European Metrology Research Programme

Delivering Impact

Faster solar cell product development

Recent growth in solar electricity generation capacity was achieved in part from subsidies, that reduced silicon cell costs by stimulating manufacturing efficiencies. Future cost reductions may need to be driven by increased cell efficiency. Multi-junction solar cells are used in high-end space applications where compactness and efficiency are critical requirements. Higher efficiencies could result in such cells becoming cost-competitive with conventional energy sources, but development was slowed by an impractical standard calibration method.

Europe's National Measurement Institutes working together

The European Metrology Research Programme (EMRP) brings together National Measurement Institutes in 23 countries to address key measurement challenges at a European level. It supports collaborative research to ensure that measurement science meets the future needs of industry and wider society.

Challenge

Multi-junction solar cells (MJSC) are made up of layered semiconductors that, together, absorb a wider range of solar energy than silicon alone. Higher energy conversion efficiencies for this type of cells are predicted, that, in time, may enable photovoltaics to become cost-competitive with conventional energy sources. Manufacturing and material advances could lead to breakthroughs, but the process requires precise measurements of cell characteristics. However, development was slowed by an impractical industry-standard calibration method.

MJSC efficiency is measured using solar simulators, that are calibrated using standard solar cells, that, in turn, were calibrated onboard high-altitude balloon flights. This standard had the advantage of removing effects of the atmosphere on incident sunlight but air safety regulations limited flight opportunities, meaning there had only been one flight available between 2005 and 2019.

Measurement of efficiency is critical to MJSC commercialisation, as errors translate in the market to considerable costs from under or over-supply of energy. In a competitive environment where speed to market is essential, a new standard was urgently needed, providing at least the same calibration certainty as for the existing method.

Solution

The EMRP project *Metrology for III-V materials based high efficiency multi-junction solar cells* applied laboratory-based, differential spectral responsivity (DSR) calibrations, using laser-based spectral measuring methods to establish a 'synthetic' multi-junction solar cell calibration standard.

This standard achieved measurement uncertainties comparable to balloon flight calibrations, that could be performed in the laboratory.

Calibration procedures and measurement uncertainty budgets were also included in a good practice guide on multi-junction reference solar cell calibration methods.

Impact

AZUR SPACE, the German manufacturer of high-performance MJSCs for satellite applications, provided solar cell assemblies for use as reference cells for the project. It subsequently contracted project partner PTB to provide ongoing calibration services for its reference solar cells. At the time of writing, this has involved the delivery of four-junction MJSCs on which to perform qualifications and product characterisations, that led to the commercialisation of new cell designs.

Airbus Defence and Space is already a customer and agreed to use AZUR SPACE's four-junction design to power its Neosat telecommunications satellite scheduled for launch by the European Space Agency before the end of 2021.

AZUR SPACE commented that the new synthetic calibration method has become essential for the photovoltaic industry, especially as safety rules continue to limit opportunities for operating balloon flights.

Since 2007, AZUR SPACE has disseminated its technologies developed for the space market to the terrestrial concentrated photovoltaic market, that is a growing part of its business.

Speed is of the essence in solar photovoltaic product development. The new calibration standard for multi-junction solar cells has allowed AZUR SPACE to plan and provide more certainty for its product development process. In the context of a global solar PV market expected to be worth US$134 billion by 2021, higher efficiency cells will, in time, disseminate to the terrestrial energy market, enabling higher returns on investment for end-users, reduced land use requirements, and further growth in overall solar photovoltaic generation capacity.

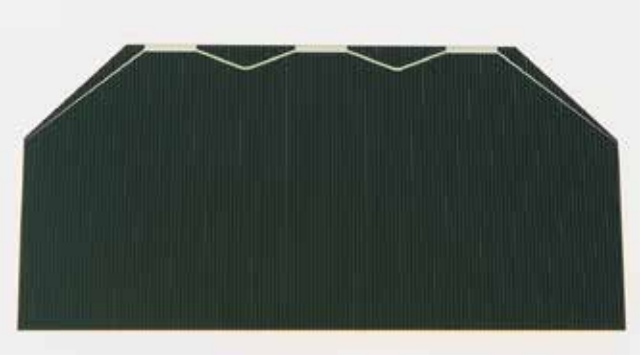
Metrology for more efficient solar cells

The EMRP project *Metrology for III-V materials based high efficiency multi-junction solar cells* developed a range of metrological techniques to support the development of more efficient photovoltaics.

Prior to the project, multi-junction solar cells were recognised as a promising solar cell technology but lacked reliable methods to measure some important properties, including efficiency.

The project developed traceable, reliable, cost-effective calibration methods, and measurement standards, to measure MJSC device efficiency, and other parameters, providing equivalent confidence levels as for silicon cells. Good Practice Guides for MJSC calibration procedures were also produced.

Outputs of the project also included new types of connectors between cells, new modelling methods to understand the movement of electrons across connectors, and new methods to accurately measure electrical properties of MJSCs at the nanoscale.



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