

## Plasmonic Enhanced Light Absorption by Silver Nanoparticles Formed on Both Front and Rear Surface of Polycrystalline Silicon Thin Film Solar Cells

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The manufacturing cost of thin-film photovoltaics can potentially be lowered by minimizing the amount of a semiconductor material used to fabricate devices. Thin-film solar cells are typically only a few micrometers thick, whereas crystalline silicon (c-Si) wafer solar cells are 180~300  $\mu\text{m}$  thick. As such, thin-film layers do not fully absorb incident light and their energy conversion efficiency is lower compared with that of c-Si wafer solar cells. Therefore, effective light trapping is required to realize commercially viable thin-film cells, particularly for indirect-band-gap semiconductors such as c-Si. An emerging method for light trapping in thin film solar cells is the use of metallic nanostructures that support surface plasmons. Plasmon-enhanced light absorption is shown to increase the cell photocurrent in many types of solar cells, specifically, in c-Si thin-film solar cells and in poly-Si thin film solar cell. By proper engineering of these structures, light can be concentrated and coupled into a thin semiconductor layer to increase light absorption. In many cases, silver (Ag) nanoparticles (NP) are formed either on the front surface or on the rear surface on the cells. In case of poly-Si thin film solar cells, Ag NPs are formed on the rear surface of the cells due to longer wavelengths are not perfectly absorbed in the active layer on the first path. In our cells, shorter wavelengths typically 300~500 nm are also not effectively absorbed. For this reason, a new concept of plasmonic nanostructure which is NPs formed both the front - and the rear - surface is worth testing. In this simulation Al NPs were located onto glass because Al has much lower parasitic absorption than other metal NPs. In case of Ag NP, it features parasitic absorption in the optical frequency range. On the other hand, Al NP, which is non-resonant metal NP, is characterized with a higher density of conduction electrons, resulting in highly negative dielectric permittivity. It makes them more suitable for the forward scattering configuration. In addition to this, Ag NP is located on the rear surface of the cell. Ag NPs showed good performance enhancement when they are located on the rear surface of our cells. In this simulation, Al NPs are located on glass and Ag NP is located on the rear Si surface. The structure for the simulation is shown in figure 1. Figure 2 shows FDTD-simulated absorption graphs of the proposed and reference structures. In the simulation, the front of the cell has Al NPs with 70 nm radius and 12.5% coverage; and the rear of the cell has Ag NPs with 157 nm in radius and 41.5% coverage. Such a structure shows better light absorption in 300~550 nm than that of the reference cell without any NPs and the structure with Ag NP on rear only. Therefore, it can be expected that enhanced light absorption of the structure with Al NP on front at 300~550 nm can contribute to the photocurrent enhancement.

**Keywords:** Plasmonic, light trapping, polycrystalline silicon

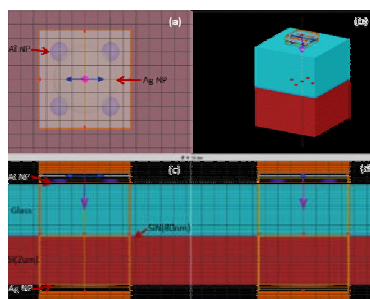


Fig. 1.

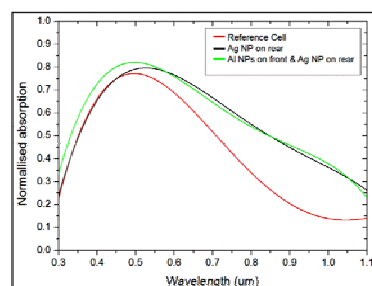


Fig. 2.