Wavelength Conversion Particle

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1 Abstract

Among the many kinds of renewable energy, photovoltaic power generation has shown remarkable growth and is rapidly penetrating. The crystalline Si photovoltaic method is mainstream and its production volume is expected to increase steadily in future. However, the unit price for generated electricity must be reduced to facilitate the further penetration of photovoltaic power generation, and improving conversion efficiency and cutting costs have become urgent priorities for PV manufacturers and material suppliers. We developed Wavelength-Conversion Particles (WCP); applicable to PV module encapsulation sheets of the PV module and capable of reducing loss due to the spectrum mismatch between the sensitivity of the crystalline Si cell and sunlight, and achieving higher conversion efficiency.

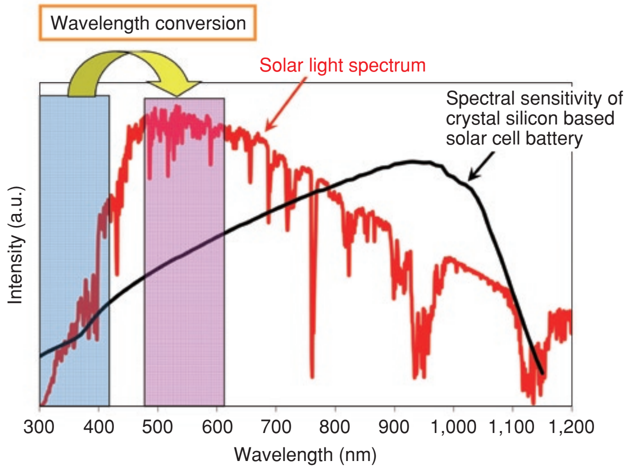

Figure 1 The solar spectrum and spectral sensitivity of the silicon crystal

2 Key New Product Features

- High wavelength conversion efficiency, providing long-term durability for PV modules.
- Good dispersibility in EVA sheets as well as retaining initial transparency, achieved by the composite particles consisting of acrylic resins and specialized phosphors.
- Existing PV module assembly lines can be adapted.

3 Development Background

In 2007, to utilize sun light effectively, we focused on fluorescent material capable of converting short-wavelength light (ultraviolet rays) to long-wavelength light (visible light) and started research work. In 2011, we analyzed the durability and optical scattering effect etc. and found WCP, which was phosphor contained inside acrylic resin particles, effectively improved wavelength-conversion efficiency (Figure 2).

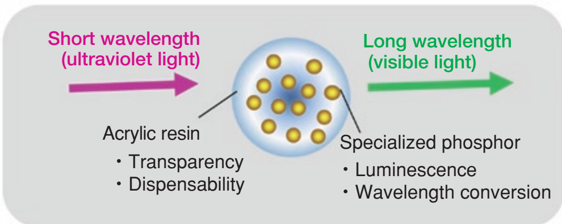

Figure 2 Acrylic resin capsules enhance the wavelength conversion

4 Technical Content

Table 1 and Figure 3 show the performance characteristics and exterior appearance of WCP respectively.

To start WCP development, we turned our attention to the excitation spectrum, phosphor intensity and fluorescence quantum efficiency of phosphor, sunlight spectrum, and spectral sensitivity of crystal silicon-based solar PV cells. Consequently, we found the phosphor effective in converting UV photons efficiently and improving the efficiency of crystal silicon-based solar PV cells. We also optimally exploited our own fine particle manufacturing technology to encapsulate phosphor with acrylic resin and adjust the diameters, distributions and in-capsule concentrations of its particles. WCP can be applicable to most currently used encapsulation sheets, including EVA (Ethylene-Vinyl Acetate), which is the mainstream option as well as olefin, ionomer and polyvinyl butyral-based resin sheets. Moreover, a wavelength-conversion function can also be imparted to the encapsulated sheet without a sheet manufacturing process by compounding WCP with other additives during the sheet manufacturing process. The solar PV battery module using an EVA encapsulation sheet as a light-receiving surface-side encapsulation material, which was imparted with the wavelength conversion function, improved conversion efficiency by a relative value of 2.2% compared to that using a conventional EVA encapsulation sheet. A reliability assessment result also showed a level equivalent to that using conventional EVA encapsulation sheets. Sales of this WCP material as WCP-I commenced in the first half of 2014 and were commercialized by one encapsulation sheet manufacturer (Figures 4 and 5).

Table 1 Property of Development Product

Item	Unit	WCP
Excitation wavelength	nm	300−400
Emission wavelength	nm	500−600
Emission color	—	Green color
Particle diameter	μm	90−110

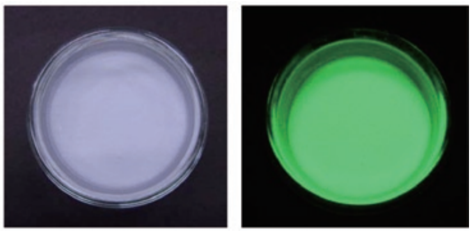

Figure 3 Appearance of wavelength conversion particle

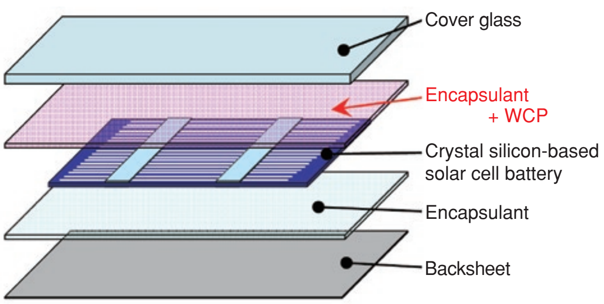

Figure 4 The photovoltaic module using WCP

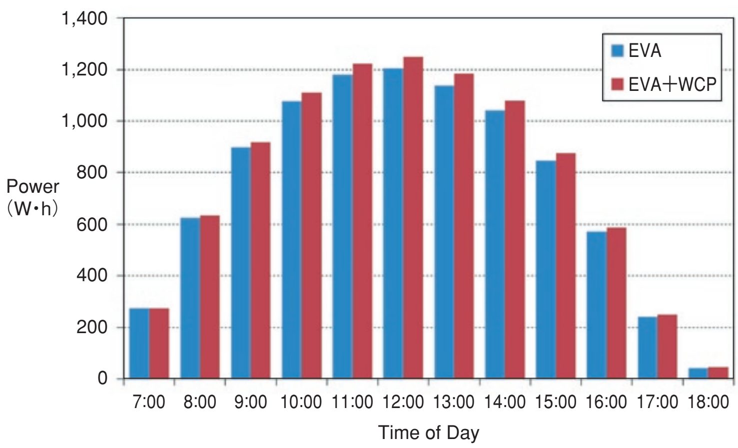

Figure 5 Exposure test of PV module with WCP

5 Future Business Development

- Development of next-generation high efficiency wavelength-conversion material
- Development of new applications to utilize the wavelength-conversion function (anticounterfeit, authenticity discrimination, optical element, etc.)

【Reference】

1) 2014, Solar Cell Battery and Related Technology, Prospects of the Current and Future Market, Fuji Keizai (2014)