Materials Science & Engineering Doctoral Defense

Silicon thin-film contacts to crystalline silicon solar cells

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Abstract

The application of silicon thin films in solar cells has evolved from their use in amorphous silicon solar cells to their use as passivating and carrier-selective contacts in crystalline silicon solar cells. Their use as carrier-selective contacts has enabled crystalline silicon solar cell efficiencies above 26%, just 3% shy of the theoretical efficiency limit. The two cell architectures that have exceeded 26% are the silicon heterojunction and tunnel oxide passivating contact cell. These two cell architectures use two different forms of silicon thin films. In the case of the silicon heterojunction, the crystalline wafer is sandwiched between layers of intrinsic amorphous silicon, which acts as the passivation layer, and doped amorphous silicon, which acts as the carrier-selective layer. On the other hand, the tunnel oxide passivating contact cell uses a thin silicon oxide passivation layer and a doped polycrystalline silicon layer as the carrier-selective layer. Both cell structures have their distinct advantages and disadvantages when it comes to production. The processing of the silicon heterojunction relies on a low thermal budget and leads to high open-circuit voltages, but the cost of high-vacuum processing equipment presents a major hurdle for industrial scale production while the tunnel oxide passivating contact can be easily integrated into current industrial lines, yet it requires a higher thermal budgets and does not produce as high of an open-circuit voltage as the silicon heterojunction. This work focuses on using both forms of silicon thin films applied as passivating and carrier-selective contacts to crystalline silicon thin films.

First, a thorough analysis of the series resistivity in silicon heterojunction solar cells is conducted. In particular, variations in the thickness and doping of the individual contact layers are performed to reveal their effect on the contact resistivity and in turn the total series resistivity of the cell. Second, a tunnel oxide passivated contact is created using a novel deposition method for the silicon oxide layer. A proof-of-concept device is presented demonstrating the potential of this deposition method. Finally, future work is presented in improving the tunnel oxide passivating contact.

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