تحديثات في الكهرباء باستخدام الطاقة الشمسية

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الملخص :

يطلق على الأجهزة التي تقوم بتحويل الطاقة الشمسية إلى طاقة كهربائية بالخلايا الكهروضوئية وتم حتى الآن استخدام تلك الأجهزة الحديثة على نطاق واسع بواسطة استعمال مواد مختلفة من بينها البلور سي الأحادي ...حيث يستخدم هذا البلور الأحادي والذي يعتمد على الخلايا الشمسية وينطوي على جوانب سلبية وقيود يصعب التصرف حيالها مما يتطلب إجراء بعض التخفيضات وقيود كبيرة على التطبيقات المستخدمة على نطاق واسع... وتبقى التحديات متعلقة بكيفية تطوير عناصر حديثة مثل خلايا قابلة للتكيف تعتمد مباشرة على الطاقة الشمسية.

وللتغلب على هذه القيود المتعلقة بخلايا السيليكون البلورية المحفورة بفعل أشعة الشمس يتطلب الأمر تشكيل خلايا مائلة من أشعة الشمس.

يتطرق هذا البحث إلى بعض أنواع التحديثات والابتكارات الكهروضوئية ذات الأغشية الرقيقة ...كما يعطي وجهة نظر مستقلة حول هذه الأنواع من الخلايا الشمسية.

Innovation in electricity using solar thermal power

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Abstract

The devices that specifically changes the solar energy into electric energy are called photovoltaics. These devices are right now created by using an assortment of materials, among which the single-crystalline Si is most broadly utilized. The single-crystalline Si sun based cells, however, have inalienable downsides and restrictions, in which considerable fetched decreases are required for expansive scale applications, and challenges stay in modern item advancement such as adaptable sun based cells An elective introduction to overcome the restrictive limits of crystalline silicon sun powered cells is to form incline film sun situated cells. This research mentions some types of

lean film photovoltaic innovation and gives the viewpoint of future of these types of the solar cells.

Introduction

Photovoltaic power generation is a state-of-the-art technology that can directly convert infinite, pollution-free sunlight into electricity. Therefore, electricity can be obtained anywhere in sunlight, and unlike other power generation methods, it is a clean energy source that does not have any pollution such as air pollution, noise, heat, and vibration. In addition, fuel transport and maintenance of power generation facilities are almost unnecessary, long life, and easy installation and selection of facility size. However, current photovoltaic power generation has disadvantages of low solar energy density and low conversion efficiency of the photovoltaic power generation system, requiring a large installation area and relatively high foot shear cost.

The development and mass distribution of low-cost, high-efficiency solar cell technology at a price level that can compete with each other must precede. Since the method of generating solar insolation by electricity was first observed by Becquerel in 1839, solar power generation technology began to be studied in earnest. Fig.1.shows and classifies the types of solar cells that currently in use or being developed. Among them, this paper examines each of the thin-film solar cells that are predicted to be the main targets of future research and development, and examines the characteristics and future prospects of each technology in turn.

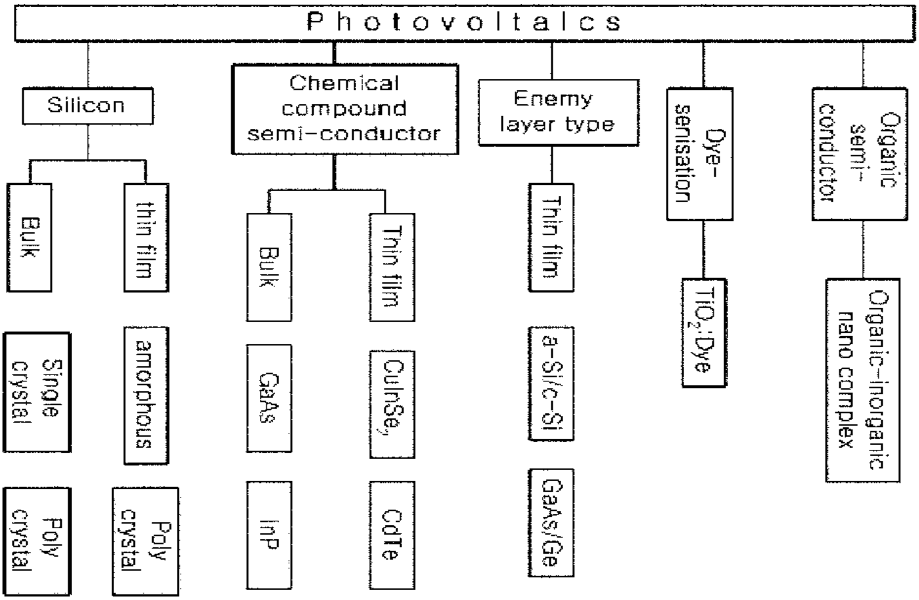
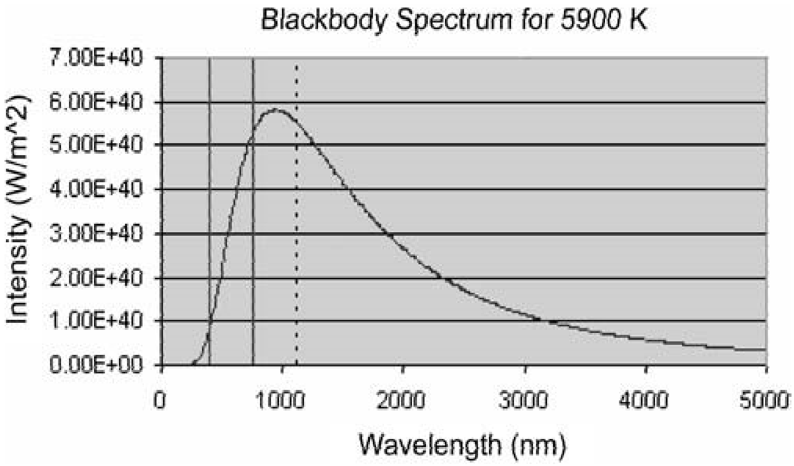


Fig. 1 Classification of solar cells considering the shape and the materials.

Technology of thin-film photovoltaic cell

Principles of solar cells

The solar spectrum can be approximately depicted by a black body radiation spectrum of 5,900K. Fig. 2 shows this spectrum.



The **Fig. 2. Solar spectrum of the blackbody.**vertical real line of the figure separates the visible light region. In photovoltaic cells, only light with energy equal to or greater than the energy gap of the material is absorbed. The principle of solar cell generation using sunlight is shown in Fig. 3.

Solar batteries are basically made of semiconductor p-n junction, and that's due to the high electron density in the n-type semiconductor region and the high hole density in the p-type semiconductor region, charges are diffused to the opposite sides due to the difference in charge concentration, A space charge region occurs, This space charge layer generates a built-in electric field inside the solar cell and uses this electric field to obtain the flow of charges generated by light above the energy gap. Therefore, in order to increase the energy conversion efficiency of a solar cell, the generation of electric charges by absorbing light must be large, and the strength of the built-in electric field must be large. And it is necessary to minimize the dissipation due to electrical resistance before the charges moved by the built-in electric field reach the external electrode. In this respect, studies to maximize the efficiency of solar cells are being conducted from various angles. In terms of materials, the development of materials having an optimal energy gap is ongoing, and it is currently known that the optimal energy gap of the light absorbing layer is around 1.5 eV. Fig. 4. Is a graph showing the current-voltage characteristics of a typical solar cell. Here, the amount of energy that the solar cell can obtain is shown in Fig.4.It is related to the area of the quadrant made by the solid line and the current axis and voltage axis. That is, as shown in Equation (1), the efficiency (η) of the solar cell is determined by the point where

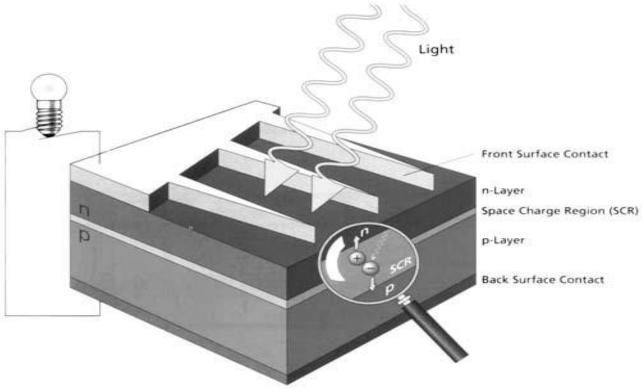


Fig. 3. Principle of electric powered generator using

the area of the fourth quadrant becomes the maximum, and the incident energy (P input) is the sum of the solar spectrum.

$$\eta \ = \ [(Imax \times Vmax)/Pinput] \times 100\%$$

(1)

On the other hand, the point where the solid curve meets the voltage axis is defined as open-circuit voltage (Voc), and the point where the solid curve meets the current axis is defined as short circuit current (Jsc). In solar cells, the maximum available current and maximum available voltage are Jsc and Voc, respectively. On the other hand, the fill factor (FF) is a factor that measures the useful power obtained from solar cells, and is defined as in Equation (2).

$$FF = (Imax \times Vmax)/(Jsc \times Voc)$$

(2)

From Equation (1) and Equation (2), the solar cell efficiency (η) and FF, Jsc, and Voc are related to each other, which can be expressed as Equation (3).

$$\eta = [(Jsc \times Voc \times FF)/Pinput] \times 100\%$$

(3)

In conducting research to improve the efficiency of photovoltaic cells, researchers obtain Jsc, Voc, and FF from the above-mentioned current-voltage characteristics, and conduct research related to material, process, device and module manufacturing to maximize this.

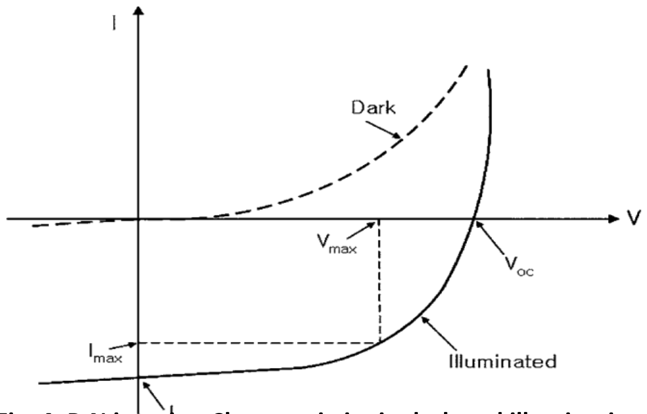


Fig. 4. P-N junction Characteristics in dark and illumination.

Amorphous silicon solar cell

Unlike the p-n structure of a crystalline solar cell, a thin-film a-Si solar cell has a p-i-n structure in which an i-type layer that does not contain impurities is inserted between the p-type layer doped with impurities and the n-type layer. First, a structure in which a transparent electrode (ITO), a-Si (pin), and a back electrode are stacked on a glass substrate in order, and second, a substrate made of metal or plastic. There is a structure in which a back electrode, a-Si (nip), a transparent electrode (ITO), and a metal grid electrode are stacked in this order. In addition, since some of the incident light is not absorbed by the a-Si layer but reaches the back electrode, the back electrode is a technology that returns the light to the a-Si layer once more by using a metal (gold, silver, etc.) with good light reflectivity.

Single crystal Si solar cells use crystallized Si wafers made by melting and cooling solid Si raw materials, but a-Si solar cells introduce raw material gas such as SiH4 (silane) into a vacuum device and decompose them by glow discharge, and then use glass, etc. The reason why a-Si grown by PECVD has good properties is due to residual hydrogen present in the a-Si semiconductor and the effect that hydrogen has on the electro-optical properties of a-Si is explained by Lewis et al. Studies on the control of n-type and p-type by doping in the PECVD method were first published by Spear and Lecomber, and the application of the PECVD method to a-Si solar cells began to be actively carried out. Table 1 summarizes the efficiencies of a-Si solar cells fabricated so far and their device characteristics.

Table 1. Efficiency summary of a-Si solar cell

	Area (cm2)	Voc (mV)	JSC (mV/cm2)	FF (%)	Efficiency (%)	Organization
Single juction cells	3.960	874	15.62	71.3	9.7	ARCO solar
	0.998	872	16.54	71.2	10.3	APS
	1.06	864	16.66	71.7	10.3	Chronar
	0.27	940	15.2	69.4	9.9	ECD
	0.28	862	17.6	65.8	10	IEC

	0.99	886	17.46	70.4	10.9	Glasstech
	1.00	887	19.4	74.1	12.7	Sanyo
	1.08	879	18.8	70.1	11.5	Solarex
	0.10	878	16.6	72.2	10.5	Spire
Dual juction cells	0.28	1,6211	11.72	65.8	12.5	USSC/Cannon
	0.76	1,6851	9.03	68.1	10.3	Solarex
Triple juction cells	0.27	2,5411	6.96	70	12.4	ECD
	1.00	2,2891	7.9	68.5	12.4	Sharp

Currently, the highest reported efficiencies of a-Si solar cells are about 12.5% per 1 cm^2 for single-junction cells and 15% for multi-junction cells. This relatively low efficiency is due to the degradation of a-Si thin films by absorption of light. As a method to prevent degradation of the thin film due to light absorption, a technique of forming an anti-reflection film on the surface of a solar cell is sometimes used. In addition, since some of the incident light is not absorbed by the amorphous Si layer but reaches the back electrode, the back electrode is used as a metal with good reflectivity (gold, silver, etc.), and the light is returned to the a-Si layer once more to achieve efficiency We are making improvements. The efficiency and stability of a-Si solar cells are also affected by defects in a-Si:H. Therefore, it is very important to minimize defects in the structure of a-Si solar cells. In order to secure the economic feasibility of a-Si solar cell, it is necessary to improve device efficiency and reduce cell manufacturing cost. Currently, the plasma CVM (chemical vaporization machining) method, a patterning technology developed by Kiyama et al., is drawing attention in this respect. Fig.5. shows the manufacturing process of a-Si solar cell using the plasma CVM method currently in use. In addition, as a method to improve the deposition rate of a-Si, the Hydrogen Dilution method or the Hot-wire CVD method has been attempted, and through this, research is being conducted to improve the deposition rate and at the same time increase the efficiency.

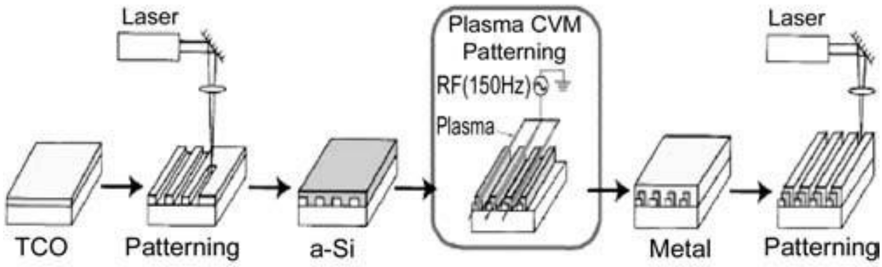


Fig. 5. a-Si submodule manufactured utilizing plasma cvm pattering for the a-Si designing.

GaAs solar cell

Compound semiconductors such as GaAs, GaAlAs, GaInAsP, and InP have been attracting attention as materials for photovoltaic cells for a long time.These group III-V compound semiconductors have excellent optical properties and are steadily being developed, and their material properties are also improving a lot. Compound semiconductors are also solar cell materials, which have the advantage of easy thin-film formation, high light absorption coefficient, and selectivity of optical band gap.Among the III-V compound semiconductors, GaAs-based materials are the most widely used materials. Since these are direct transition type semiconductors, they have a larger light absorption coefficient compared to indirect transition type silicon, and absorb more than 90% of sunlight, it has the characteristic that it is sufficient to have only the thickness of several µm. However, in order for group III-V solar cells to be widely used in the global solar cell market in the future, it is first necessary to lower the manufacturing cost of solar cells using them. A typical structure of a high-efficiency single-junction solar cell using GaAs is shown in Fig.6.GaAs has a higher rate of recombination of a small number of carriers generated by light on the surface compared to silicon.

To suppress this, a window layer made of GaAlAs with a wider band gap than GaAs is usually inserted. In other words, in most cases, GaAs-based solar cells are structured to minimize the recombination rate at the surface, which is a common feature of direct-bandgap semiconductors. High-efficiency III-V semiconductors are generally deposited by metalorganic CVD (MOCVD). This method is a method of obtaining a high-quality thin film, which is the basis for achieving high efficiency, and is particularly suitable for large area and mass production. Therefore, research and development for the commercialization of the MOCVD method is very active. The MBE (molecular-beam-epitaxy) method is mainly used by research institutes, but the deposition rate is very slow, so it is not yet well used commercially.

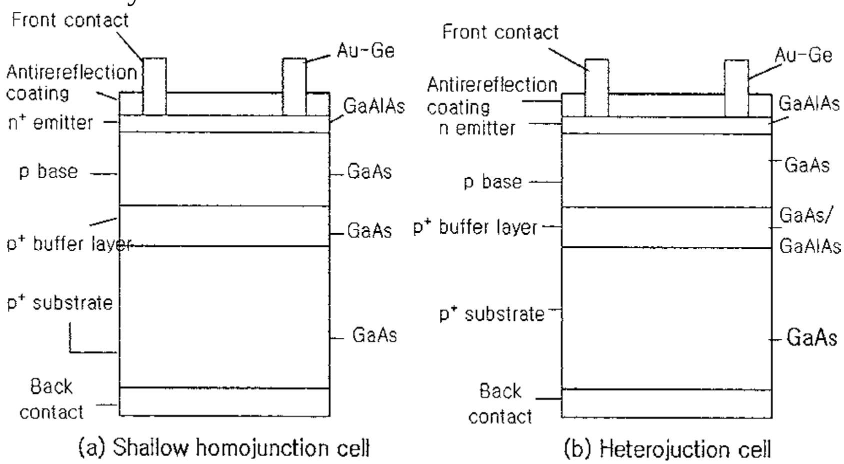


Fig. 6. Two common structures of GaAs high-efficiency cells.

The Tadem type single crystal III-V solar cell was first manufactured by adopting the AlGaAs/GaAs structure in the early 1980s, and its efficiency was 16.5%. However, since the band gaps of these early tandem solar cells were not designed ideally, they had a conceptual value as the first tandem solar cell, but were not satisfactory in terms of efficiency. Therefore, efforts to improve the efficiency through optimization of the tandem structure and new technology continued. As a result, the efficiency could be increased up to 20% by the use of condensing devices in the mid-1980s, and at a similar time. Fraas et al. developed a GaAsP/GaAsSb solar cell, which was able to increase the efficiency up to 22%. Since the efficiency cannot exceed 30% in theory with a single junction solar cell, a multi-junction tandem cell structure has begun to be developed to overcome this. If two or more cells are stacked in the same direction in this way, additional absorption may occur while the light that cannot be absorbed from the upper part moves to the bottom part, and this allows the solar spectrum to be used more efficiently. , It is possible to obtain increased efficiency. In recent years, a multi-tandem cell solar cell having an InP/GaInAs structure has also been developed, and its efficiency reaches a level of over 30%. Table 2 summarizes the efficiency of GaAs solar cells composed of single junction and tandem cells and their device characteristics.

In order to commercially apply GaAs and most of the group III-V solar cells, which are currently commercially used for space use, it is necessary to further lower the manufacturing cost of GaAs solar cells. For this, the use of cheaper materials and the development of cheaper manufacturing processes are essential. Therefore, in recent years, as an attempt to solve the high price problem of group III-V photovoltaic cells, research on the use of polycrystalline group III-V compound semiconductors is actively underway, and new deposition techniques required for this are also being researched and developed at the same time.

Table .2. Efficiency summary of solar CIS cells

Area (cm2)	Voc (mV)	JSC (mV/cm2)	FF (%)	Efficiency (%)	Organization
4.003	1,035	27.57	85.3	24.3	ASEC
4.00	1,011	27.55	83.8	23.3	Kopin
3.91	1,022	28.17	87.1	25.1	Kopin
16.00	4,034	6.55	79.6	21.0	Kopin
1.01	8.22	19.7	62.2	10.1	SMU
0.25	1,018	27.56	84.7	23.8	Spire/Purdue Univ.
0.25	1,029	27.89	86.4	24.8	Spire
4.02	878	29.29	85.4	21.9	Spire
0.25	1,190	23.8	84.9	24.1	Spire
16.14	1,035	26.9	85.4	24.2	Spire
0.5	2,403	13.96	83.4	17.6	Varian
4.0	1,045	27.6	84.5	24.4	Varian
0.250	2,385	13.99	88.5	29.5	NREL

0.250	1,049	28.5	84.4	25.3	NREL
0.108	813	27.92	82.9	18.9	NREL
4.00	2,488	14.22	85.6	30.3	Japan energy
41.4	-	-	-	25.1	Boeing
0.250	1,154	4,988	86.4	27.6	Spire
0.250	1,065	5,911	80.2	21.3	Spire
0.0746	959	1,509	87.3	24.3	NREL
0.0746	899	6,343	82.5	27.5	NREL
0.103	2,663	2,320	86.9	30.2	NREL

Organic solar cell

It has long been known that organic matter has photoconductivity, photovoltaic and photovoltaic effects, and these properties have been mainly used in photographic phenomena and dry printing. The study of organic thin-film solar cells was first studied by Kearns and Calvin in 1958, and by casting air-oxidized tetramethyl-p-phenylenediamine (TMPD) on magnesium phthalocyanine (MpGh) disks, this is the first time a junction solar cell has been made. However, at that time, there was a limit to the development of organic photovoltaic cells due to poor efficiency because the surrounding technical environment for organic photovoltaic cells was not properly equipped. Since then, a lot of research and development has been conducted for more than 20 years, but an organic solar cell with a long life has not been developed. Most of the organic solar cells developed in the early days can be characterized as low efficiencies of 10^{-8}% - 1% when looking at the efficiencies measured by sunlight.

Figure 7 shows the general structure of an organic solar cell. It is a structure in which an ITO layer, which is a transparent electrode, is stacked on a glass substrate, a charge transport layer for charge transport, and a p-type organic material used as an active layer is deposited, and an n-type organic substance for generating a built-in electric field is stacked. A hole transport layer and an electron transport layer are sometimes used to effectively transfer the electric charges generated by absorbing light above the energy gap of organic materials.

The hole transport layer uses an organic material that is lower than the work function of ITO used as the anode, and the electron transport layer uses an organic material that has a larger work function than the Al used as the cathode. It is structured to be able to. A brief look at the manufacturing process of an organic solar cell shows that ITO is deposited on a glass substrate through sputtering, followed by patterning, followed by a substrate cleaning process, and in the case of a single molecule, an organic thin film is evaporated by the evaporation method. Evaporation, and in the case of a polymer, deposit by spin coating or screen printing. Since then, Al:Li is mainly used as the back electrode, and is deposited by the evaporation method. Most of the organic photovoltaic cells that have been developed recently are composed of an n-type layer made of parylene inductors and a p-n junction made of a p-type conductive material such as phthaio-cyanine.

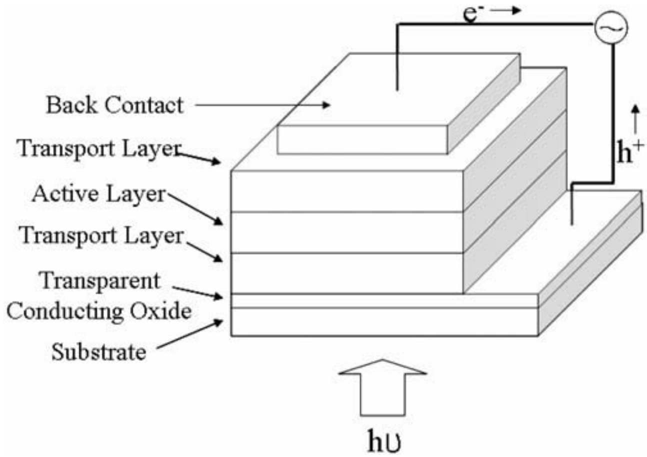


Fig. 7. Schematic of organic sun powered cell.

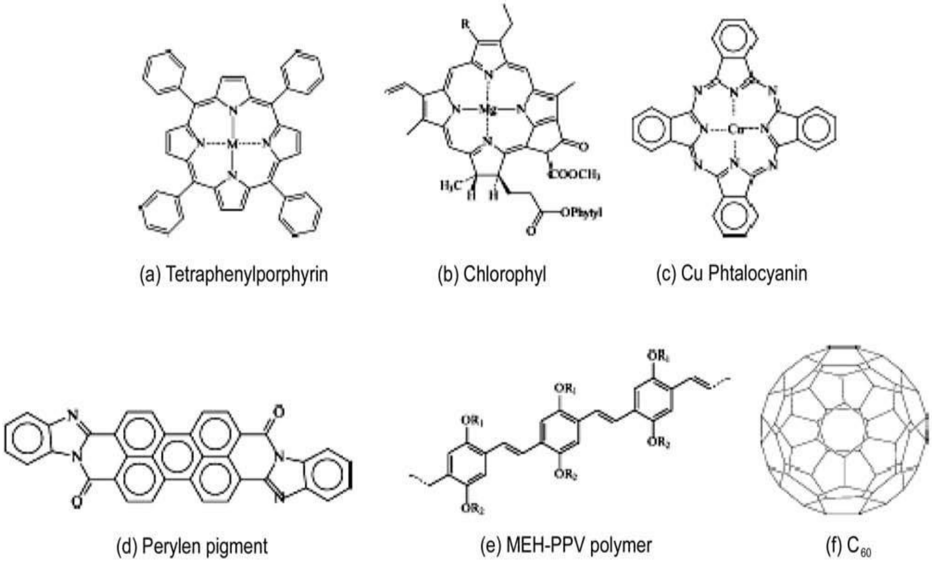


Fig. 8. Materials for organic sun powered cells: (a)-(c); benefactors, (d)-(e); acceptors

Figure 8 shows the n-type and p-type organic materials that are widely used in organic solar cells. Their efficiency reaches about 1% and the fill factor reaches 65%. Various problems have been found in organic thin-film solar cells having MIS (metal insulator-semiconductor) and MS (metal-semiconductor) structures, mainly because they absorb only a little amount of incident light from organic substances and have low transparency of the electrode. Is caused. Various types of solar cells developed to date using organic thin films are summarized in Table 3.

Table.3. efficiency summary of organic solar cell

Voc (mV)	JSC (mV/cm2)	FF (%)	Efficiency (%)	Organization
−630	1.96	46	0.71	NREL
700	1.2	43	1.2	-
1,200	-	50	2.3	Princeton University
800	4.2	0.59	2.5	-‘Gilch’ Method
800	4.5	0.62	2.9	- ‘Sulphonyl’ Method

925	6.3	-	2.4	-
540	6	0.57	2.1	-
820	5.25	0.61	2.5	LIOS
450	1.4	45	2.8	-
400	1.04	40	1.15	-
460	7.6	50	1.75	-
450	6.55	49	1.44	-
1,290	0.49	23	0.15	-

Although the efficiency of organic solar cells is much lower than that of other solar cells, they are continuously attracting attention and research by many researchers because of the fundamental capabilities of organic materials. In organic materials, since the mobility of holes generally appears much faster than that of electrons, the efficiency of the organic solar cell can be improved by increasing the mobility of electrons. If these problems are overcome well in the future, it is predicted that a solar cell with an efficiency higher than 7%, the world's best organic solar cell currently owned by Simense, will be possible. Recently, in order to manufacture more efficient organic solar cells, organic-inorganic composite solar cells are starting to be developed, which is more effective by depositing Nano-sized inorganic particles together with organic materials to compensate for the electron transport ability, which was a disadvantage of organic materials. If organic solar cells achieve high efficiency in the future, processes for mass production must also be developed, and screen printing is expected to be suitable for such large area mass production.

Conclusion

As described above, the currently commercialized and used solar cell is a single crystal solar cell, but it is predicted that high-efficiency inorganic thin-film solar cells such as CIS will play an important role in the future. The solar cell market is expected to continue to increase at a rapid pace in the future. In the solar cell development part, technology development that can be manufactured at 100 yen/W in 2005 and 75 yen/W in 2010, this is treated as the main content. Until 2005, it is expected to focus on the technology development of silicon-based thin-film solar cells or CIS-based thin-film solar cells, which have been developed so far. Is in demand. In terms of power generation cost, it is required to achieve a lower cost by 2010 at the current electricity rate level and at the same level as that of nuclear power plants or thermal power plants by 2030. If this goal is achieved in the future, it is expected that 50-80 GW solar cells will be introduced in more countries by 2030.Fig.9.schematically shows the future development trend of thin film solar cells ·Since the thin-film solar cell is more suitable for the use of houses or exterior walls of buildings than the single crystal Si-based solar cell currently used, the market entry is expected to be very fast, and rapid development is expected in the future. In addition, if the efficiency of the organic-inorganic composite solar cell reaches the 10% level, it can occupy the a-Si solar cell market, and the market competitiveness of organic solar cells is expected to increase significantly in the future

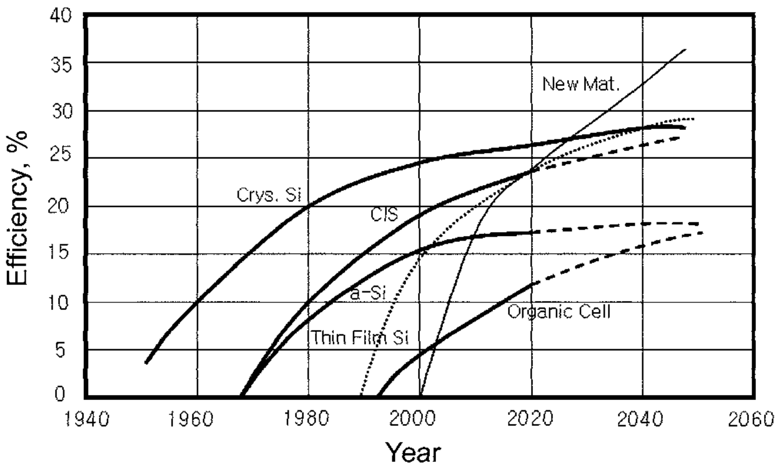


Fig.9. Anticipated cell effectiveness increment of different sorts of sun powered cells.

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