

# Importance of Development of High-efficiency Solar Cells and Modules toward Creation of Clean Energy Society

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The renewable energy is very important to create clean energy society. Especially, the photovoltaics (PV) is expected to contribute as the primary energy with cumulative installed PV with 5TW and 22TW by 2030 and 2050, respectively according to the Shell's Sky Scenario [1]. However, because global cumulative PV capacity installed is only 1.185TW in the end of 2022, further development of science, technology and deployment of PV is necessary.

For realizing the above scenario and vision, we need to conduct the following issues:

1. Development of high performance, low cost and highly reliable PV materials, cells, modules, and systems.
2. Further development of smart energy management including regulations, and self-consumption in cooperation with storage battery technologies.
3. Development of new application fields such as automobile applications towards the creation of future clean energy infrastructures.

In this paper, our recent approaches on development of high-efficiency solar cells and modules, and VIPV (vehicle integrated PV) for PV-powered vehicles are presented.

The development of high-performance solar cells offers a promising pathway toward achieving high power per unit cost for many applications. The multi-junction solar cells have great potential of more than 44% and 50% with 3-junction and 6-junction solar cells [2], although the current best efficiencies of 3-junction and 6-junction solar cells are 39.5% and 39.2%. Cost reduction of solar cells and modules is also very important for widespread applications. The Si tandem solar cells [3] have potential of low-cost and high-efficiency with an efficiency of more than 36% and 42% with 2-junction and 3-junction Si tandem solar cells. Most recently, the authors have achieved 35.8% with InGaP/GaAs/Si 3-junction tandem solar cells (area of 23 cm<sup>2</sup>) and our new world record efficiency 33.7% with InGaP/GaAs/Si tandem cell modules (775 cm<sup>2</sup>). In the presentation, current status of perovskite/Si 2-junction tandem solar cells is discussed. The development of PV-powered vehicles is very attractive and very important for creation of mobility society using solar energy. The impacts of high-efficiency solar cell modules upon reduction in CO<sub>2</sub> emission and charging cost of electric vehicles are shown. In addition, potential for driving distance of PV-powered vehicles installed with Si tandem solar cells was analyzed. The III-V/Si 3-junction tandem solar cell modules have potential of driving distance of more than 30 km/day average and more than 50 km/day on a clear day.

## References

- [1] Shell, Sky Scenario (2018). [www.shell.com/skyscenario](http://www.shell.com/skyscenario).
- [2] M. Yamaguchi et al., *J. Appl. Phys.* **129**, 240901 (2021).
- [3] M. Yamaguchi et al., *J. Phys. D: Appl. Phys.* **51**, 133002 (2018).