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Improving the performance of thin-film silicon solar cells by optimizing anti-reflection layers and analyzing structural defects using the FDTD method

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Abstract

Light reflection is one of the main factors that reduces the efficiency of silicon solar cells. In conventional thick silicon cells, anti-reflection structures such as textured surfaces are used, but this method is not effective for new generation thin-film cells with a thickness of approximately 3 μm. In this study, silicon thin-film cells with a single anti-reflection layer (Si_3N_4) and a double anti-reflection layer (MgF_2/Si_3N_4) were simulated using the finite difference time domain (FDTD) numerical method. The results showed that, for the cell with a single-layer coating, the lowest reflection is achieved when the thickness of the Si_3N_4 layer is 62 nm. In the double-layer structure of MgF_2/Si_3N_4, the most optimal thicknesses were 112 and 62 nm, respectively. In addition, the electrical performance of the cell was carried out in two ideal (defect-free) and real (taking into account volumetric and surface defects) states. The electro-optical analysis showed that the presence of defects can reduce the cell efficiency by about 50% compared with the ideal state.

Keywords: Thin-film silicon solar cell, Electro-optical simulation, Anti-reflective layer, Volume defect, Surface defect

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