DIAMOND WIRE SAWN POLY C-SI WAFERS

CREATING POLY C-SI WAFER

The polycrystalline silicon (poly c-Si) wafers used as a starting point for the production of solar cells and, inevitably, modules are cut from much larger blocks. Molten silicon is crystalized and formed into large ingots. These ingots are sawn into bricks, which are then sawn into wafers less than 200 µm thick.

Figure 1: Poly c-Si ingot, bricks and wafers

The cutting of wafers from bricks is traditionally achieved through using steel wires and a liquid containing abrasive particles to wear down gaps between the wafers. This traditional method has a number of shortcomings:

• Wire is worn down by the abrasive liquid and needs to be replaced after each block is cut.
• A thick gap is cut between each wafer, often as thick as the wafer itself, creating significant wastage.
• Silicon particles need to be separated from abrasive particles before the abrasive can be reused.

DIAMOND WIRE

Instead of using wires and abrasive, wires with diamond attached have begun to be used. These diamond pieces are attached using resin or electroplating, and overcome the failings of traditional abrasive sawing by:

• Reducing the wear on the wires, allowing them to be used multiple times.
• Allowing for thinner cuts, and more wafers per block.
• Greater cutting efficiency, leading to a faster process.

This allows for sawing with diamond wire to run at lower operating costs, and make more efficient use of expensive poly c-Si material.

For these reasons, diamond wire sawing has been widely deployed on monocrystalline silicon (mono c-Si) wafers for a number of years, but is only now coming to mass production of poly c-Si wafers due to additional development of the texturing process being required.

STANDARD TEXTURING

A key part of the structure of a solar cell is the texture of the front surface. The texture allows solar cells to make more effective use of incident sunlight by reflecting it multiple times on the cell surface.

To create this texture, chemicals are used to slowly etch the surface of the wafer. The chemicals used for the texturing of mono and poly c-Si are different, due to the surface properties and the structure of the wafer. The old standard process for texturing poly c-Si wafers needs the rough surface created from traditional wafer sawing to initiate the texturing. However, diamond wire leaves the wafer surface very smooth, resulting in low-quality texturing when using standard chemicals.

Figure 2: Wafer surface before texturing. Standard (left) and diamond wire sawn (right), with visible regular structure.

Figure 3: Increased light absorption on textured silicon wafer

ALTERNATIVE TEXTURING

There are a handful of alternative methods which allow for the texturing of diamond wire sawn poly c-Si wafers in principle. These fall into three categories.

• Stronger etching techniques: These processes, often referred to as “black silicon”, have the potential to improve light capture, giving the cells a consistent black look and slightly higher power.
• Surface damaging pre-processes: Techniques of roughening the surface of the wafer (e.g. sand blasting), resulting in cells very similar to those from traditional abrasive sawing processes.
• Modified texturing processes: Optimization of the standard texturing process allowing it to even exploit reduced surface roughness of the diamond wire sawn wafers.

The modified texturing processes has triggered a much wider adoption of diamond wire sawn wafers as it comes at little increased cost whilst providing good texturing results. Whereas techniques within the other two categories above are either too expensive or immature – or both.

With the modified texturing processes being available as cost effective solution, diamond wire sawn wafers are quickly becoming the standard for poly c-Si with traditional wafers being much rarer.

Figure 4: Surface of diamond wire sawn wafer after texturing with modified process, regular structure still partially visible.
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VISUAL APPEARANCE

The modification to the existing texturing process only facilitates the reaction of the standard etching chemicals with the smoother surface. Due to the consistent cutting movement of the diamond wire the surface structure is very regular, as can be seen in figures 2 and 3. After texturing, this regularity still exists in the textured surface, and at some viewing angles such cells can have a lighter visual appearance.

Figure 5: Cells from diamond wire process with one displaying the lighter visual appearance visible at some viewing angles

PERFORMANCE

Extensive internal testing by Hanwha Q CELLS has shown that this effect is mostly aesthetic, with the slight reduction in power fully accounted for during power measurement and labelling in the factory. Moreover, there is no effect on the energy yield of the cells or modules. Testing by measuring the performance at different inclination angles yields identical results for modules using both diamond wire sawn and traditionally cut wafers.

The altered visual appearance of the cells does increase the potential glare from the module. However, the glass being the main source of reflection, the contribution of the cell to the total light reflected off the module is minor. As such there is no measureable effect on the glare caused by the module as a whole.

Figure 6: Incident Angle Modifier (IAM) of diamond wire and standard process cells lit from different incident angles

YIELD AND DEGRADATION

Diamond wire for sawing has been the method of choice for most manufactures of mono c-Si wafers for a number of years. Extensive lab, climate chamber, load and field testing have shown that there is no measurable difference in the yield, degradation or long term performance of diamond wire cells versus those traditionally sawn.

SUMMARY

Diamond wire sawn poly c-Si wafers are becoming the standard wafers in the PV industry, due to the overall cost savings. To avoid increases in costs, particularly to price sensitive utility and commercial projects, Hanwha Q CELLS uses the modified texturing processes on poly c-Si wafers. It has been shown that there is only a slight change to the visual appearance of the cells, with no effect on specific energy yield (kWh/kWp).

The change to the visual appearance only affects the Q.PLUS and Q.POWER ranges. The Q.PEAK range retains its consistent black appearance at all viewing angles so is the perfect choice for more aesthetically demanding residential applications.

Figure 7: The same Diamond Wire Module seen from different angles, with one (left) displaying lighter visual appearance

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