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Simulation of a-Si/c-Si heterojunction solar cell

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A B S T R A C T

There is currently a lot of scientific research being done to increase the efficiency of solar cells. Because solar cells do not absorb photons with low energy beyond band gap energy and therefore, their efficiency is low. In order to absorb light from a wider spectrum, heterojunction must be created from materials with different band gap. In this paper, the photoelectric parameters of the a-Si/c-Si heterojunction solar cell formed from amorphous silicon with a band gap energy of 1.5 eV and crystalline silicon with a band gap energy of 1.12 eV were studied.

Keywords:solar cell, heterojunction, simulation, thickness, absorption, photogeneration

1. Main text

Heterojunction solar cell living technology has been introduced to increase the efficiency of solar cells. HIT technology has been developed by Japanese scientists and is now widely used in industry. Because through HIT technology, the efficiency of silicon-based solar cells has been increased to 28%. In HIT technology, the upper and lower parts of crystalline silicon with special conductivity are coated with amorphous silicon. Figure 1 shows a heterojunction solar cell with a HIT structure.

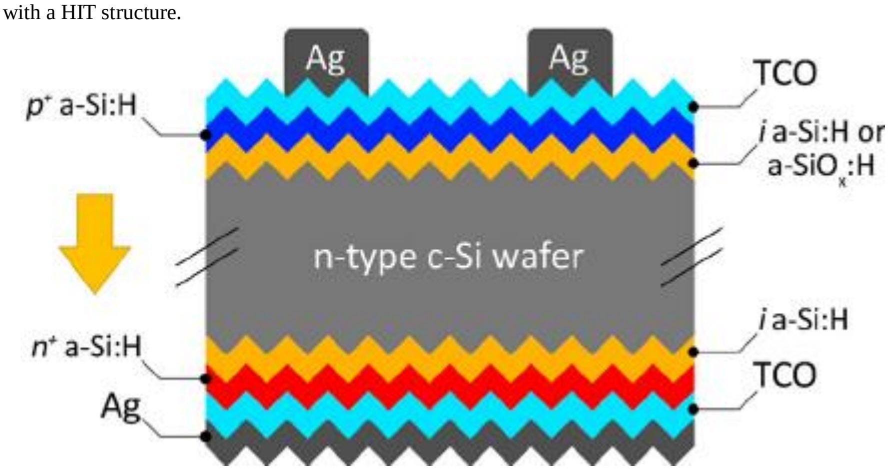

Figure 1. Solar cell (HIT) formed by the heterojunction of amorphous and crystalline silicon

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Considering the structure, the crystal is coated with amorphous silicon with special conductivity at the top and bottom of the silicon. The purpose is to passivate the surface of crystalline silicon [1], because hydrogenated amorphous silicon has the property of passivating the surface of crystalline silicon. The function of amorphous silicon with n and p-type conductivities is to separate the electron cavity pairs formed in crystalline silicon and to ensure that they reach contact [2]. In the formation of HIT solar cells, amorphous silicon is deposited on the surface of crystalline silicon, and its deposition temperature is much lower than the growth temperature of conventional solar cells [3]. Studies on hit solar cells have shown that its temperature stability is better than that of crystalline silicon-based solar cells. That is why these HIT solar cells are recognized as an alternative to traditional crystal silicon sauce solar cells. To know the principle of operation of HIT solar cells, it is necessary to draw its zonal diagram. Figure 2 shows a zonal diagram of the HIT solar cell. This solar element also has a number of shortcomings. For example, cavities encounter a potential barrier to the transition from crystalline silicon to amorphous silicon, and only cavities with energy up to this potential barrier can cross this barrier. The pits face a potential barrier between relatively small crystalline silicon and n amorphous silicon. Also, only electrons with energy greater than the height of this barrier can cross the barrier. There are potential barriers for electrons and cavities that do not allow them to move in the opposite direction, so they only try to move in their own direction [4]. Due to the potential differences between crystalline silicon and p amorphous silicon and crystalline silicon and n amorphous silicon, the salinity and efficiency of the solar cell are also reduced.

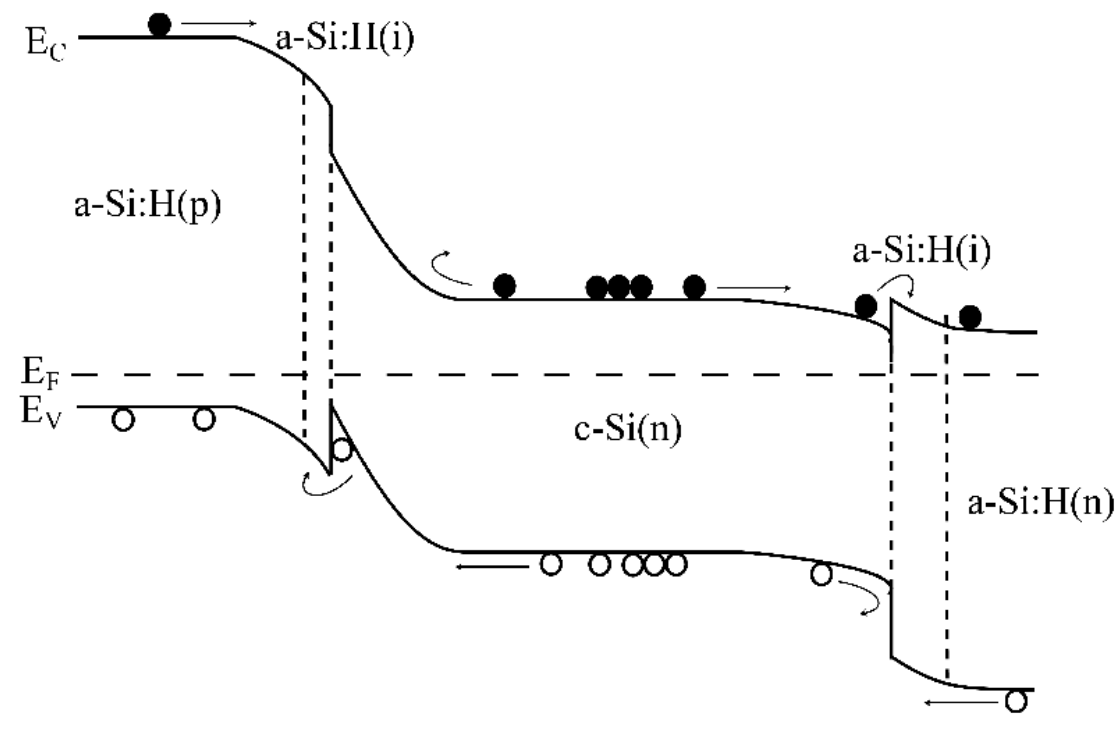

Figure 2. Band structure of the HIT solar cell

Modeling heterojunction solar cells is a complex process [5] because it is difficult to create a quality p-n junction. In this dissertation, we have repeatedly tried to model HIT solar cells in the SCAPS-1D program, but failed to achieve a clear result. Each time he made a mistake in determining the potential. We therefore limited ourselves to modeling the optical properties of this solar cell using PVLIGHTHOUSE's Wafer Ray Tracer module.

We first determined the optical properties of a simple n-a-Si/p-Si structural single-transition solar cell. Figure 3. The dependence of the absorption, transition, and return coefficients of the n-a-Si/p-Si solar cell with an a-Si layer thickness of 100 nm on the wavelength of light is described. Amorphous silicon-based solar cells have been found to absorb radiation mainly in the wavelength range of 300-700 nm. Crystal silicon, on the other hand, was found to absorb light in the visible field, which is close to infrared. the n-a-Si / p-Si solar cell, on the other hand, found that the main light absorption coefficients were mainly in the wavelength range of 600–1000 nm. The transition coefficient is very low but the light reflection coefficient is very high, which means that the light reflection coefficient at the amorphous silicon and air boundary is greater than the light reflection coefficient at the air and crystalline silicon boundary.

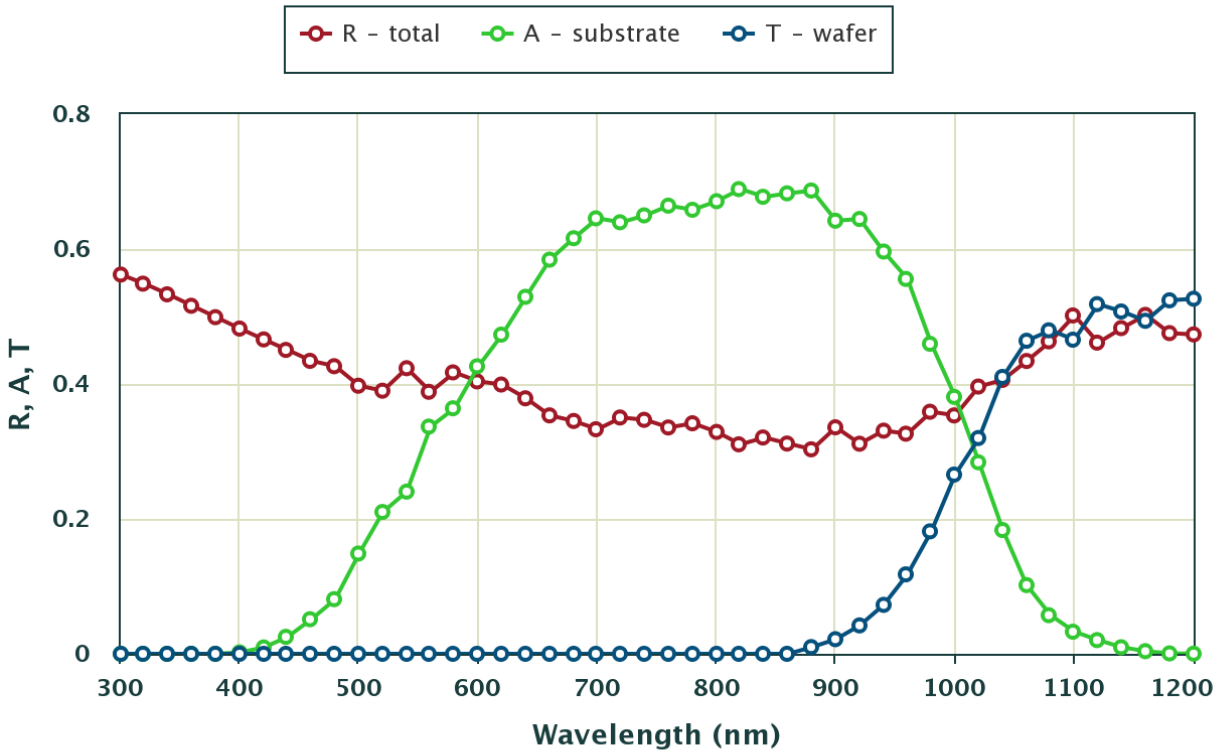

Figure 3. The dependence of the absorption, transition and return coefficient of the solar cell n-a-Si/p-Si with a layer thickness of 100 nm on the wavelength of light.

This is because the refractive index of amorphous silicon is higher than that of crystalline silicon, because the greater the difference between the refractive indices of the two media, the greater the reflection coefficient at the intersection. Amorphous silicon is mostly very thin because it is grown on silicon. Therefore, the dependence of the photogeneration coefficient of the solar cell n-a-Si / p-Si on the thickness of amorphous silicon was studied. Table 1 shows that the photogeneration coefficient of the n-a-Si / p-Si solar cell depends on the thickness of the a-Si layer. The best result was obtained in the thinnest layer of amorphous silicon, which was 39.61%. In addition, as the thickness of the amorphous silicon increases, the photogeneration coefficient increases and decreases, due to the fact that the phenomenon of interference occurs within the amorphous silicon layer depending on the thickness.

Table 1. The dependence of the photogeneration coefficient of the n-a-Si/p-Si solar cell on the thickness of the a-Si layer

2. a-Si thickness, mkm	3. Photogeneration
4. 0.1	5. 39.61
6. 0.2	7. 35.92
8. 0.3	9. 38.59
10. 0.4	11. 32.94
12. 0.5	13. 31.65
14. 0.6	15. 30.74
16. 0.7	17. 30.33
18. 0.8	19. 29.90
20. 0.9	21. 29.14
22. 1	23. 29.09

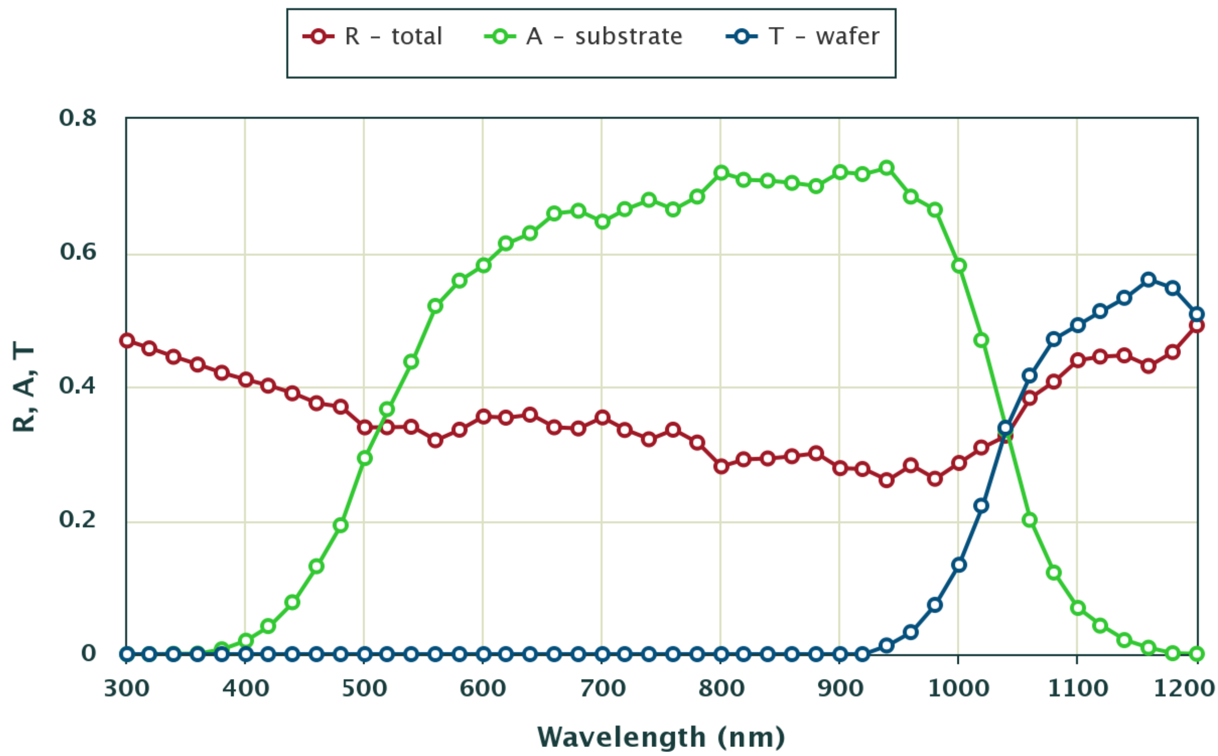

Figure 4. Dependence of the transition, absorption and return coefficients of a simple planar HIT structural solar cell on the wavelength of light

A planar HIT structured solar cell with amorphous layer thickness of 100 nm and crystalline silicon thickness of 200 μm was modeled. Figure 4 illustrates the dependence of the transition, absorption, and return coefficients of a simple planar HIT structural solar cell on the wavelength of light. It has been found that the absorption spectrum in the visible field is wider than the absorption spectrum of a normal heterojunction solar cell.

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