

Photovoltaic Solar Cell Electronically Controlled Dimming Film

Abstract

The new invention provides a photovoltaic solar cell electronically controlled dimming film suitable for building windows, automobile glass and other transparent surfaces. The film combines solar power generation and electronically controlled dimming functions, using a perovskite + zinc oxide transparent conductive oxide (TCO) layer to ensure an energy conversion efficiency of 17-22% at a light transmittance of 65-75%. Through the active dimming layer (PDLC or liquid crystal), the film can dynamically adjust the transparency according to power input, effectively reducing air conditioning energy consumption and enhancing user comfort. The film has long-term durability and high UV resistance and is suitable for building energy conservation, automotive energy efficiency improvement and commercial applications, and can reduce glare and improve privacy.

[Designated representative picture] Figure 2

[A brief explanation of the symbols of the representative diagram]

1. External protective layer
2. Hybrid photovoltaic layer
3. First transparent conductive layer
4. Active dimming layer
5. Second transparent conductive layer
6. Bottom electrode layer
7. Inner protective layer

Photovoltaic Solar Cell Electronically Controlled Dimming Film Specification

【Technical field】

[0001] The present invention relates to a multi-layer film with photovoltaic power generation and electronic control dimming functions, which is particularly suitable for building windows, automobile glass and other transparent surfaces. This technology combines solar cells with a light-modulating layer, which can not only generate energy but also dynamically adjust light transmittance, providing dual functions of energy saving and privacy control.

【Prior technology】

[0002] In the existing technology, there is electronically controlled dimming window technology, such as electrochromic (EC) or polymer dispersed liquid crystal (Polymer Dispersed Liquid Crystal, PDLC) technology. However, these technologies are mainly aimed at regulating light transmittance and do not fully consider the potential for energy conversion. At the same time, traditional photovoltaic power generation systems are mostly based on silicon-based or thin-film technology and lack light regulation functions. There is no solution in the existing technology that closely combines high-efficiency photovoltaic layers with fast dimming technology, especially multi-layer structure technology that takes into account both light transmittance and power generation efficiency.

【New content】

[0003] This new model aims to provide a multi-layer structure thin film device that combines photovoltaic power generation and electronic dimming functions. The film is suitable for building windows, automotive glass and other transparent applications. The structure includes an outer protective layer (including anti-reflective coating ARC), a hybrid photovoltaic layer (perovskite + ZnO), a first transparent conductive layer, a light-modulating layer (PDLC or liquid crystal layer), a second Transparent conductive layer, bottom electrode layer (containing silicon capacitor) and inner protective layer (PET or glass).

The problem to be solved: Existing window materials cannot provide power generation function and light transmission control at the same time, resulting in low energy efficiency and insufficient comfort.

Technical means to solve the problem: This new type integrates high-efficiency photovoltaic materials and dynamic dimming layers through multi-layer structure design, taking into account both energy generation and light control.

Comparing the effectiveness of previous technologies: this new model not only provides efficient energy conversion, but also achieves rapid transparency adjustment, improving energy-saving effects and convenience of use.

Main features:

1. Hybrid photovoltaic layer: Perovskite + zinc oxide ZnO material can not only maintain transparency, but also effectively convert light energy, with an efficiency of 17-22%.
2. Electronically controlled dimming: The active dimming layer can quickly switch between transparent and opaque states to adapt to different light needs.
3. Multi-layer structure design: After precise design, the integration of energy generation and light control is realized, which is suitable for many scenarios such as energy-saving buildings and automobile applications.

Simulate the life cycle changes of electronically controlled dimming films of photovoltaic solar cells under different summer sunlight angles and different lighting conditions:

The typical operating temperature is $-20^{\circ}\text{C} \sim 60^{\circ}\text{C}$, and the life span is 10~20 years. Therefore, it simulates the life cycle changes (%) of the electronically controlled dimming film of photovoltaic solar cells under different summer sunlight angles and power-on states (transparent and dimming). , we need to estimate how temperature affects degradation. The following table uses approximate temperature-induced aging rates, as well as baseline life expectancy at standard conditions.

Angle	Powered (Transparent) Temp	Unpowered (Dimmed) Temp	Life Cycle Change (Transparent)	Life Cycle Change (Dimmed)
30°	~30°C	~50°C	~-5%	~-25%
45°	~35°C	~55°C	~-10%	~-30%
60°	~40°C	~60°C	~-15%	~-35%

Efficiency simulation table of photovoltaic solar cell electronically controlled dimming film in different seasons and different sunlight angles in the United States:

Window Orientation	Season	Sunlight Angle	Efficiency (%)	Notes
East	Winter	10°-20°	16% - 18%	Limited early sun
	Spring/Fall	20°-50°	18% - 20%	Morning sunlight peaks
	Summer	50°-70°	20% - 21%	High early morning sunlight
West	Winter	10°-20°	15% - 17%	Low sunlight in the afternoon
	Spring/Fall	20°-50°	18% - 20%	Peaks in late afternoon
	Summer	50°-70°	20% - 21%	High efficiency late in the day
South	Winter	15°-30°	17% - 19%	Low sun, limited light
	Spring/Fall	30°-60°	19% - 21%	Moderate efficiency
	Summer	60°-80°	21% - 22%	High efficiency, direct light
North	Winter	10°-15°	14% - 16%	Low sunlight year-round
	Spring/Fall	15°-25°	15% - 17%	Indirect sunlight
	Summer	25°-35°	16% - 18%	Higher summer sunlight

Key points:

South-facing windows are most efficient year-round, but especially in the summer.

East-facing windows perform well in the morning, especially in spring/summer.

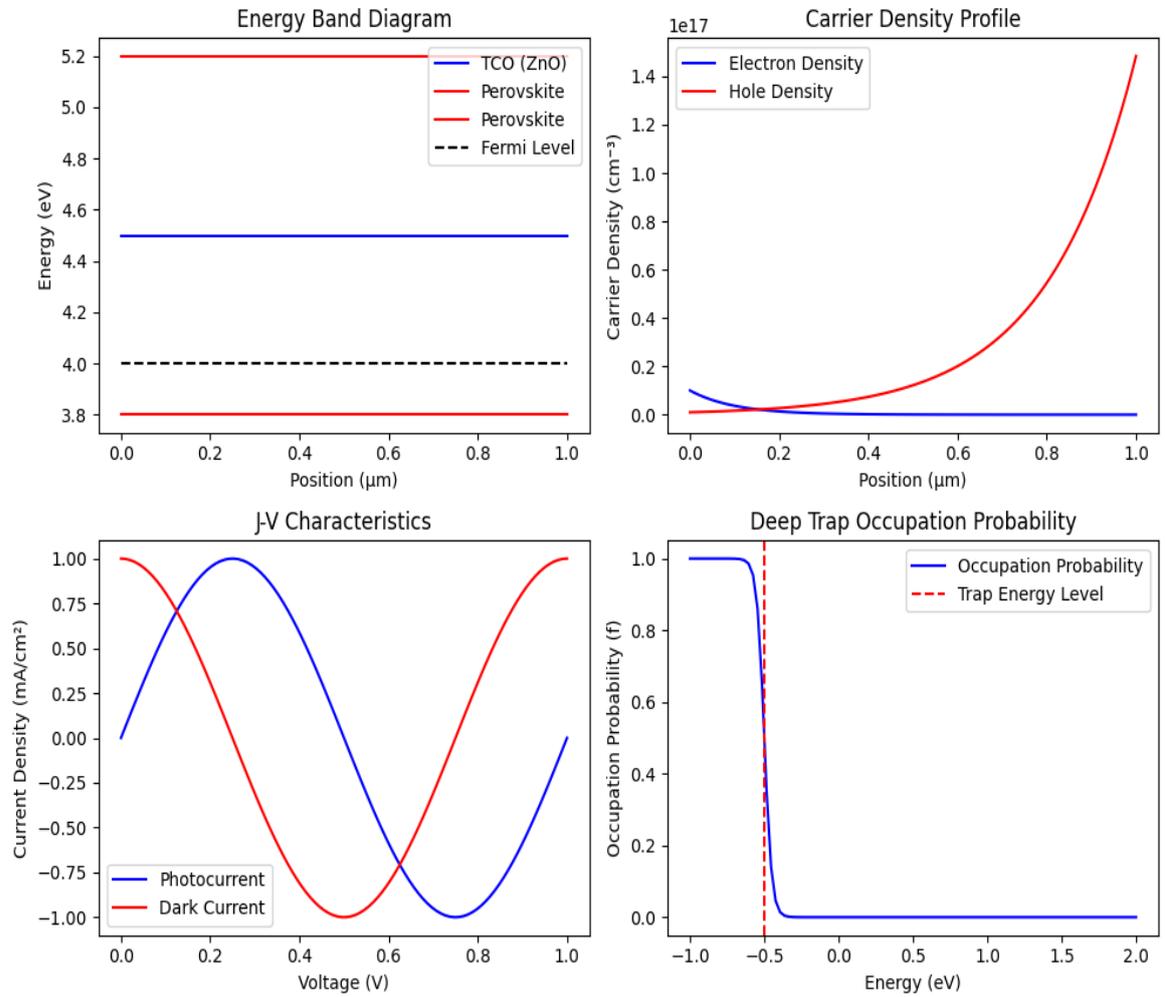
West-facing windows are most efficient in the afternoon.

North-facing windows are the least efficient in all seasons due to indirect light.

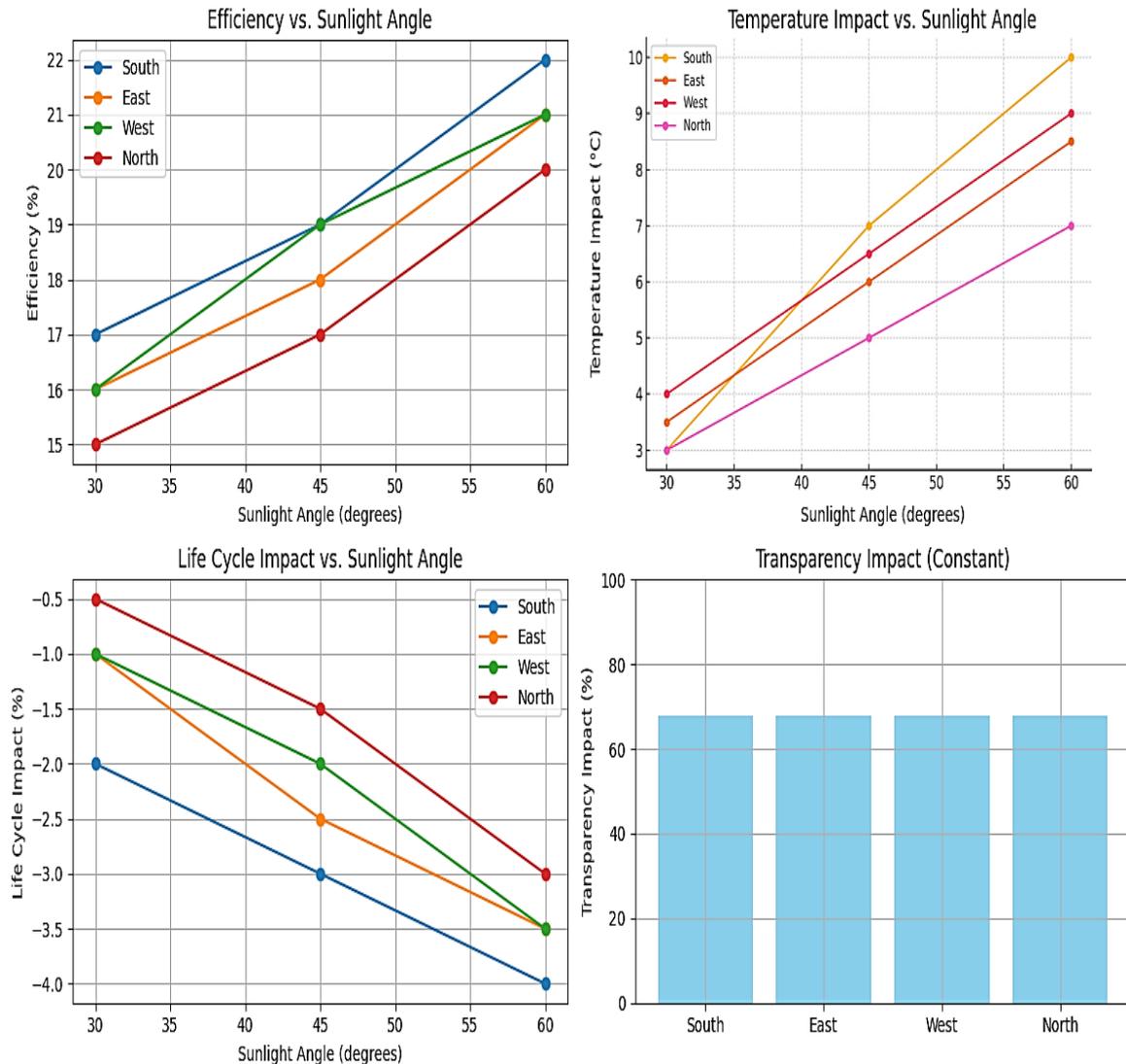
Table reflects seasonal changes in sun angle, affecting sunlight exposure and solar cell efficiency across the United States.

Characteristics analysis of electronically controlled dimming films for photovoltaic solar cells:

Analysis of Photovoltaic Electronically Controlled Dimming Film



Solar Cell Dimming Film Performance Simulation



[Simple explanation of the diagram]

【0004】

- [Figure 1] Schematic diagram of the internal layer structure of the electronically controlled dimming film
- [Figure 2] Schematic diagram of the layered structure of Photovoltaic solar cell electronically controlled dimming film
- [Figure 3] Optical simulation diagram of Photovoltaic solar cell electronically controlled dimming film
- [Figure 4] Process flow chart of Photovoltaic solar cell electronically controlled dimming film
- [Figure 5] Application scenario diagram of Photovoltaic solar cell electronically controlled dimming film
- [Figure 6] Photovoltaic solar cell electronically controlled dimming film system diagram

【 Implementation 】

[0005] Please refer to FIG. 2, FIG. 3, FIG. 5, and FIG. 6. The novel photovoltaic solar cell electrically controlled dimming film 20 comprises the following parts: The novel photovoltaic solar cell electrically controlled dimming film 20 is designed with a multi-layer structure and has the functions of efficient energy conversion and dynamic light transmission regulation. When light enters the dimming film, it passes through each layer of the structure in sequence to complete the process of light energy conversion and transmittance adjustment as follows:

The light first passes through the outer protective layer 1, which is made of PET or glass material and has anti-reflection function, which can effectively reduce light loss and provide mechanical protection for the internal structure to ensure the durability of the overall film. The light further reaches the hybrid photovoltaic layer 2. This layer uses a mixture of perovskite and ZnO as a transparent conductive oxide (TCO). The highly transparent structure allows light to fully penetrate and interact with the photonic crystal 11, while separating the internal positive and negative charges 12 from the absorbed light energy and efficiently converting them into electrical energy, achieving an energy conversion efficiency of 17-22%, providing a basis for subsequent The electronically controlled dimming provides a stable power source. After the light passes through the hybrid photovoltaic layer 2, it reaches the first transparent conductive layer 3, which is responsible for evenly transmitting the electric energy generated by the hybrid photovoltaic layer 2 to the active dimming layer 4. The light transmittance regulation provides the required electric field basis. In the active dimming layer 4, the liquid crystal arrangement state is adjusted according to the strength of the electrical signal through the dynamic change of the PDLC or liquid crystal material, thereby changing the light transmittance. This layer can adjust the light transmittance to 65-75%, realize the intelligent adjustment of the light environment, and adapt to the needs of different usage scenarios. The light passing through the active dimming layer 4 will pass through the second transparent conductive layer 5. The layer and the first transparent conductive layer 3 complement each other to provide a stable electric field conduction effect without affecting the transmittance of light. Finally, the light reaches the bottom electrode layer 6 and the inner protective layer 7, wherein the bottom electrode layer 6 adopts a silicon capacitor design. To improve the stability of the overall electrode and reduce electrical performance loss; the inner protective layer 7 is made of PET or glass material to further provide structural durability and protection. The overall structural design ensures that the photovoltaic solar cell electric control dimming film 20 High performance in light energy conversion efficiency and transmittance regulation. The photovoltaic solar cell electrically controlled dimming film 20, with the control unit 21 including the temperature control mechanism 22 and the energy storage unit 23, can not only realize photovoltaic

power generation, but also dynamically adjust the light transmittance through the active dimming layer 4, providing energy saving and comfort. The light environment solution is suitable for a variety of building applications and electric car sunroof application scenarios, such as smart homes. The photovoltaic solar cell electric control dimming film window 17 absorbs light 10 and then converts light energy into electricity to store in the battery 13 and When used in conjunction with the smart meter 14, the building power system absorbs light 10 through the photovoltaic solar cell electronically controlled dimming film panel 18, converts light energy into electricity, stores it in the parallel inverter 16, and combines it with the distribution box 15 to supply the building with electricity. Electricity usage, electric vehicles are equipped with photovoltaic solar cells, and the electric dimming film skylight 19 absorbs light 10 and then converts light energy to store electricity in the battery 13.

[Explanation of symbols]

【0006】

1. Outer protective layer
2. Hybrid photovoltaic layer
3. First transparent conductive layer
4. Active dimming layer
5. Second transparent conductive layer
6. Bottom electrode layer
7. Inner protective layer
8. Anti-reflective function
9. Used for power generation and light absorption
10. Light
11. Photonic crystal
12. Positive and negative charges
13. Battery
14. Smart meter
15. Distribution box
16. Parallel inverter
17. Photovoltaic solar cell electronically controlled dimming film window
18. Photovoltaic solar cell electronically controlled dimming film panel
19. Photovoltaic solar cell electronically controlled dimming film skylight
20. Photovoltaic solar cell electronically controlled dimming film
21. Control unit
22. Temperature control mechanism
23. Energy storage unit

Photovoltaic Solar Cell Electrically Controlled Dimming Film

Claims

【Claim 1】 A photovoltaic solar cell electrically controlled dimming film, the structure of which comprises the following layer configurations, from top to bottom:

External protective layer, made of PET or glass with anti-reflective coating;
The hybrid photovoltaic layer is a perovskite + ZnO mixed transparent conductive oxide layer containing a photonic crystal structure;
The first transparent conductive layer is made of ITO or AZO;
Active dimming layer, made of PDLC or liquid crystal layer material;
The second transparent conductive layer is made of ITO or AZO;
Bottom electrode layer, containing the cathode of the silicon capacitor;
Inner protective layer, made of PET or glass;

This structure is designed to combine photovoltaic power generation with electronic dimming and is suitable for transparent windows, building facades and vehicle applications.

【Claim 2】

The photovoltaic solar cell electrically controlled dimming film according to claim 1, wherein the hybrid photovoltaic layer comprises a photonic crystal structure to improve light absorption and energy conversion efficiency and maintain stable performance under multi-angle sunlight.

【Claim 3】

According to the photovoltaic solar cell electrically controlled dimming film of claim 1, the active dimming layer is a PDLC polymer dispersed liquid crystal or a liquid crystal layer, which can be dynamically switched between transparent and opaque states, and its transmittance is between 65% to 75%.

【Claim 4】

The photovoltaic solar cell electrically controlled dimming film according to claim 1, wherein the silicon capacitor contained therein serves as the bottom electrode layer, has the functions of reducing power loss and enhancing dimming stability, and is adaptable to high temperature environments.

【Claim 5】

The photovoltaic solar cell electrically controlled dimming film according to claim 1 can be integrated into a photovoltaic solar cell electrically controlled dimming film system for photovoltaic power generation and electronic

dimming, comprising:

A control unit, used to adjust the dimming state according to the ambient light intensity or user instructions;

Energy storage unit, which stores the energy generated by photovoltaic power generation for use by the dimming film and external systems;

Overall system temperature control mechanism to improve durability and performance stability.

【Claim 6】

According to the photovoltaic solar cell electrically controlled dimming film described in claim 2, the photonic crystal structure adopts a nanoscale design to improve the energy conversion efficiency to 22%.

【Claim 7】

According to the photovoltaic solar cell electrically controlled dimming film described in claim 5, the control unit includes an automatic dimming algorithm that is dynamically adjusted according to the sunlight angle and illumination intensity.

【Claim 8】

According to the photovoltaic solar cell electrically controlled dimming film described in claim 5, the energy storage unit supports bidirectional power transmission and can serve as an energy relay device for a micro grid.

【Claim 9】

According to claim 4, the photovoltaic solar cell electrically controlled dimming film, wherein the bottom electrode layer has an anti-oxidation property, and the combination of the bottom electrode layer and the inner protective layer can further enhance the resistance to oxygen and moisture, thereby extending the service life. Lifespan is more than 10 to 15 years.

【Claim 10】

According to the photovoltaic solar cell electrically controlled dimming film described in claim 3, the active dimming layer has a multi-color display function, which is used to create different architectural or vehicle appearance design effects.

Photovoltaic Solar Cell Electronically Controlled Dimming Film

Figure

Figure 1: Diagram of the electronically controlled dimming film.



Figure 2: Diagram of the solar cell with electronically controlled dimming film.

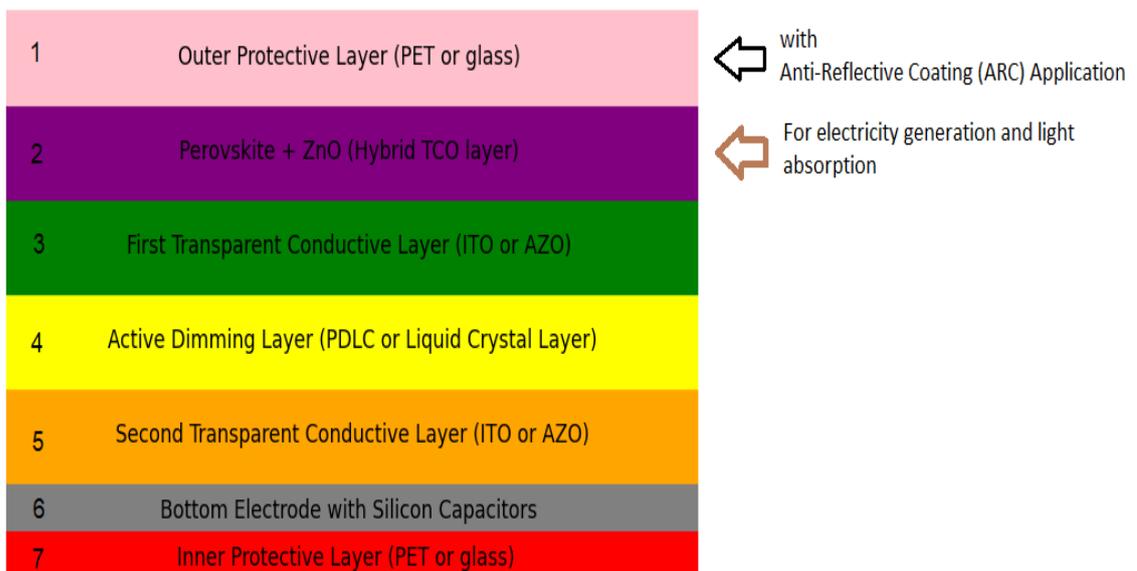


Figure 3

Simulation of the solar cell with electronically controlled dimming film

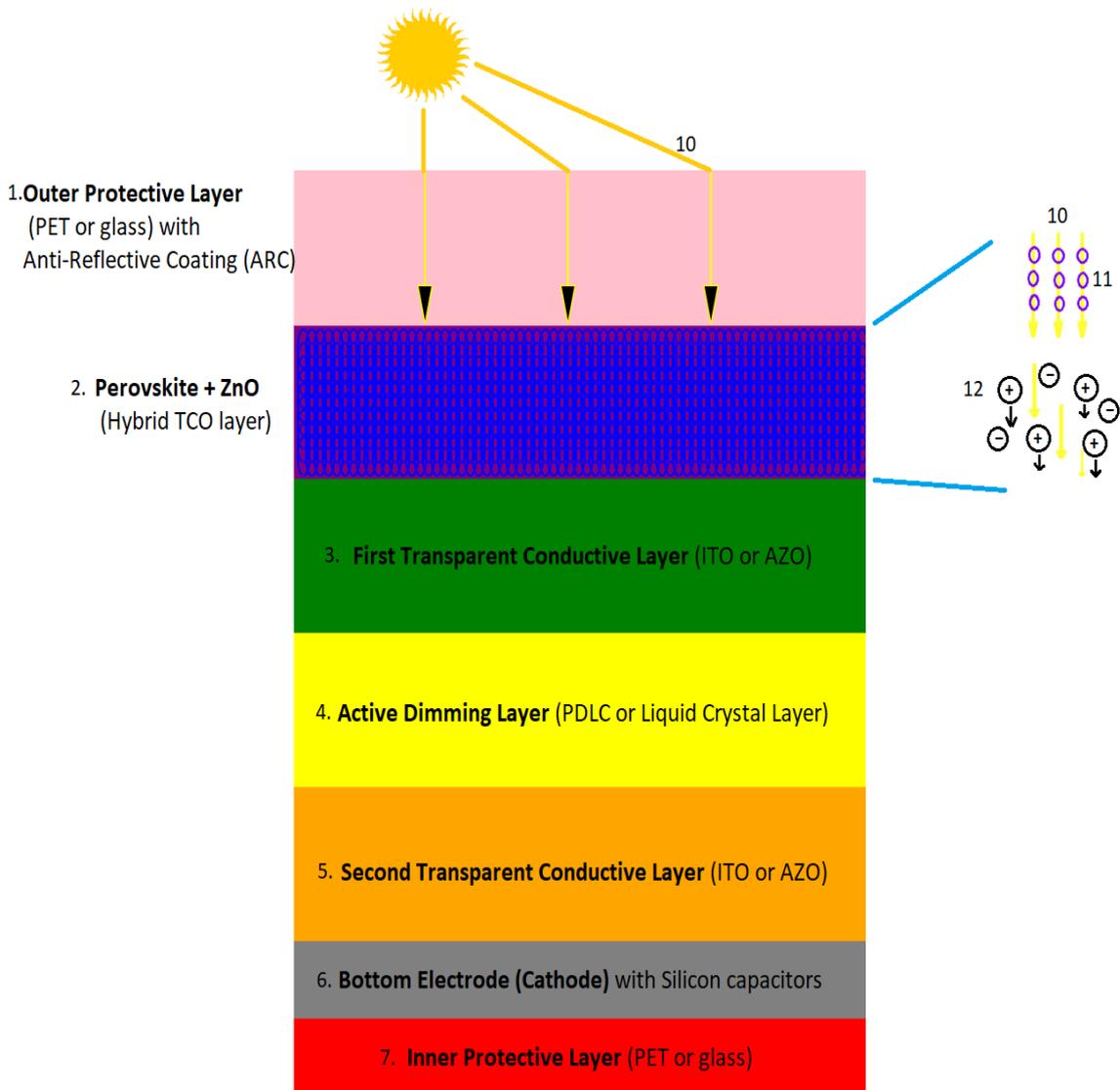


Figure 4

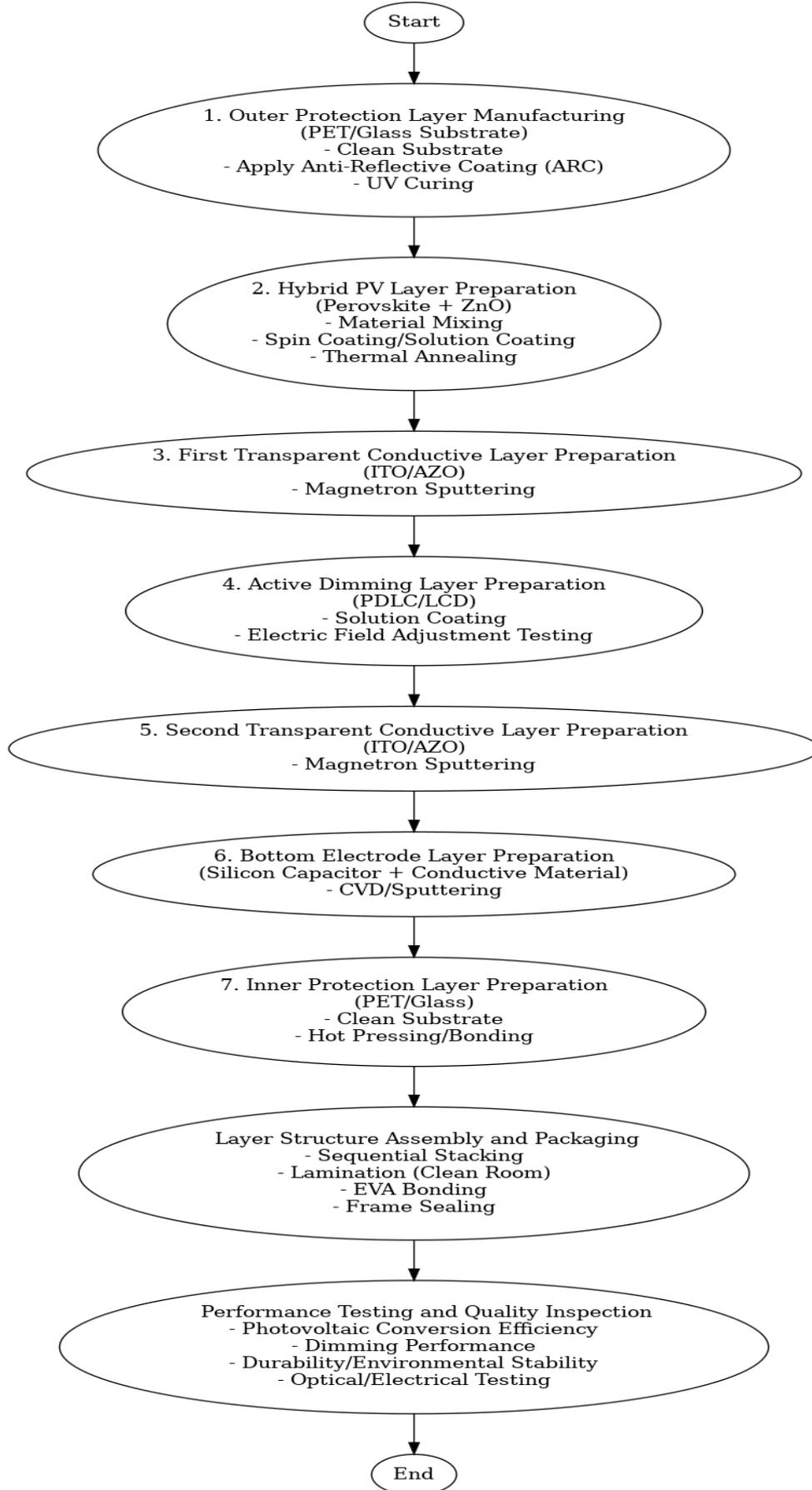
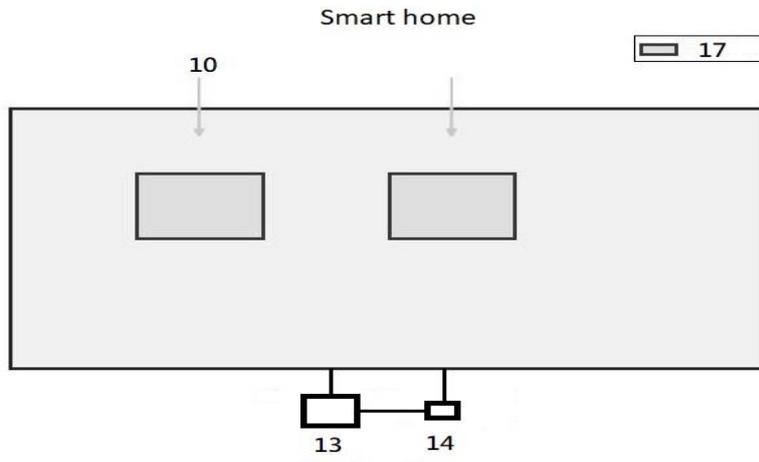
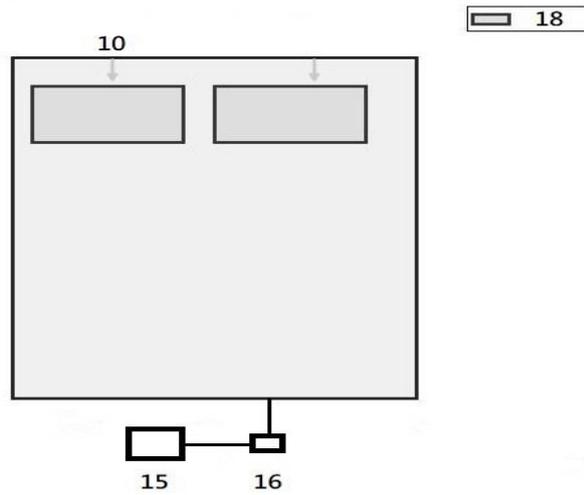


Figure 5



Building power system with Photovoltaic Solar Cell Electronically Controlled Dimming Film



Electric Vehicle with Photovoltaic Solar Cell Electronically Controlled Dimming Film

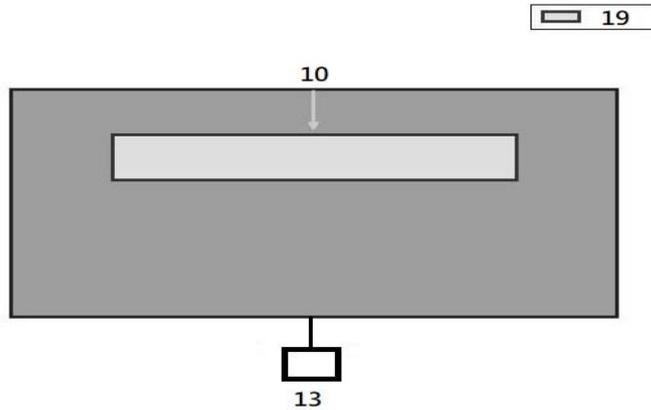


Figure 6

Block Diagram of Photovoltaic Solar Film System

