Silicon Cracking in Plated c-Si Solar Cells

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Introduction

Several batches of C-Si solar cells were processed through electrolytic plating for deposition of Cu bus bars and finger grids in TetraSun's pilot line.

The solar cells were subsequently tabbed with both manual and automated soldering process for the fabrication of small modules.

EL imaging of the tabbed solar cells shows that some portions of the device are electrically disconnected. This is leading to a severe reduction of the expected module output power (Figure 1).

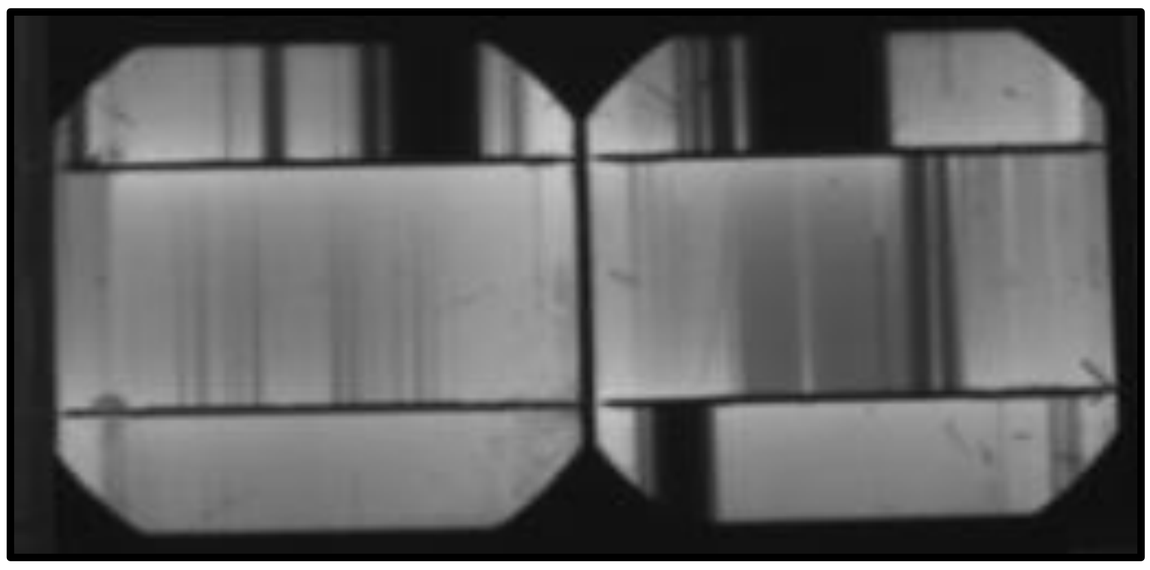


Figure 1: EL image of two tabbed solar cells showing electrically disconnected areas within the device

Pull Test Data

Some solar cells were prepared with PV ribbon soldered to the bus bars. These cells were first inspected with EL imaging and then sorted in defected cells and defect free cells. EL images of defected cells were showing the characteristic signature of the electrically disconnected areas while a typical EL image of defect free cells is shown in Figure 2. A standard pull test was completed on both groups of solar cells. The pull test data of defected solar cells is very different with respect to defect free cells. A comparison of the pull test for defected cells and defect free cells is show in in Graph 1.

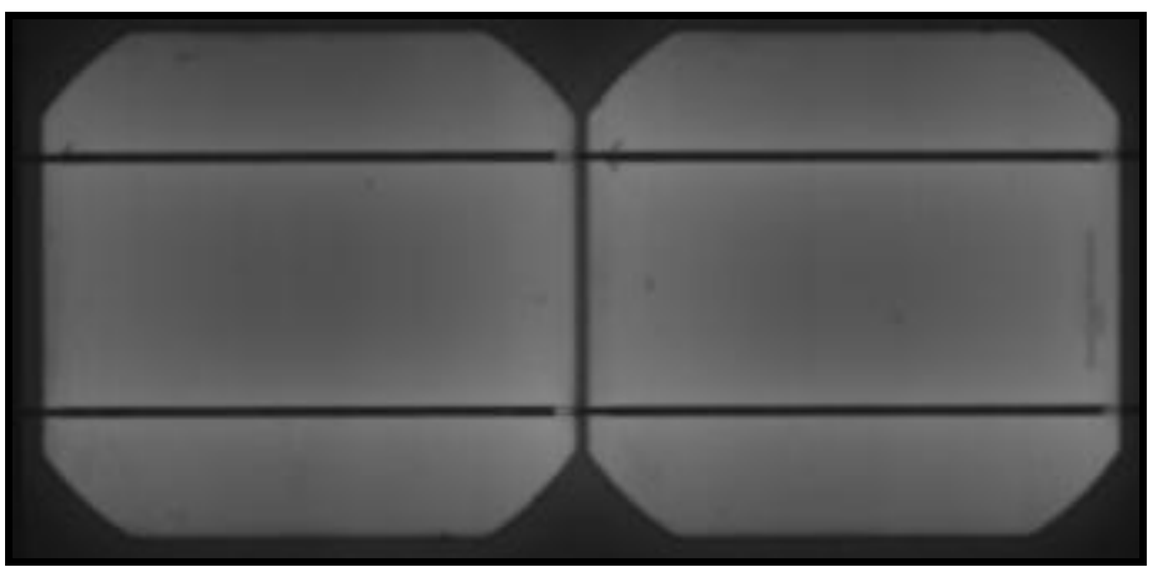
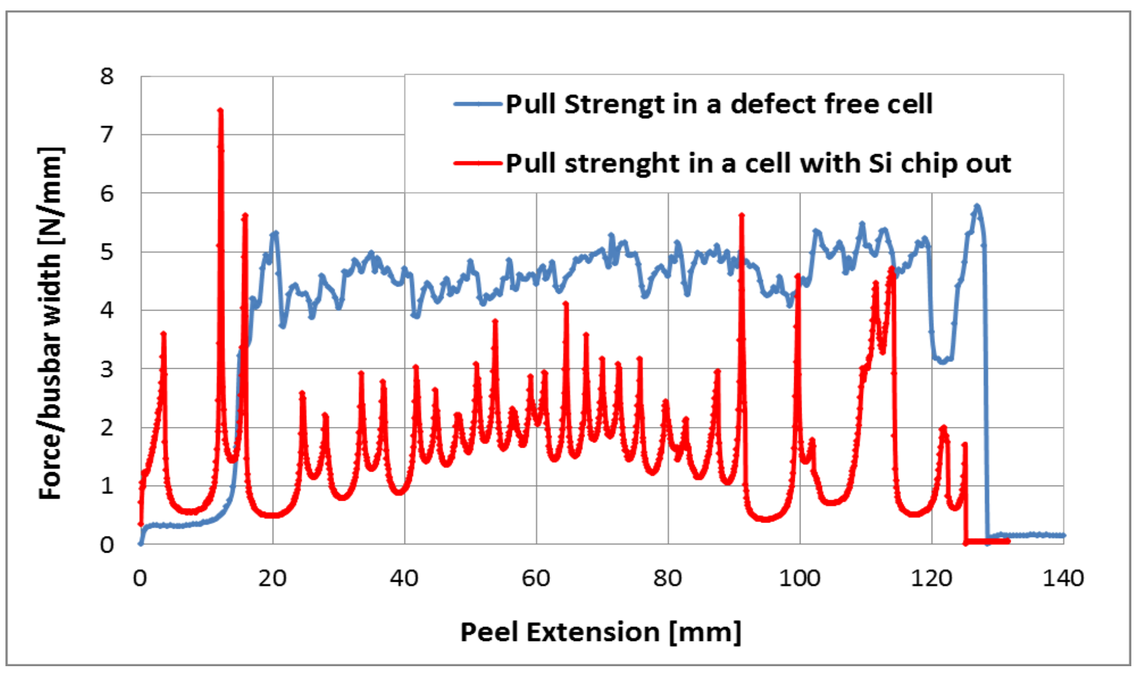


Figure 2: EL images of two tabbed solar cells free form soldering defects



Graph1: Pull test comparison of defected cells and defect free cells

Failure Analysis

SEM inspection in the corresponding dark regions of the EL images does neither show adhesive failure between the silicon and the metal layer nor adhesive failure within the metal stack.

In these areas the silicon is clearly cracking at the edges of the bus bar (Figure 3). The cracking can be so severe to induce dislocation or chip out of the silicon which eventually results in cut metal fingers. (Fig 4). This is the reason for the electrical discontinuity observed in the device with the EL inspection.

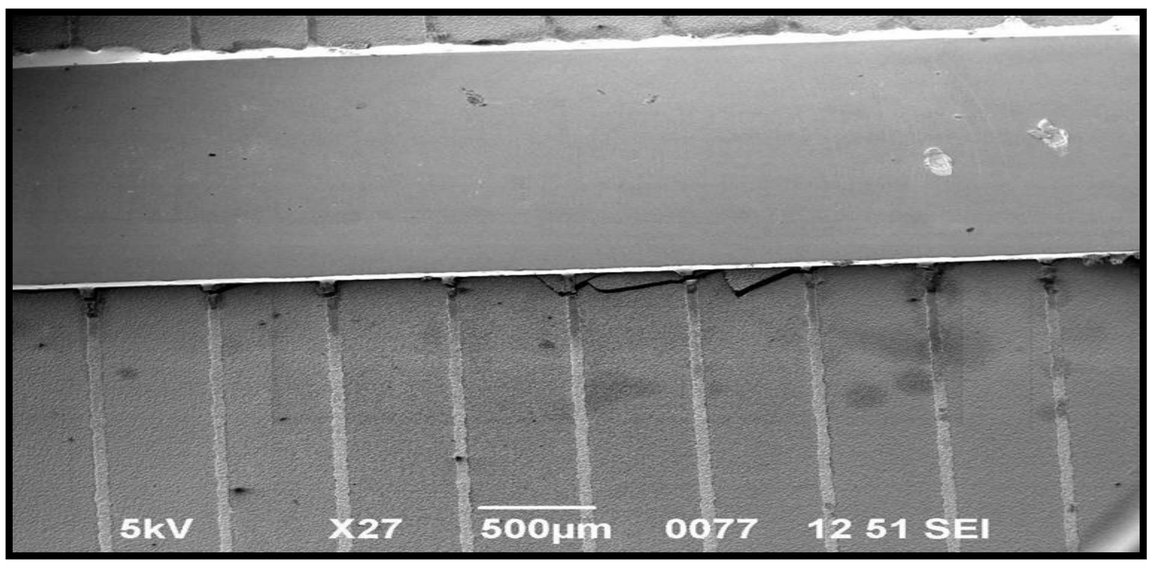


Figure 3: SEM image of cracked silicon along the bus bar

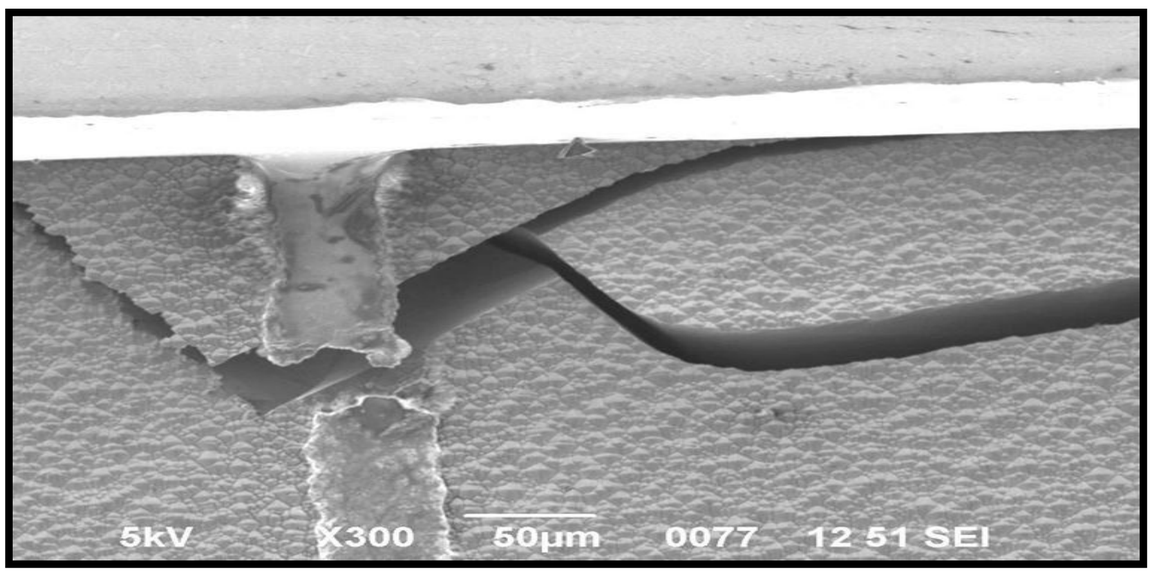


Figure 4: SEM image of cut metal finger due to Silicon chip out

CONCLUSIONS

TetraSun c-Si cells with plated bus bars and finger grids show a very good pull strength around 5 N/mm. A reduced pull force approaching the ≥1 N/mm criteria is directly correlated to defected solar cell that show electrically disconnected areas under EL inspection.

SEM analysis confirms that the periodically reduced pull strength is not a failure related to the metallization but is physically correlated to a cracking of the silicon itself. The cracking can be so severe that occasionally it leads to break the metal fingers detaching them from the bus bar. This results in electrical disconnect of section of the solar cell from the rest of the device.

Though this failure mode can be reduced by adjusted parameters of the soldering process, the physical mechanism that leads to the silicon fracturing is not yet entirely understood [1], [2].

REFERENCES:

[1]: THE LINK BETWEEN MECHANICAL STRESS INDUCED BY SOLDERING AND MICRO DAMAGES IN SILICON SOLAR CELLS
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[2]: SOLDERING INDUCED DAMAGE TO THIN SI SOLAR CELLS AND DETECTION OF CRACKED CELLS IN MODULES
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