

Solar Cell Manufacturing Technique Increases Efficiency and Lowers Costs

Efficiency levels, high costs limit solar cell advances

High-efficiency solar cells are the key to electricity cost reduction and widespread use of photovoltaic technology. Current high-performance solar cells—those with efficiencies greater than 25%—are expensive due to process complexity, costly metallization schemes, and high capital expenditure costs. Lower cost cells are not efficient enough (<22%) due to diffusion and metal-induced recombination in silicon (Si) absorbers to reach the optimum target of $\sim 3\text{¢/kWh}$. The desired target is 25% efficiency at $\sim 25\text{¢/watt}$.

Novel technique offers low-cost way to passivate both cell sides, increasing efficiency

This double-side polysilicon (poly-Si)/silicon oxide (SiO_x) TOPCon (tunnel oxide passivated contact) cell concept provides a unique opportunity to meet cost and efficiency targets simultaneously. A novel approach deploys low-cost, manufacturable screen-printed TOPCon on both sides of the solar cell. The key design feature is that TOPCon on the front side is selectively placed under the metal grid with $\sim 5\%$ area coverage, while the remaining 95% area on the front has undiffused Si wafer passivated with silicon oxide/silicon nitride or aluminum oxide (Al_2O_3)/silicon nitride (SiN) dielectric. This provides nearly the same passivation as full-area TOPCon without appreciable absorption of light. It also allows the use of thick TOPCon (~ 200 nanometer), eliminating the risk of contact punching or shunting due to screen-printed contacts to thin poly.

The innovation also includes a new method of patterning front TOPCon by selective area laser oxidation. This design and process sequence enhances efficiency and reduces cell processing costs by eliminating traditional diffusion technology. Further, the proposed bifacial cell structure offers a much lower temperature coefficient that will further increase energy harvesting and lower costs. Most passive emitter rear contact (PERC) manufacturing lines can be transformed easily into TOPCon lines by adding polysilicon (poly-Si) deposition tools, enabling the rapid and low-cost adoption of this technology.

Summary Bullets

- This double-side polysilicon/silicon oxide TOPCon (tunnel oxide passivated contact) solar cell concept provides a simple and low-cost way to passivate front and back surfaces of silicon wafers to enhance

efficiency.

- Provides current and voltage comparable to full-area double-side TOPCon but with no appreciable absorption in front polysilicon and without compromising short circuit current density
- Includes a novel and fast way to pattern polysilicon using laser-induced selective oxidation

Solution Advantages

- **Advanced:** Deploys low-cost, manufacturable screen-printed TOPCon on both sides of a silicon wafer to enhance efficiency
- **High performance:** Provides current and voltage comparable to full area double-side TOPCon but with no appreciable absorption in front poly-Si and without compromising short circuit current density
- **Efficient:** Allows the use of thick poly-Si on a wafer front without risking current degradation due to screen-printed contacts
- **Cost effective:** Eliminates numerous processing steps needed to remove, pattern, or etch deposited layers
- **Progressive:** Opens pathways for low-cost Si/perovskite-type tandem solar cells with an efficiency potential over 30%

Potential Commercial Applications

- Silicon cell manufacturing
- Photovoltaic cells

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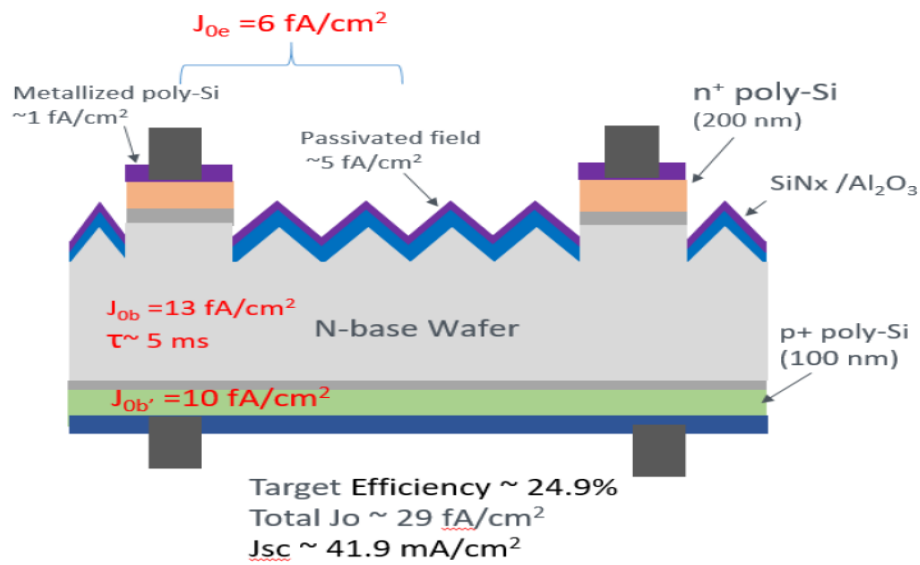
IP Status

<p>Patent application has been filed</p>: PCT/US2023/023992

Publications

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Images



An example double-side TOPCon solar cell structure and efficiency

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