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Si-embedded metal oxide transparent solar cells

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ABSTRACT

Transparent photovoltaic (TPV) is the technology of solar cells to convert light to electric energy. Different from the typically dark or opaque solar cells, TPV is transparent by passing the visible range lights. Metal-oxide semiconductor TPV was developed for short ultraviolet (UV) utilization. The solid-phase sputtering method was applied to sequentially deposit p-type NiO onto n-type ZnO forming the electric field. The pristine metal-oxide TPV has strong absorption of UV but bears the inevitable limit of carrier collection. Extension of light-utilization is a pivot to enhance TPV performances. And thus, a thin Si film was embedded between p-NiO and n-ZnO to improve TPV performances according to the enhanced quantum efficiency as well as the extended absorbing light. The Si-embedded TPV has 40% transmittance to achieve the large open circuit voltage (0.6 V) and short circuit current density (2.8 mA/cm^2) values for high light-conversion efficiency of 4.8%. This may be the first report for the hybrid of Si-embedded metal-oxide heterojunction for TPVs. Si film would enhance the metal-oxide TPV performances due to the improved carrier collection efficiency and the extended light utilization for longer wavelengths. The inorganic TPV may be applied for the invisible power generator.

1. Introduction

Transparent photovoltaic (TPV) device is the solar cell having high transparency in the visible-range light. And thus, human beings may not recognize the existence of TPV entities but the electric energy is generated through the invisible power generator. This kind of invisible TPV may open a new era for on-demand energy supplying system, by being applied in windows of cell phones, displays, vehicles, and buildings [1–3].

According to the wavelengths, the visible-range light has the rainbow colors, which takes about 50% energy amount of the Sun spectrum. The human eyes can see the rainbow-colored visible spectrum, however, they are insensible for the short or long-wavelength lights, such as ultraviolet (UV) or infrared (IR). Due to the longer wavelength, IR light has less photon energy and is inefficient for the solar-driven light into the electric power generation. But the short UV wavelength light has strong photon energy, even may cause harmful effects to eye diseases and skin cancers [4–6]. Meanwhile, the strong UV absorption is effective in solar cell applications, with the additional benefit of reducing or removing the UV-induced damage to human health and materials.

Recently, researches for TPVs [7] have been focused on the solution-phase processes, typically in the type of organic [8–10], perovskite [11,12] and dye-sensitized [13] solar cells. However, the wet-type solar cells still have critical issues for the limited scale and low transparency. Moreover, the instability in the air environment has been a long assignment of solution-processed solar cells.

Due to the reliable performances, metal-oxide materials have been adopted for many electronic devices. In addition, the environmental friendly metal-oxides are usually non-toxic and favorably low-cost

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