Materials Science & Engineering Doctoral Defense

Metallization and Interconnection Concerns for Silicon Photovoltaic Cells and Modules

School for Engineering of Matter, Transport and Energy

Barry Hartweg

Advisor: Zachary Holman

Abstract

The metallization and interconnection of Si photovoltaic (PV) devices are among some of the most critically important aspects to ensure the PV cells and modules are cost-effective, highly-efficient, and robust through environmental stresses. The aim of this work is to contribute to the development of these innovations to move them closer to commercialization.

Shingled PV modules and laser-welded foil-interconnected modules present an alternative to traditional soldered ribbons that can improve module power densities in a cost-effective manner. These two interconnection methods present new technical challenges for the PV industry. This work presents x-ray imaging methods to aid in the process-optimization of the application and curing of the adhesive material used in shingled modules. Further, detailed characterization of laser welds, their adhesion, and their effect on module performances is conducted. A strong correlation is found between the laser-weld adhesion and the modules' durability through thermocycling. A minimum laser weld adhesion of 0.8 mJ is recommended to ensure a robust interconnection is formed.

Detailed characterization and modelling are demonstrated on a 21% efficient double-sided tunnel-oxide passivating contact (DS-TOPCon) cell. This technology uses a novel approach that uses the front-metal grid to etch-away the parasitically-absorbing poly-Si material everywhere except for underneath the grid fingers. The modelling yielded a match to the experimental device within 0.06% absolute of its efficiency. This DS-TOPCon device could be improved to a 23.45%-efficient device by improving the optical performance, n-type contact resistivity, and grid finger aspect ratio.

Finally, a modelling approach is explored for simulating Si thermophotovoltaic (TPV) devices. Experimentally fabricated diffused-junction devices are used to validate the optical and electrical aspects of the model. A peak TPV efficiency of 6.8% is predicted for the fabricated devices, but a pathway to 32.5% is explained by reducing the parasitic absorption of the contacts and reducing the wafer thickness. Additionally, the DS-TOPCon technology shows the potential for a 33.7% efficient TPV device.

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Zoom Link: https://asu.zoom.us/j/5937837327