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The New Age of Silicon Photovoltaic Modules: Optimisation with Half cells, Ribbons, Films, Wires …

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Abstract

Silicon solar cells have been interconnected by soldering and laminated into modules using essentially the same process as used in the 1970's. However, as solar cell efficiencies have gradually increased, the larger photocurrents result in efficiency-limiting resistive losses and consequently new approaches which can achieve higher module efficiencies are being sought. Photovoltaic module manufacturers are currently exploring a wide range of alternative module technologies that can potentially achieve higher energy conversion at a competitive cost. These technologies range from half-cell, shingled modules, modules with flat ribbons having light redirecting surfaces or films, round wires and triangular wires. The question is how best to decide what technology to use. Is it module power under standard test conditions or electricity yield in the field that is important? Increased durability can also help reduce the levelised cost of electricity through increased module operating lifetime, so how can the durability of all these new module technologies be quickly assessed without necessitating expensive experimental validations of these new technologies?

This presentation will explore this question in light of the research which is being conducted as part of ARENA funded project 2017/RND002 in partnership with ribbon/wire producer Sizhuo PVTech (Hebei province, China), silicon PV module producer LONGi Solar (Jiangsu province, China), DSM Advanced Solar (Geleen, Netherlands) and researchers from Australian National University and ECN (part of TNO) in the Netherlands. In particular, we will consider the balance between the optical enhancement in modules that can be achieved by using the light redirecting surfaces of ribbons and wires in balance with both the electrical resistance losses and possible implications with regard to the thermomechanical stress introduced in the silicon wafers by different wire and ribbon shapes during interconnection and lamination.

Supporting Information

Photovoltaic module manufacturers are currently exploring a range of alternative module technologies in order to achieve higher energy conversion at a competitive cost. These technologies range from use of half-cells, modules with flat ribbons with light redirecting films [1], round wires [2-4] and triangular wires [5]. However, this is a complex optimisation process that must consider: (i) the effects of optical enhancements due to redirection and scattering of light incident on the interconnection metal; (ii) the resistive losses due to current flow in the cell and module metallisation; and (iii) the thermomechanical stress that interconnection schemes can induce in the silicon wafers of modules. To-date, the third factor has often been ignored. In this presentation we will highlight that optimisation strategies which do not consider the stress that some wire shapes potentially induce in the silicon wafers may limit module durability and restrict further cost savings in terms of use of thinner wafers [6].

Figure 1 shows the predicted STC power gain and electricity yield gain of half-cell PERC cell modules with different interconnection metal geometries (compared to reference half-cell modules with flat ribbons). Figure 2 shows the maximum simulated thermomechanical stress in silicon wafers of the modules interconnected by different ribbon/wire geometries.

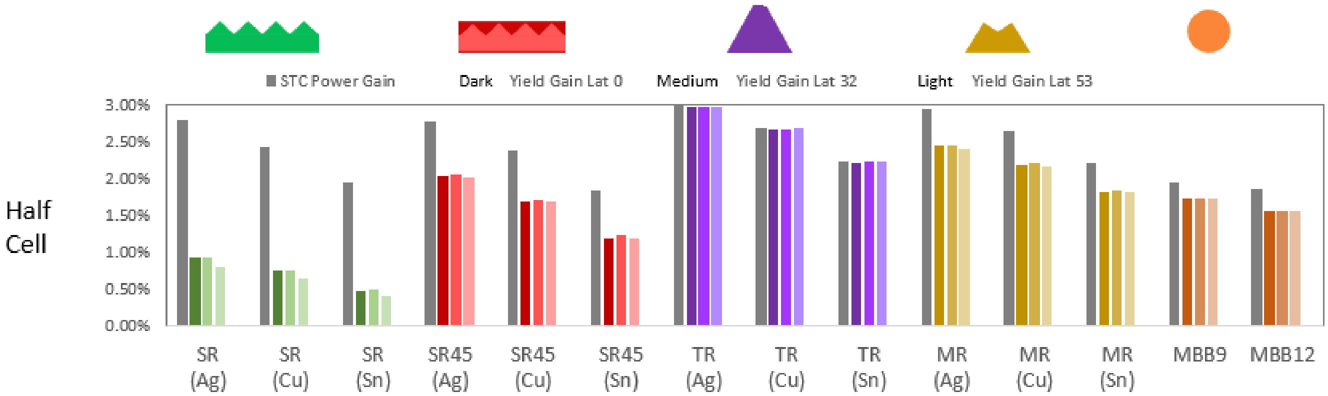

Figure 1. Percentage STC power gain and electricity yield (kWh) for latitudes 0° (dark), 32° (medium) and 53 (light) for half-cell modules with reference to a 5BB half-cell module.

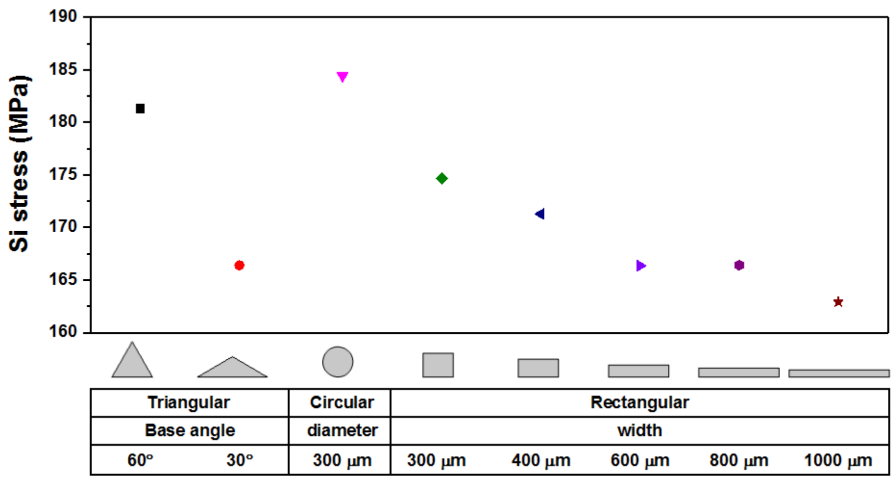

Figure 2. Maxiumum thermomechanical stress induced in silicon wafers by interconnection using different wire/ribbon cross-sectional shapes. All shapes have the same cross-sectional area.

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