level and output. There is an enormous difference between the illumination levels indoors and outdoors. SANYO provides two types of products, indoor products for use in the low illumination levels common in indoor environments and outdoor

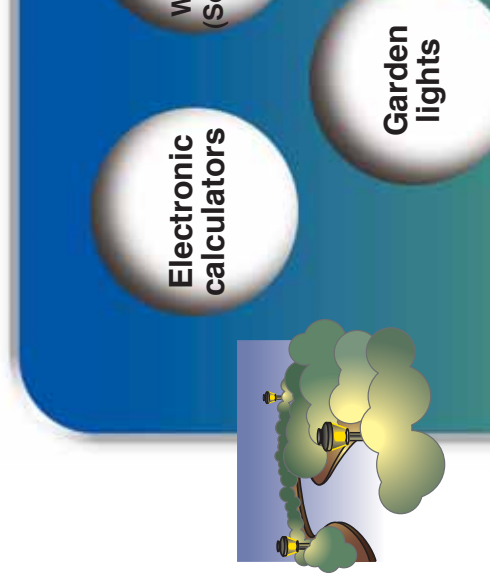


■ **Solar cells with a variety of connections**  
 Since, unlike the fabrication technique connected, multiple cells can be connected, multiple cells can be connected to create batteries with a variety of voltages. (This series connection idea is the same as in a battery.)

■ **Solar cells with a variety of substrates**  
 The methods used to form amorphous silicon on stainless steel or plastic films, to form thin-film solar cells, solar cells that can be bent, can be created. It is also possible to create areas with high sensitivity.

■ **High sensitivity in the visible light region**  
 The human eye is sensitive to light in the visible light region. Since amorphous silicon solar cells are sensitive to solar cells, they can also be used in the visible light region.

## Application Examples



# Amorton List (Glass Substrate)

## General-Purpose Products

- Specifications
- 1 Indoor products

Model	Typical operating characteristics (Initial)			External dimensions (mm)	Weight (g)
	FL-200lux	FL-50lux (Reference value)	FL-10lux (Reference value)		
AM-1456	1.5V- 5.3µA	1.4V- 1.30µA		25.0X10.0	0.7
AM-1411	1.5V- 8.0µA	1.4V- 2.00µA		29.6X11.8	1.0
AM-1437	1.5V- 8.0µA	1.4V- 2.00µA		29.6X11.8	1.0
AM-1407	1.5V- 11.5µA	1.4V- 2.85µA		38.0X12.5	1.3
AM-1417	1.5V- 12.5µA	1.4V- 3.10µA		35.0X13.9	1.3
AM-1424	1.5V- 20.0µA	1.4V- 5.00µA		53.0X13.8	2.0
AM-1454	1.5V- 31.0µA	1.4V- 7.75µA		41.6X26.3	3.0
AM-1513	1.8V- 15.0µA	1.6V- 3.75µA		55.0X13.5	2.0
AM-1805	3.0V- 15.5µA	2.6V- 3.85µA		55.0X20.0	3.0
AM-1801	3.0V- 18.5µA	2.6V- 4.60µA		53.0X25.0	3.6
AM-1815	3.0V- 42.0µA	2.6V- 10.50µA		58.1X48.6	7.8
AM-1816	3.0V- 84.0µA	2.6V- 21.00µA		96.7X56.7	15.6

## Indoor products (for high illumination levels)

Model	Typical operating characteristics (Initial)			External dimensions (mm)	Weight (g)
	FL-200lux	SS-10k lux (Reference value)	SS-50k lux (Initial)		
AM-1819	3.0V- 6.9µA	4.0V- 0.41mA		31.0X24.0	2.2
AM-1820	3.0V- 13.3µA	4.0V- 0.79mA		43.0X26.0	3.1

\* Glass thickness is 1.1mm.  
FL: White fluorescent lamp  
SS: Solar simulator

## 2 Outdoor products

Model	100mW/cm <sup>2</sup>			External dimensions (mm)	Weight (g)
	Typical operating characteristics (Initial)	Pmax (Vop-Iop)	Pmax (Vop-Iop)		
AM-5308	(1.7V- 68.8mA)	117mW (1.9V- 61.5mA)	58mW (1.9V- 29.2mA)	50.1X 47.2★	6.4
AM-5302	(1.7V- 105.0mA)	181mW (1.9V- 95.5mA)	86mW (1.9V- 45.1mA)	31.2X 117.8	16.3
AM-5413	(2.2V- 16.7mA)	39mW (2.6V- 15.0mA)	18mW (2.6V- 7.1mA)	33.0X 23.9★	2.1
AM-5412	(2.2V- 39.8mA)	93mW (2.6V- 35.8mA)	44mW (2.6V- 16.9mA)	50.1X 33.1	7.3
AM-5610	(3.3V- 5.1mA)	18mW (3.9V- 4.6mA)	8mW (3.9V- 2.2mA)	25.0X 20.0	2.2
AM-5613	(3.3V- 31.6mA)	110mW (3.9V- 28.2mA)	52mW (3.9V- 13.3mA)	60.1X 36.7	9.8
AM-5608	(3.3V- 36.0mA)	125mW (3.9V- 32.0mA)	59mW (3.9V- 15.1mA)	60.1X 41.3	11.0
AM-5605	(3.3V- 115.4mA)	401mW (3.9V- 102.7mA)	189mW (3.9V- 48.6mA)	62.3X 117.8	32.5
AM-8706	(3.9V- 19.9mA)	81mW (4.6V- 17.7mA)	39mW (4.6V- 8.3mA)	36.1X 41.3★	4.1
AM-8704	(3.9V- 23.8mA)	97mW (4.6V- 21.0mA)	46mW (4.6V- 9.9mA)	41.2X 41.3★	4.6
AM-8705	(3.9V- 26.9mA)	109mW (4.6V- 23.8mA)	52mW (4.6V- 11.3mA)	36.1X 55.1★	5.4
AM-8703	(3.9V- 32.1mA)	131mW (4.6V- 28.5mA)	62mW (4.6V- 13.4mA)	41.2X 55.1★	6.2
AM-5710	(3.9V- 32.6mA)	134mW (4.6V- 29.0mA)	63mW (4.6V- 13.7mA)	62.3X 37.0★	6.3
AM-8702	(3.9V- 34.4mA)	140mW (4.6V- 30.5mA)	67mW (4.6V- 14.4mA)	57.7X 41.3★	6.5
AM-5706	(3.9V- 45.9mA)	186mW (4.6V- 40.5mA)	88mW (4.6V- 19.1mA)	70.0X 50.0	15.5
AM-8701	(3.9V- 46.6mA)	190mW (4.6V- 41.2mA)	90mW (4.6V- 19.4mA)	57.7X 55.1★	8.6

# Amorton Film

Amorton Film is an exceptionally thin, lightweight silicon solar cell fabricated on plastic film. In addition to these advantages, Amorton crack. Its standard configuration includes the amorphous silicon solar cell which maintains overall thickness.



## General-Purpose Products

- Specifications

Model	100mW/cm <sup>2</sup>	
	Typical operating characteristics (Initial)	Pmax (Vop-Iop)
AT-7665	3.0V- 38.6mA	125mW (3.6V- 38.6mA)
AT-7664	3.0V- 104.0mA	335mW (3.6V- 104.0mA)
AT-7666	3.0V- 343.0mA	1109mW (3.6V- 343.0mA)
AT-7963	4.5V- 223.0mA	1083mW (5.4V- 223.0mA)
AT-7S63	15.0V- 134.0mA	2104mW (16.8V- 134.0mA)
AT-7S64	15.0V- 269.0mA	4208mW (16.8V- 269.0mA)

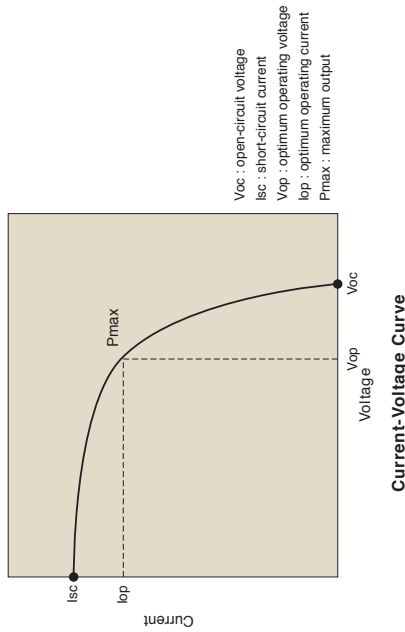
# Amorton Products for Watches

Amorton Products for Watches	Glass
	Stainless steel
	Film

SANYO Amorton products are widely used in solar watches. SANYO can provide custom Amorton

## Features of Amorton

The features of Amorton are shown by the current-voltage curve in the figure.  
The curve changes depending on the incident light intensity and the surrounding temperature.



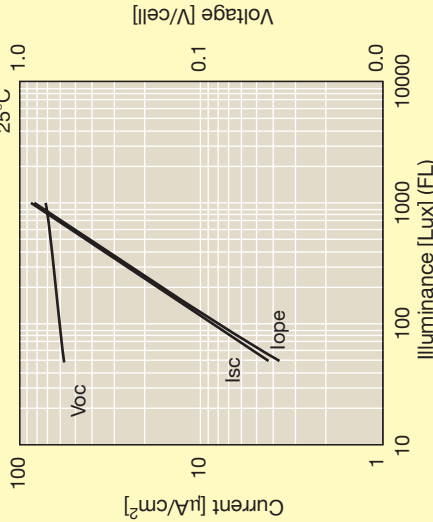
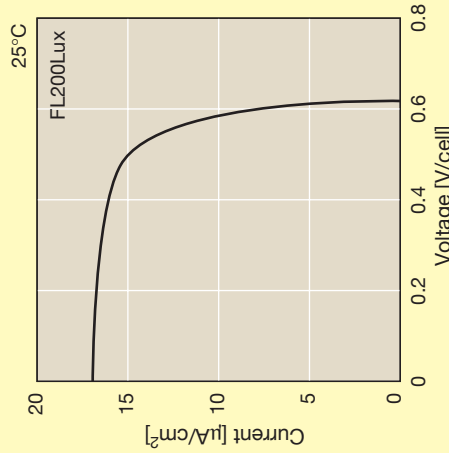
$V_{oc}$  : open-circuit voltage  
 $I_{sc}$  : short-circuit current  
 $V_{op}$  : optimum operating voltage  
 $I_{op}$  : optimum operating current  
 $P_{max}$  : maximum output

Current-Voltage Curve

## Output Characteristics

### Output Characteristics of Indoor use Amorton

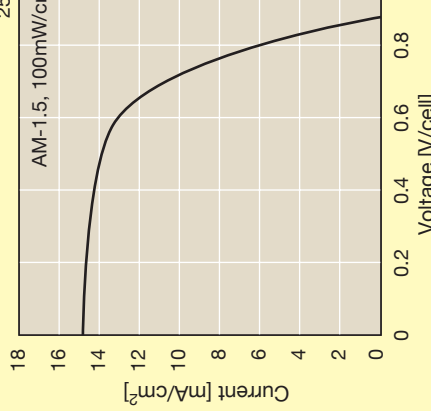
Artificial light, such as fluorescent and incandescent light, is used indoors. The illuminance of these light sources ranges from 20 lux to 1,000 lux. Indoors, therefore, Amorton is most suitable for small equipment such as electronic calculators. Please use under 1,000 lux.



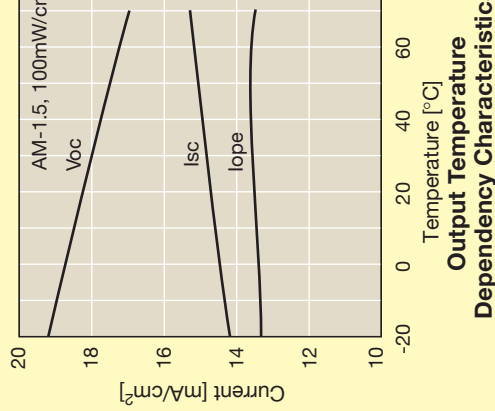
Typical Cell Characteristics (25°C)

Open-circuit voltage	Short-circuit current	Maximum output	Light source
0.63 V/cell	17.0 $\mu A/cm^2$	7.0 $\mu W/cm^2$	FL200lux

**Output Characteristics of outdoor**  
 Natural light ranges in illuminance from 1 lux (AM-1.5, 100mW/cm<sup>2</sup>) or more. Amorton for compact equipment such as chargers.



Current - Voltage



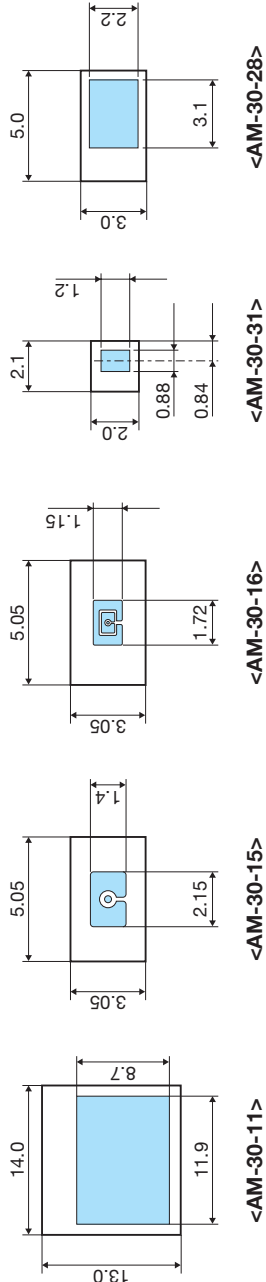
Output Temperature Dependency Characteristic

# Amorton Photosensors List

Model	Number of elements	External dimensions (mm)	Short-circuit current TYP.	Dark current (VR = 50mV) MAX.
AM-30-11	C, CS, CA	14.0 X 13.0 (Glass 1.1t)	17.7 $\mu$ A*1	—
AM-30-15	C	5.05 X 3.05 (Glass 0.7t)	Center area: 80nA*2 Around area: 2.8 $\mu$ A*2	Center area: 100pA Around area: 100pA
AM-30-16	C	5.05 X 3.05 (Glass 0.7t)	Center area: Around area (Inside): Around area (Outside):	Center area: 100pA Around area (Inside): 100pA Around area (Outside): 100pA
AM-30-28	CS	5.0 X 3.0 (Glass 0.7t)	7.5 $\mu$ A*2	10pA
AM-30-31	C	2.1 X 2.0 (Glass 0.4t)	1.2 $\mu$ A*2	10pA
AM-30-33	C	5.0 X 3.0 (Glass 0.7t)	7.5 $\mu$ A*2	10pA

\*1: At 200lux, white fluorescent light  
 \*2: At 1000lux, fluorescent light for color illuminator  
 \* For terminal configurations, refer to page 8.

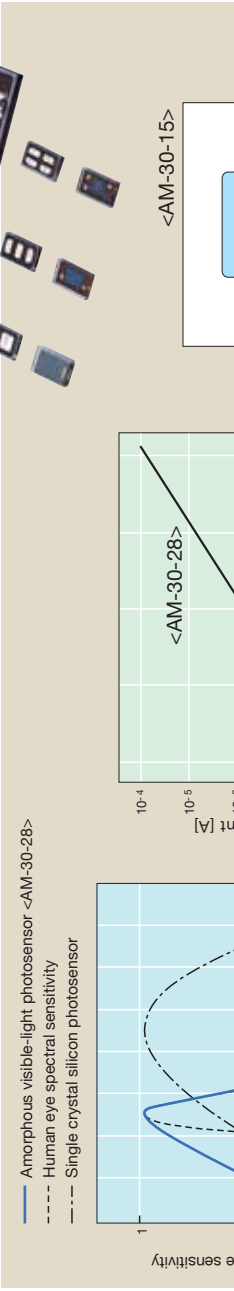
Effective area



**SANYO can also provide custom products.**

# Features of Amorton Photosensors

Amorphous Photosensor is a kind of Photo Diode, and can detect light and its intensity.

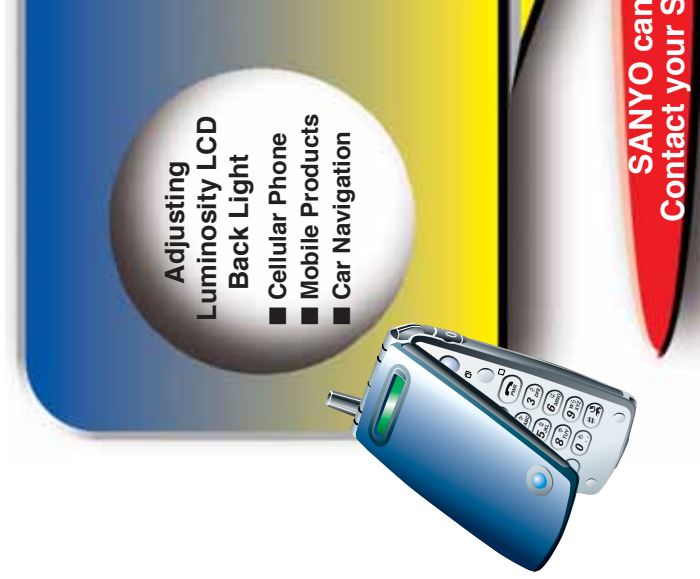


# Amorton Photosensors Circuit Diagram

OP amplifier detects photosensor output and convert to voltage. The signal is linearly amplified.

# Amorton Photosensors Application

The following shows typical applications of amorton photosensors.



# Solar Cell Output and Light Sources

The output of solar cells differ depending on the categories of light sources to which they are exposed. This is because photoelectric conversion efficiency changes with respect to the wavelength and intensity of the light.

## 1. Categories of light sources

The general light source for solar cells is sunlight out of doors, and fluorescent or incandescent light indoors. The following outline describes the various categories:

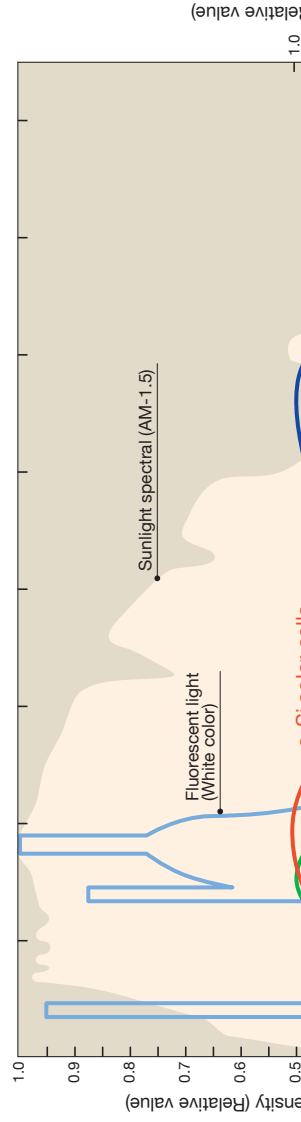
Light source		
	Sunlight	Artificial light
AM-0	Outer space (solar light at global average revolution orbit)	General-use incandescent light, halogen lamp
AM-1	When the sun is directly overhead (0m above sea level at the equator, vertical sunlight at meridian passage)	Daylight, white, and warm white colors
AM-1.5	When zenithal angle (Sunlight angle 0° when sun is directly overhead) is 48.2°.	Mercury-vapor lamp, sodium-vapor lamp, xenon lamp
Other	AM-2 (when zenithal angle is 60°), etc.	

## 2. Brightness

When sunlight and fluorescent light are compared in terms of brightness, the results are shown as follows:

[Light Source]	Sunlight	Fluorescent light
	Condition Illuminance (lux)	Condition Illuminance (lux)
Direct sun	100,000 to 120,000	Design stand (partially illuminated) Around 1,000
Bright	50,000 to 100,000	Office/conference room 300 to 600
Cloudy	10,000 to 50,000	Restaurants/coffee shops Below 200
Rain	5,000 to 20,000	

## 3. Radiant spectrum of light source and spectral sensitivity of solar cells



## Precautions in Handling Amorton and Amorphous Photosensors

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Do not scratch the rear surface with a hard object because it could damage amorphous silicon (1µm thick active layer) and causes electrical malfunction even though the surface is protected by resin coating.



Be careful not to get injured with the sharp edges of the substrate material (glass or stainless steel).



Employ robust and airtight encapsulation when the cell is expected to receive mechanical shocks by falling objects or exposed to harsh weather conditions. Note shattered glass pieces can cause injury and humid environment can damage the cell.



Avoid touching the cell in the daytime because you may get burned with heat particularly when the insolation is strong.



Do not touch the light-receiving side with bare hands because it stains the surface and affect electrical output.

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