Preparation Method of Light Absorbing Layer of Perovskite Solar Cell

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Abstract. Perovskite cell is a new type of high-efficiency solar cell, which has the advantages of simple fabrication process and low production cost, and has a very broad prospect in the future market development. However, based on the current technology, perovskite cells still have problems that restrict their development and growth, mainly because they cannot guarantee the coexistence of high-efficiency conversion characteristics and stability, and the hysteresis effects of voltage and current and device stability are serious problems hinder the development of the industry. Therefore, it is necessary to optimize the preparation method of perovskite solar cells and solve the main problems affecting their stability during the using period to ensure that perovskite cells can be used efficiently and stably.

Keywords: Perovskite Cell; Preparation Method; Light Absorbing Layer.

1. Introduction

With the continuous development of today's industrial age, the rate of resource consumption on the earth is also increasing rapidly. In particular, non-renewable resources in nature such as coal, oil and natural gas are indispensable resources in human daily life. The exploitation of mine energy and coal energy has also caused environmental problems. If no effective method is taken to solve the energy problem, the human beings will also be affected by the shortage of energy in the future. Therefore, the development of clean, safe, widespreaded and sufficient energy is imminent. The perovskite solar cell studied in this paper is a clean and pollution-free cell energy, and has the characteristics of low cost, which is very suitable for promotion.

2. Generalization of Perovskite Solar Cells

Perovskite solar cells are a new discovery on the road of exploring environmental energy sources. They not only have the advantages of high photoelectric conversion efficiency and simple preparation methods, but also have a wide range of applications and adaptability. Therefore, they have attracted more and more people's attention. At present, researchers are still conducting in-depth research in the further improving the photoelectric efficiency of the solar cell. As early as 2013, the photoelectric conversion rate has reached 20.1%, which is the highest in the history of perovskite cell development. This exciting breakthrough, making people gradually believe that perovskite solar cells can have the similar photoelectric conversion efficiency of traditional monocrystalline silicon solar cells or even surpass it. Perovskite solar cells originated from traditional liquid dye-sensitized solar cells (DSSC). Because perovskite crystal materials have good light absorption properties and are also the main media of photoelectric conversion, this type of cell is also given the name of perovskite solar cell[1].

3. The Composition and Principle of Perovskite Solar Cells

3.1 The Composition of Perovskite Solar Cells

ITO/FTO conductive glass, electron transport layer (ETL), perovskite light-absorbing layer, hole transport layer (HTL) and metal counter electrode constitute a perovskite solar cell, of which the perovskite light-absorbing layer is the focus of this paper , the light-absorbing layer of perovskite solar cells will be introduced next.

The most special part of the perovskite layer structure is its excellent physical structure of insulation, ferroelectricity, superconductivity and anti-magnetism, and its ability to exhibit so many functional characteristics is due to the layer structure of its peculiar ABX3 crystal form.

3.2 The Principle of Perovskite Solar Cells

Perovskite solar cells are a type of solar cells, and the principle of solar cells is a process of converting light energy into electrical energy. As for the conversion of light, it needs to use some specific devices, the general conversion device can generate photoelectric effect or by using photovoltaic effect to convert solar energy into electrical energy for output. Thus, solar cells are also collectively referred to as photovoltaic cells or solar chips. The discovery of photoelectric effect can be traced back to 1887, when the famous German physicist Hertz discovered the phenomenon in an experiment. Following in-depth research, Einstein reasonably explained the photoelectric effect, that is, csome substances can generate excitation currents under the illumination of electromagnetic radiation waves at a certain limit, and the modern use of sunlight radiation photoelectric semiconductor substances for power generation is based on this principle.

Therefore, the photovoltaic mechanism of perovskite solar cells is also consistent with this. The surface of the perovskite layer is stimulated by high-frequency sunlight irradiation, so that electron holes are formed inside the perovskite structure, and the active excitons are continuously moving in the perovskite. Then separates inside the cell to form electrodes, and then connects to the external circulation circuit for electrical energy output[2].

4. Preparation Method of Perovskite Light-absorbing Layer

The perovskite light absorbing layer is the most important component of the perovskite solar cell, and its quality is a key factor affecting the photoelectric conversion efficiency and the performance of the cell device. Therefore, it is very important to optimize the preparation process of the perovskite light absorbing layer. The current methods for preparing high-quality perovskite light-absorbing layers to obtain high-efficiency photovoltaic devices include liquid-phase one-step method, liquid-phase two-step method, and gas-phase method.

4.1 Liquid Phase One-step Method

The principle of evaporative decomposition is the main principle of the liquid phase one-step method to fabricate the light-absorbing layer of perovskite thin films. The perovskite film formed after evaporative decomposition becomes more uniform and compact. It should be noted that the MAPbl3 material is easily decomposed in a high temperature environment of more than 350 °C, so when using MAPbl3 as an evaporation source, we must pay attention to adopting a dual-source decomposition method to evaporate and deposit it to avoid unnecessary losses during the decomposition process. The first person to prepare perovskite films using dual-source deposition was Professor Snow, but this method requires continuous vapor deposition of Pbl2 and MAI materials, respectively, to prepare high-quality perovskite films, so the preparation difficulty will increase[3].

4.2 Liquid Phase Two-step Method

The liquid-phase two-step method is a method of reducing the perovskite thin film to the surface layer of the light-absorbing layer by chemical reaction. It is difficult to control the quality of the film formation when using this method to prepare the solar cell light absorbing layer. The person who first proposed this method to prepare the solar cell light absorbing layer thin film is Professor Gratzel. The main preparation process is to deposit Pbl2 on the mesopores. The film is then immersed in the MAI solution to react to form a perovskite film. The conversion efficiency of the light-absorbing layer of the solar cell made by this method can reach 15%. After continuous optimization and improvement, a Pbl2 film was deposited on the plane of the light-absorbing layer, and then a high-concentration solution of MAI was added dropwise to be able to spin off quickly. Finally, a MAI surface layer was formed on the Pbl2 layer, which was heated at high temperature to intensify the reaction between them. The reaction can quickly form a uniform perovskite light-absorbing layer. In order to increase the quality and crystallinity of the perovskite layer, the perovskite film can be annealed in DMF solvent, and the perovskite grains can be rapidly crystallized and enlarged, by controlling the growth process of crystallization, the photoelectric conversion rate of the perovskite light-absorbing layer can be effectively improved. The two-step method can more effectively control the quality of the light-absorbing layer film than the one-step method, because the two-step method makes the surface morphology of the film easier to control, but the solution spin coating process is likely to cause surface pinholes and reduce the surface coverage. It is easy to cause direct contact between the ETL and the HTL, and finally the shunt and voltage reduction are generated, so the production efficiency is not high[4].

4.3 Vapor Phase Co-evaporation Deposition

The vapor phase co-evaporation deposition is a method of heating and evaporating materials in a high vacuum environment, and depositing a thin film to cover the surface during the evaporation process. The perovskite layer obtained by this method has high purity, and the grains are stacked tightly and uniformly, and the coverage rate is high. Therefore the surface of the film becomes smooth and uniform. However, due to the high equipment requirements used in this method, the preparation process will cause a large waste of materials, and the preparation environment has high requirements.

4.4 Vapor Phase Auxiliary Solution Deposition Method

Vapor phase auxiliary solution deposition is a method of obtaining a coating or a synthetic coating on the surface layer of the light-absorbing layer of a solar cell by chemical gas or steam. First, a chemical reaction needs to be carried out on the surface of the light-absorbing layer to form nucleation sites, and then these nucleation sites are used as a basis to continuously grow to form a thin film. The crystalline thin film formed in this way is flat and usually has a perfect structure and high quality. This method is greatly affected by the deposition rate, because the deposition rate affects the crystallization output during the reaction, so it will affect the quality of the light-absorbing layer. It must be carefully selected between a high deposition rate and a high-quality film. And due to the characteristics of the deposition reaction, the resulting perovskite film may also be deposited on other components, causing cleaning difficulties, etc[5].

4.5 Other Methods

In addition to the above preparation methods for the light-absorbing layer of perovskite solar cells, there are also some more special preparation processes. For example, through 3D printing technology, perovskite materials are melt-printed into thin films, by ultrasonic spraying technology, the perovskite material is directly sprayed to form a light-absorbing layer film, the perovskite thin film is prepared by the blade coating method. The surface of the light absorbing layer thin film prepared by this method is uniform and flat, and the grain size can even reach the micron level. The perovskite light-absorbing layers prepared by these methods can all have high photoelectric conversion efficiency, but because their preparation process is relatively complicated and cumbersome, they are not used much.

5. Conclusion

At present, perovskite solar cells have become a hot research topic in the solar cell industry. The cost is low, the preparation process is relatively simple, and it has the characteristics of high conversion efficiency. In order to solve the problem of human energy shortage in the future, it is necessary to deeply study and optimize the preparation method of the light-absorbing layer of solar cells.Therefore, in order to solve the problem of light, temperature and humidity, and lead toxicity, and to promote the further development of the commercial application of solar cells, it is necessary to optimize its preparation process and provide measures to ensure its stability, so that its use is more stable and the photoelectric conversion efficiency is higher.

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