



Development of High-efficiency Solar Cells for Solar Vehicle Applications

Abstract: Solar photovoltaics (PV) are expected to play a massive role in the world in order to mitigate climate change. Figure 1 shows installed capacity of various energy sources in 2050 reported by the IRENA [1]. The PV is expected to contribute as No. 1 energy source with share of about 46.9%. Following, 20.4% for onshore wind, 8.2% for hydro, 6.6% for offshore wind, 6% for gas, 2.7% for CSP, 2.3% for biomass, 1.7% for nuclear, 1.1% for tide and 0.9% for geothermal are listed in the IRENA prediction [1]. PV is thought to be ready to become one of main energy sources, several developments are necessary.

For realizing such a vision and roadmap, several developments for the PV are necessary. We need 1) to develop high-efficiency, low-cost and highly reliable PV materials, cells, modules and systems, 2) to develop smart energy management including regulations, and self-consumption in cooperation with storage battery technologies, and 3) to develop new application fields such as automobile and agriculture applications towards the creation of future clean energy infrastructures as shown in Table 1 [2].

In this paper, our recent approaches on development of high-efficiency solar cells and modules, and VIPV (vehicle integrated PV) for solar-powered electric vehicles (solar-EV) are presented. The impacts of high-efficiency solar cell modules upon expanding driving range, reduction in CO₂ emission and charging cost of electric vehicles are shown. 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 [3], 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 [4] have potential of low-cost and high-efficiency with an efficiency of more than 41% and 45% with 2-junction and 3-junction Si tandem solar cells. The III-V/Si 3-junction tandem solar cell modules with an efficiency of more than 36% have potential of driving distance of more than 30 km/day average and more than 50 km/day on a clear day. Most recently, the authors have achieved high-efficiency (35.8%) with InGaP/GaAs/Si 3-junction tandem solar cell with an area of 23 cm² and new world record efficiency (33.7%) InGaP/GaAs/Si 3-junction tandem solar cell module with an area of 775 cm².