New solar cell technology bridges the gap between cost and climate change goals

Cutting-edge technology is combining with unmet demand in a now stagnant solar PV market to progress clean energy transitions. A new disruptive bifacial p-PERT PV cell technology, with over 90% bi-facility and higher stability, providing n-type Si performance in p-type silicon is coming to Europe and the U.S.

Analysts predict that solar and wind energy will provide almost 50% of the world's power by 2050, with renewables accounting for 90% of new power capacity expansion globally in 2021-22. However sustained growth in the market is contingent on the continued decrease of the price of solar energy. The key is highly efficient photovoltaic cells, with high energy production and higher energy density per installed unit, while maintaining low production costs. According to the International Energy Agency, advancement on energy technologies is failing to keep pace, raising concerns about meeting long-term climate goals.

SolAround offers a possible solution: its new p-PERT PV solar cell technology produces 10- 40% more energy per unit area installed, per installation type and operating conditions, compared to current mono-facial and bifacial systems. This is at standard market PERC cost-of-production, lowering the cost of solar energy (LCOE) by 25% relative to monofacial systems and by 7-10% relative to other Bifacial cell technologies available or coming to market.

Counting the cost of climate change

The use of the company's technology-based PV panels maximizes energy density and reduces energy costs, whilst significantly impacting the environment by helping to reach climate change goals. This high-efficiency, high-bifaciality, highly stable p-PERT PV solar cell technology presents an ideal and cost-effective solution for the $450B global solar market. The IP-protected technology is suitable for mass-production at almost any standard PERC production line, by replacing only a few steps in the process and 2-3 tools, and is commercially ready for use.

Headquartered in Israel, SolAround's team has a proven track record in the development of Bifacial PV cells and panels and their transfer to industrial development, alongside mass industrial production of these cells in Germany.

The science behind the cells

The SolAround cell is a bifacial p-PERT cell, i.e. cell with n^+-p-p^+ structure fabricated using monocrystalline p-Si starting material. In contrast to PERC type cells, with local Al alloyed p^+ regions, the p-PERT cell is based on a Boron doped p^+ -layer covering the entire back surface. The cell structure is similar to the structure of n-PERT cells made on n-type Si, achieving the highest efficiency for solar cells produced by diffusion technologies. The advantage of p-PERT cells in comparison to n-PERT cells is the ability to achieve the same high parameters at a significantly lower cost, all whilst using the industry familiar and preferred p-Si.

A seemingly simple replacement of the original n-Si turns out to be possible due to the SolAround developed technology, which ensures the absence of degradation of the lifetime of minority charge carriers in the cell base region. According to its CEO, Avishai Drori, SolAround is unique in its reporting and use of high-temperature (diffusion) processes that do not degrade the carrier lifetime in p-type material.

Positive news for the solar era

Describing the process as 'the holy grail of renewable solar energy' Drori commented: 'Our solar PV technology will be an energy cost-efficiency game changer for solar enterprise companies looking to enter their solar era and significantly enhance their revenues from electricity to unprecedented levels. It will also play a major role in contributing to the global climate goals and protecting our environment.'

So what are the advantages, in real terms?

According to SolAround, they include:

- Higher Front Efficiency Potential. Achieving very high efficiency cell values is unambiguously associated with the possibility of ensuring a high bulk lifetime, and this is also the reason for the highest efficiency achieved in n-Si solar cells. Improving the technology for growing high-quality p-Si and its preservation in the process of manufacturing solar cells is the basis for achieving the maximum efficiency of solar cells.

  The $PERC^+$ bifacial cell is limited to ~23 % front efficiency vs. p-PERT with its front efficiency potential reaching 24% and above. The structure potential of the

SolAround ISE Fraunhofer rooftop test installation - Geilenkirchen, Germany

SolAround bifacial/monofacial comparative test installation - Adlershof, Germany

SolAround cell is proven to have beyond 23% front efficiency by measurements of the Implied Open Circuit Voltage, iV_{oc}, exceeding 700 mV. SolAround will reach 23% and above front efficiency when working in an industrial and clean line environment after an improved back contact system, not of the TOPCON type. SolAround's Boron doping technology and cell structure allow the use of wafers of higher resistivity, i.e. with lower doping compared to wafers in use for PERC cells: 2 – 5 Ohm.cm instead of 0.5 – 1.5 Ohm.cm, enabling much higher starting bulk lifetimes. This, together with preserving the high lifetime level over the entire process, allows a much higher potential front and rear-side efficiency levels compared to PERC. These factors, together with what the company terms a 'simpler' cell structure and its unique opto-electric design, lead to inherently higher front side efficiency for p-PERT compared to PERC and $PERC^+$.

The presence of a continuous rear p^+ layer reduces the series resistance and energy losses on it, increasing the FF and the

SolAround R&D Center, Konstanz, Germany

efficiency of the cell. At the same time, the continuous surface field (BSF) formed due to a continuous rear p+ layer, improves the passivation quality of the rear cell surface.

- Bifaciality: due to its cell's back structure the p-PERT cell has a 90%-92% bifaciality factor, superior to the PERC+ bifacial, bifaciality factor of 65-70%.
- Total energy generation expressed in terms of the equivalent efficiency, bifacial efficiency, pending installation type; p-PERT reaching 27%-30%, vs. PERC+, bifacial, 24%-27%
- Higher long-term stability: lower LID/ Le-TID - SolAround's Boron-BSF potentially provides a much better long-term stability of its rear-side passivation compared to any 'thin film' technology, as PERC, PERC+.

  a) SolAround's Boron doping technology allows the use of higher wafer resistivity values (= lower base doping) compared to wafers in use for PERC, contributing to a near-zero Light-Induced Degradation (LID) and Elevated Temperature Light-Induced-Degradation (Le-TID), both of less than 0.5%, relative to PERC/PERC+ cells which suffer from a much higher degradation (LID/Le-TID) in the order of 2%, when not specifically treated by added process steps. These factors, together with the very high temperatures involved in the p-PERT process relative to the ones involved in PERC processes, provide p-PERT with a much higher stability performance along the solar panel's lifetime.

  b) Improved stability levels were proven by independent measurements in the Fraunhofer CSP institute, Germany, which showed close to zero cell degradation, the lowest compared to other cell technologies.

- As expected, the PID degradation which is caused by the disruption of the passivation layer is reduced as result of the continued positive influence of the built-in back field (BSF).
- Easy implementation: the SolAround process can be applied in almost every existing production line, by adding up to 3 additional steps and eliminating others, depending on choice of tools, including dopant deposition and a high temperature Boron diffusion step.
- Cost of production: the inherent production cost of p-PERT is similar to the cost of PERC. This is easily proven by a differential CAPEX and OPEX comparison of process steps, of the two technologies, p-PERT and p-PERC, in a specific production line.
- Narrow production distribution. The manufacturing experience showed a very narrow distribution of cells' performance around the average value. PERC+ technologies, on the other hand, are reported to have wider performance distribution which negatively affects the overall yield.

SolAround bifacial installations, Jordan Valley

Looking to the future

SolAround's p-PERT silicon cell structure is a good candidate for the silicon sub-cell of tandem solar cells, in combination with sub-cell based on semi-conductor with wider width of forbidden band gap, such as perovskite. The company is in the R&D phase for developing such tandem cells, as part of a bi-lateral consortium with the Helmholtz Center, Berlin, JCMwave Germany, and the Ben Gurion University, Israel. SolAround's role in that consortium is the design of the entire bifacial tandem solar cell device, 4-terminal design, optimization of the p-PERT sub-cell, highly professional outdoor rooftop measurements and bifacial/tandem devices energy generation modeling and simulations.

www.sol-around.com

Key facts:

p-PERT technology

- Simple & stable cell structure
- Controllable Boron Doping, on Boron or Ga Doped p-Si Wafers
- 22.5%-23% front efficiency
- >90% bifaciality
- 27%-30% equivalent efficiency, per installation type
- Higher stability (near zero Le-TID)
- Standard production costs
- Applicable for almost any cell production line, with minor adaptations and investment.
- Module power: applicable to any new high-power module concept, adding 7%-10% added power vs. PERC-Bifacial modules, and 25% vs. PERC-Monofacial modules.
- Ready for production

Financial key facts

- 25% energy cost (LCOE) reduction vs. monofacial modules
- 7%-10% cost of energy (LCOE) reduction vs. other bifacial cell technologies available or coming to market. (PERC+, Topcon, HIT/HJT, IBC)
- 10% to 25% emission reduction, respectively
- 1GWp solar farm:
  - IRR: 40%-60% higher i.e. from 7-10% to 10-15% over 30 years
  - NPV: additional $150-450m in revenues, per 1GWp installed, over 30 Years.
- Allowing solar project competitiveness vs. Asian module prices.