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Overview of solar power generation methods

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Abstract

Because of its abundance, cleanliness and environmental friendliness, solar energy has become an important renewable resource in energy development worldwide, with good techno-economic characteristics and development prospects. The technology roadmap for solar power generation has attracted a lot of attention from stakeholders such as power plants, power companies, equipment manufacturers and investors.This thesis addresses photovoltaic power generation systems, summarizes the main technology types and current status of photovoltaic and solar thermal power generation, analyzes the development of global photovoltaic power generation technologies, comprehensively investigates key development areas, analyzes the development trend of photovoltaic, analyzes the advantages and disadvantages of photovoltaic power generation by evaluating its value, and studies its development prospects. The paper analyzes the main types of technology and the current situation of PV power generation, investigates the technical characteristics in terms of system architecture and application forms, and evaluates the trends. The development prospect of PV is analyzed

Keywords

Monocrystalline Silicon Solar Cells, Polycrystalline Solar Cells, Inverter type solar cell, Organic Solar Cells, Graphene Solar Cells, Chalcogenide Solar Cells

1. Introduction

Energy is the fundamental driving force for the world's development and progress, and an inexhaustible source for sustaining global economic growth and prosperity. Currently, the global energy situation and energy supply and demand are undergoing profound changes, and it is imperative to optimize the composition structure of energy. Compared with traditional fossil fuel energy, renewable energy has the advantage of clean and efficient, is an important direction for the future development of the energy sector. Solar energy as a widely distributed and inexhaustible renewable energy, is currently the most widely used and also has the most promising development of one of the clean energy. According to the International Energy Agency projections, in the five years from 2019 to 2024, the global renewable energy generation will grow by more than 50%, making the share of renewable energy generation in the total global power generation from the current 26% to 30%. Among them, about 60% of the increment from solar photovoltaic power generation, about 25% of the increment from wind power generation. In addition, in the field of solar photovoltaic, the International Energy Agency also predicts that by then the production of distributed photovoltaic will be more than twice the existing production, and occupy nearly one-half of the total photovoltaic capacity. Solar energy is inexhaustible. It is estimated that the solar energy projected onto the earth in a year is equivalent to 137 trillion tons of standard coal produced by the heat, about 20,000 times the current global energy generated by the use of various sources of energy in a year. Solar energy in the conversion process does not produce pollution that endangers the environment. Solar energy resources are available worldwide and can be mined on a decentralized, regional basis. About 2/3 of

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China's regions can make good use of solar energy resources. Photovoltaic power generation is intermittent, generating electricity only when there is sunlight, and the amount of electricity generated is directly proportional to the strength of sunlight. Photovoltaic power generation is static operation, no moving parts, long life, no or very little maintenance required. Photovoltaic systems are modular and can be installed close to where electricity is consumed, reducing transmission and distribution costs and increasing the reliability of power supply facilities in areas far from the grid. This article summarizes several common solar cell power generation methods

2. Solar Power Technology

The following article outlines the main types of solar power in the world today and analyzes their advantages and disadvantages

2.1 Silicon Solar Cells

Monocrystalline silicon is the most widely used photovoltaic power generation material in the current photovoltaic market, and the preparation technology of monocrystalline silicon solar cells and their components has been developed for the longest time in photovoltaic power generation materials, and its industrialized preparation industry is the most mature in comparison.

The forbidden band width of the semiconductor determines the conversion efficiency of the solar cell, and the theoretical conversion efficiency limit value of the obtained monocrystalline silicon solar cell efficiency is 28%.

The University of New South Wales reported a high-efficiency drift field monocrystalline silicon cell prepared by liquid phase epitaxy, 4.11cm2 cell conversion efficiency of 16.4%, by thinning the substrate, strengthen the trapped light and other technical processing, in the standard condition of its conversion efficiency up to 24.7%. The monocrystalline silicon solar cell developed by Beijing Solar Energy Research Institute makes comprehensive use of various advanced technologies to increase the photoelectric conversion efficiency to 19.8%. [1]

In recent years, casting technology has achieved a large technological leap and is accompanied by a gradual improvement in the process of making polycrystalline silicon photovoltaic cells. Under the high level and fast rate of market demand growth of PV industry, not satisfied with the high production cost of monocrystalline silicon, polycrystalline silicon PV power generation material is gradually attached to researchers.

Through theoretical calculations obtained, the limit value of photovoltaic efficiency of polycrystalline silicon photovoltaic cells is 23%. In Germany Fraunhofer Association scientific and technical staff efforts, polycrystalline silicon solar cell photoelectric conversion rate achieved a breakthrough of 20.3%, which is also the current highest record of polycrystalline silicon photoelectric efficiency.

In 2006, Kyocera Japan made a cell efficiency of 18.5% of 15 × 15cm2 of large-area polycrystalline silicon cells, the application of PECVD-SiN technology to achieve the dual effect of reducing the reverse and passivation. It can be considered that the key issues to improve the photoelectric conversion efficiency of polycrystalline silicon photovoltaic cells are surface passivation, fleece surface structure and grain boundaries. [1]

2.2 Inorganic Solar Cells

Group III-IV compound semiconductor photovoltaic materials have the advantages of direct band gap and possessing a wide solar absorption band, which are well suited for photovoltaic power generation materials. In addition, the earth's minerals are rich in elements such as Cu, In, Se and Zn, and the available materials are widely sourced, enabling effective control of production costs and high processing efficiency. Based on these factors, leading solar cell researchers and industrial producers are focusing on inorganic photovoltaic power generation materials.

Copper indium selenide solar cells (CIS) were gradually developed in the 1980s as a type of polycrystalline thin-film cell. In view of its low cost, high efficiency, very similar to the stability of

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monocrystalline silicon solar cells and space radiation resistance and many other excellent characteristics, CIS cells have received widespread attention from photovoltaic workers around the world.

After more than 10 years of research, the German Institute of Solar Energy Technology has developed a new technology, namely, a new type of thin-film solar cell, which uses an electrodeposition continuous preparation process to produce a strip coil for thin-film solar cells on copper foil, and then assembles them into solar cells with soft characteristics through a very special encapsulation process.

The Japanese research institute invented a low-cost, safe and durable compound semiconductor film as an absorber layer to replace the original CIS cell base of rare metal materials, and to improve the conversion efficiency using the solar spectral bandwidth. [2]

In addition, nano-TiO2-based thin-film solar cells have attracted widespread attention in the world because of their unique working principle and low production cost.

2.3 Organic Solar Cells

In the field of photovoltaics, a new type of solar cell based on organic materials has emerged, known as "organic photovoltaics". Organic small molecule solar photovoltaic materials have the advantages of light weight, low cost, good chemical stability and easy preparation.

Janssen et al. prepared a class of P-N alternating copolymers by using perylenimide derivatives as N-type semiconductor materials and oligomeric phenylene vinylidene (OPV) as P-type semiconductor materials for the first time, but the charge transfer rate of these materials is low. Although perylene diimide type materials have the advantages of strong absorption in the visible region, high electron affinity energy, cheapness, and high optical and thermal stability, their low charge transfer efficiency limits their wide use in polymer solar cells.

Zhang et al. blended the polymer aromatic heterocyclic acceptor EHH-PPyPzV with MEH-PPV to make an intrinsic heterojunction cell with a photoelectric conversion efficiency of 0.03%. The energy conversion efficiency of the device still needs to be improved due to the low transmission capacity of the load. [3]

2.4 Graphene Solar Cells

Graphene as a black gold material has a wide range of promising applications in aerospace, energy, and materials science, and is regarded as a revolutionary material of the future. The unique two-dimensional structure of graphene gives it excellent electrical conductivity, good thermal conductivity, very high carrier mobility, and promising flexibility, making graphene a popular research direction for a new generation of photovoltaic power generation materials.

For example, researchers at the National University of Singapore reported an organic solar cell with graphene transparent conducting electrodes, systematically investigating the effects of graphene layers and graphene doping on the photovoltaic performance of solar cells.

Researchers from Tsinghua University reported for the first time that a graphene-based Schottky junction solar cell was prepared by covering a graphene film onto an n-type silicon wafer, and the device had significant photovoltaic properties and was tested to have a photovoltaic conversion efficiency of 1.65%.

Researchers at the Hong Kong Polytechnic University also constructed graphene-based Schottky junction solar cells by overlaying graphene films onto n-type GaAs substrates. [4]

2.5 Calcium Titanite Solar Cells

Among the new concept solar cells, chalcogenide solar cells have become a hot spot for current research because of their simple process, small mass, low price, good bendability and large area preparation. Because of its theoretical limit of up to 50% photoelectric conversion efficiency and attracted the high attention of domestic and foreign academic staff and manufacturers. Chalcogenide solar photovoltaic materials mainly include chalcogenide light-absorbing materials, hole-transporting materials, and electron-transporting materials. [5]

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In 2009, Miyasaka et al. in Japan reported for the first time an organic-lead halide photovoltaic conversion material with a chalcogenide structure. The photoelectric conversion efficiency of sensitized solar cells prepared from this material reached 3.81%.

In 2013, Snaith, who is a professor at Oxford University in the United Kingdom, developed a new type of all-solid-state chalcogenide solar cell in which the light-absorbing material of the solar cell consists of an organometallic halide chalcogenide structure. The invention is considered a groundbreaking new development in the field of chalcogenide photovoltaic materials.

In recent years, solar power generation technology represented by organic-inorganic composite chalcogenide materials has shown very bright prospects for industrialization. [6]

In this paper, the main developments of solar photovoltaic power generation around the world at this stage are analyzed, and the future development prospects are analyzed. By analyzing and summarizing the current stage of research status and problems, we can better carry out the subsequent research.

3. Conclusion

At present, solar power generation technology has the characteristics of direct photoelectric conversion, simple system structure, flexible development scale, less resource development constraints, diversified application forms and wide range of commercial applications, etc., while there are intermittent and unstable power generation output conditions. In the future, photovoltaic power generation technology will develop along the direction of improving solar cell efficiency, reducing solar cell cost and extending life, developing grid-friendly photovoltaic grid-connected technology, improving the controllability of large-capacity ground-based grid-connected photovoltaic power plants, and improving the stability of distributed photovoltaic microgrid technology. From the direction of technology application, it will develop along the direction of developing ground PV power plants and expanding the application scope of building PV. Overall, a variety of photovoltaic cell technology and application methods will coexist in the long term.

Despite the huge market potential of solar thermal power generation, at present, the global solar thermal power generation technology is still in the early stage of commercialization, and the relevant equipment and key technologies are still being perfected. The strategic significance of research and development of solar thermal power generation technology and equipment is much greater than the temporary economic benefits.

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