# Overview of Well-Established c-Si-Based Solar Cell Concepts

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**Abstract**

A unified schematic visualization of Si solar cell technologies as well as tandem interconnection schemes (2, 3, 4 terminal) with industrial relevance is presented based on a comprehensive literature review.

# Overview of Well-Established c-Si-Based Solar Cell Concepts

## Crystalline Silicon Solar Cell Technologies

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### ABSTRACT
A unified schematic visualization of Si solar cell technologies as well as tandem interconnection schemes (2, 3, 4 terminal) with industrial relevance is presented based on a comprehensive literature review.

### INTRODUCTION
Solar cells have witnessed an exponential technological evolution in the last decades that has been linked to the efforts of R&D implemented by different organizations around the world [1]. This review document presents a unified schematic visualization of eleven well-established Si solar cell technologies with current and future relevance in the solar industry. The solar cell schematics show the major internal structures of the selected technologies, the composition of the materials used and their arrangement.

### METHODOLOGY AND APPROACH
A literature review [2-7] of cell technologies was performed to determine those solar technologies with major current & future pertinence. Focus was put on established industrial single junctions Si cell technologies as well as interconnection concepts for future Si tandem solar cell technologies. The schematics represent the major functional solar cell components: front and back side with contacting and passivation structures and Si absorber material.

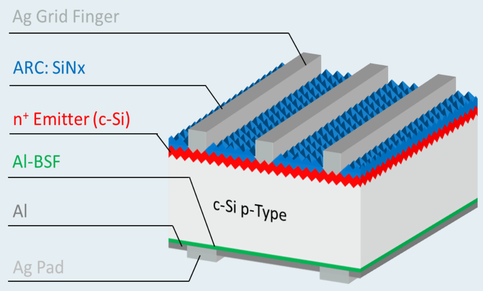
### RESULTS
The review process delivered the following well-established, industrialized single junction Si technologies (Fig. 1 a-h), which are sorted according to their efficiency potential as estimated by the NREL chart [1]:

- Standard p-type Al-Back Surface Field (BSF),
- Passivated Emitter Rear Contact (PERC),
- Passivated Emitter Rear Locally Diffused (PERL),
- Passivated Emitter Rear Totally Diffused (PERT),
- Tunnel Oxide Passivated Contact (TOPcon),
- Interdigitated Back Contact (IBC),
- Hetero Junction Intrinsic Thin Layer (HIT/HJT),
- Heterojunction Back Contact (HBC)

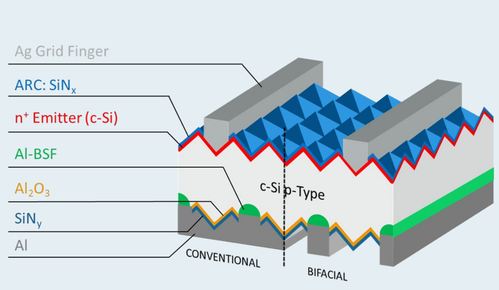
Future Si tandem technologies are in the progress of industrialization with 2, 3 & 4 terminal interconnection concepts (Fig. 2 a-c).

### SUMMARY
Technological evolution of different classes of solar cell technologies is driven by the specific efficiency potential. A continuous improvement of materials and processes has enabled the industrialization of advanced concepts. Degradation resistance and long-term stability are additional performance indicators with major impact on energy yield and cost of photovoltaic systems.

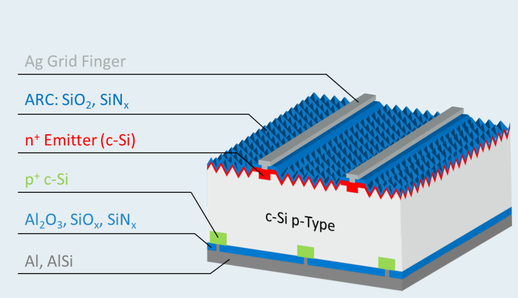
**STANDARD P-TYPE AL-BSF**



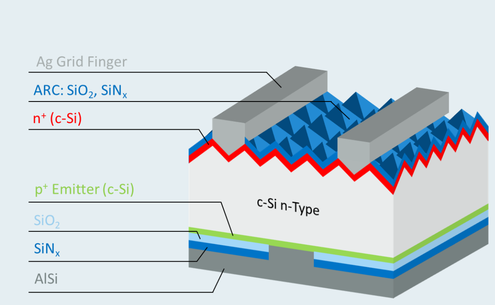

**PERC - PASSIVATED EMITTER AND REAR CELL**



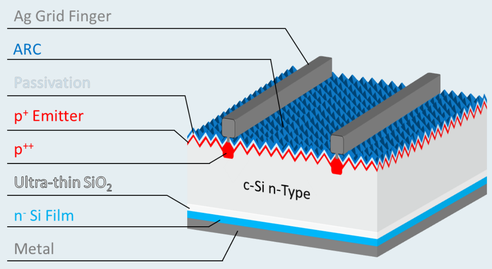

**PERL - PASSIVATED EMITTER WITH REAR LOCALLY DIFFUSE**



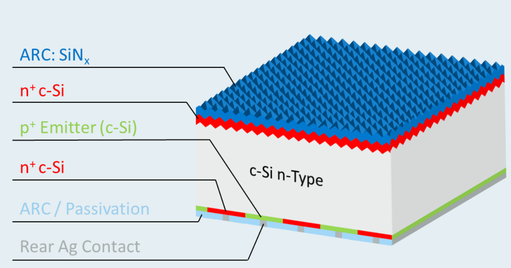

**PERT - PASSIVATED EMITTER REAR TOTALLY DIFFUSE**



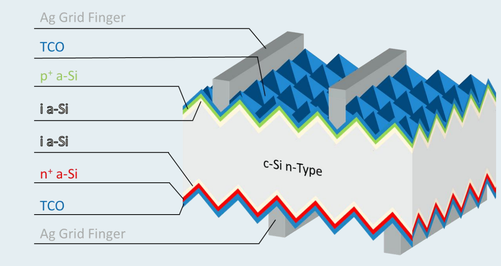

**TOPcon - TUNNEL OXIDE PASSIVATED CONTACT**



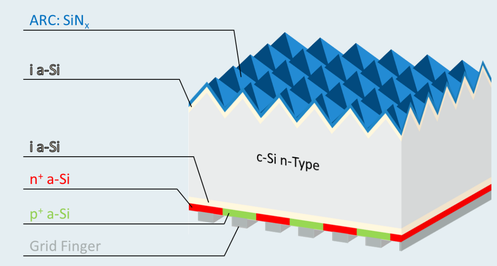

**IBC - INTERDIGITATED BACK CONTACT**



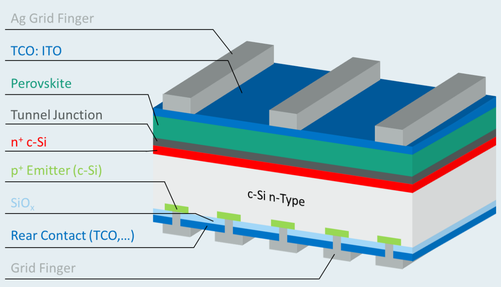

**HIT / HJT – HETEROJUNCTION WITH INTRINSIC THIN LAYER**



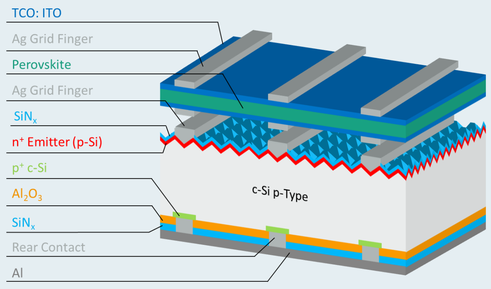

**HBC - HETEROJUNCTION BACK CONTACT**



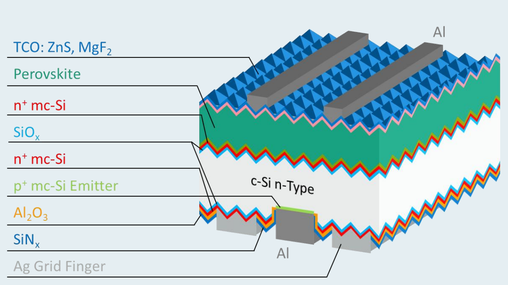

**PEROVSKITE MULTIJUNCTION SOLAR CELLS 2-TERMINAL**




**PEROVSKITE MULTIJUNCTION SOLAR CELLS 4-TERMINAL**




**PEROVSKITE MULTIJUNCTION SOLAR CELLS 3-TERMINAL**

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