1. Abstract

Thin-film solar cells optical scattering effects at rough layer interfaces are exploited to enhance the light absorption and make it possible to construct thin cells with inorganic materials such as a-Si or µc-Si [5]. SETFOS [2] is an optical and electrical device simulator, that is widely used in the OLED and OPV community. To perform an optical simulation of an arbitrary combination of inorganic or organic layers of any thickness, it is necessary to be able to treat light propagation both as coherent or incoherent.

We have therefore extended the optical model of SETFOS for the treatment of mixed systems of incoherent/coherent layers. We have broadened the scope of the simulator by including scattering effects at rough layer interfaces.

2. Incoherence

The ability of the incident light to interfere within the structure is expressed using the coherence length. Coherence within the structure can be reduced due to reflections at rough interfaces or in passing through bulk layers.

Figure 1: Amorphous silicon p-i-n solar cell used for the calculations.

The following layout was used in the simulations, as illustrated in Figure 1: Glass (1 mm), ITO (200 nm), p-a-Si (5 nm), i-a-Si (600 nm), n-a-Si (50 nm), Al (500 nm).

3. Effective Media Approximation

The effect of a rough interface can be approximated using a gradient in the effective refractive index. One introduces interlayers between layers with a rough interface which effectively reduces the reflectance of the interface [3].

Figure 2: Calculated absorbance for the a-Si solar cell. The glass and the intrinsic a-Si layer are treated as incoherent.

The following layout was used in the simulations, as illustrated in Figure 1: Glass (1 mm), ITO (200 nm), p-a-Si (5 nm), i-a-Si (600 nm), n-a-Si (50 nm), Al (500 nm).

4. Modified Fresnel Coefficients

The computed generation in the ITO, a-Si and Aluminium layer. For both short coherence length ($\sigma = 50$ nm) and surface roughness ($\sigma = 40$ nm) no interference fringes are visible in the a-Si layer.

To demonstrate the use of incoherence in a tandem structure, we calculate in Figure 8 the localized generation in the ITO, a-Si and Aluminium layer.

Three distinct simulation approaches are presented to model the optical scattering effects: Effective Media Approximation, incoherence and modified Fresnel coefficients in the Transfer-Matrix-Formalism for partial coherence. We assess and illustrate these methods using single-junction and tandem-aSi-based solar cells by calculating key figures such as the spectral layer absorbance and the localized generation.

References


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