High efficiency photovoltaic cells

High efficiency photovoltaic cells

This high-efficiency solar technology takes advantage of inexpensive silicon wafers and provides a more robust design for next-generation solar cells in space. For terrestrial applications, it can provide unprecedented efficiencies for auxiliary power units in vehicles, solar roof tiles, power plants, and smart grid systems.

NREL maintains a chart of the highest confirmed conversion efficiencies for research cells for a range of photovoltaic technologies, plotted from 1976 to the present. Learn how NREL can help your team with certified efficiency measurements .

Effective spectral utilization can be achieved by using a variety of methods, such as multiple junctions, intermediate band gaps, quantum dot spectral converters, luminescent down-shifting (LDS) layers, and up-conversion materials. Solar cell efficiency could be considerably increased by improving spectrum utilization.

Researchers at the Fraunhofer Institute for Solar Energy Systems ISE, using a new antireflection coating, have successfully increased the efficiency of the best four-junction solar cell to date from 46.1 to 47.6 percent at a concentration of 665 suns.

We are key players in developing low-cost, manufacturable techniques for increasing the efficiency of advanced silicon cells and are at the forefront of developing the highest-efficiency III-V multijunction cells for space and high-concentration terrestrial applications. We are also a driving force in three industry-relevant areas: low-cost III-V PV cells for 1-sun and low-concentration terrestrial applications, very high-efficiency (>30%) silicon-based tandem cells, and thermophotovoltaics for energy storage.

We are focusing on high-efficiency, low-cost silicon PV, considering the urgent need to develop high-throughput, low-cost, robust processes and device architectures that enable highly efficient n-type Czochralski wafer silicon cells.

The efficiency and concentration of III-V multijunction solar cells can be highly leveraged to reduce the cost of high-concentration PV systems. We are recognized for the invention, development, and technology transfer of a range of key device architectures, most recently including the inverted metamorphic multijunction solar cell.

We are developing methods to greatly reduce the cost of manufacturing III-V solar cells. This work aims to achieve single-junction cells with efficiencies >25% and tandems with efficiencies >30%, for one-sun and low-concentration applications.

We are developing high-efficiency III-V/silicon tandem solar cells by epitaxial and stacking/bonding

approaches. Our work in epitaxial III-V/Si uses an approach based on selective-area growth enabled by patterning via nanoimprint lithography. In the stacking/bonding approach, we are developing a novel cell structure using transparent, conductive adhesives for cell stacking to enable inexpensive stacked tandem cells.

Masafumi Yamaguchi, Frank Dimroth, John F. Geisz, Nicholas J. Ekins-Daukes; Multi-junction solar cells paving the way for super high-efficiency. J. Appl. Phys. 28 June 2021; 129 (24): 240901. https://doi /10.1063/5.0048653

In the days to come, Si-based tandem solar cells16 such as III-V/Si,17,18 II-VI/Si,19 chalcopyrite/Si,20 CZTS/Si,21 and perovskite/Si22 tandem solar cells are expected to play a more important role as high-efficiency, low-cost solar cells move closer to industrial manufacturing. In addition, there are other approaches such as perovskite/perovskite,23 III-V/CIGSe,24 and perovskite/CIGSe25 MJ solar cells that are still at a lower technology readiness level but may become very attractive candidates for photovoltaic energy conversion in the future.

Here, we discuss the perspectives of MJ solar cells from the viewpoint of efficiency and low-cost potential based on scientific and technological arguments and possible market applications. In addition, this article provides a brief overview of recent developments with respect to III-V MJ solar cells, III-V/Si, II-VI/Si, perovskite/Si tandem solar cells, and some new ideas including so-called 3rd generation concepts.8