EMPIR Call 2016 – Energy, Environment, Normative and Research Potential

Selected Research Topic number: **SRT-g10**
Version: 1.0

Title: Next generation solar cell calibration and characterisation techniques

Abstract

Multi-junction based solar cells (MJSCs) are already in production, but tend to be limited to niche markets due to their cost (e.g. space). A decrease in payback time (currently six months in Southern Europe) would greatly increase their use, but specific metrology is required to increase their production rate and efficiency. Proposals in response to this SRT should build metrological tools to support the life-cycle of third-generation solar cells (e.g. nanoscale measurement of dopant energy levels and traceable calibration without the need for external validation).

Keywords

Third generation solar cells, Multi Junction Solar Cells, thin-film solar cells, tandem cells, scanning probe microscopy, synthetic component cell calibration, calibration chain

Background to the Metrological Challenges

To increase the efficiency and improve the production process for solar cells, information is needed on the location of electrical defects and junction performance. Efficient production and high module efficiency are key to reducing the energy payback time. The efficiency in new cells is sensitive to < 1 % variation in open-circuit voltage, and these variations need to be measured with nm resolution to identify potential sources of improvement. Methods to measure first level photovoltaic parameters (e.g. J_{sc}, V_{oc} and efficiency), second level parameters (e.g. carrier density, doping and composition) and third level parameters (e.g. carrier lifetime and defect distribution) are performed *ex situ* at different production stages or after finishing the devices, but results in long feedback loops. To speed up development and increase production yield, new tools need to be developed for predicting materials quality and/or module performance *in-situ*.

Currently the calibration chain in the working field of photovoltaic energy harvesting in space solely relies on reference solar cells calibrated via balloon and Lear jet flights. Here the reference samples are attached to sample stages which are subsequently flown to high altitudes and their short circuit current is measured directly in sunlight. Since the last balloon flight organised by a European institute was performed in 2005, both aging and drifting of existing references cannot be investigated and several types of commercial Solar Cell devices already exist where no corresponding primarily calibrated reference device is available. This increases the measurement uncertainty in the routine quality control of European MJSC manufacturers, suppliers and end users and decreases their world-wide competitiveness.

To satisfy the need of the European industry for a SI-traceable calibration method of component solar cells for Multi Junction Solar cell, validation of the techniques developed during the EMRP project SolCell is necessary. This should involve a direct comparison of the recently developed SI-traced “synthetic” calibrations to traditional measurements at high altitudes.

Concentrator Photovoltaic (CPV) technology is a utility-scale option for the generation of solar electricity and by 2018 it is expected that CPV will compete on a levelled cost of energy price (LCOE) with silicon at locations with high solar irradiance. Although CPV research has been ongoing for decades, CPV only entered the market in the mid-2000s and characterisation tools need to be developed and validated for industrial scale. MJSCs are now aimed at terrestrial applications due to their mechanically flexible nature and lower production costs. With recent improvements in Differential Spectral Responsivity (DSR) for laboratory based calibrations of MJSC component cells, these devices can be calibrated with measurement uncertainties comparable to state of the art balloon flight measurements.

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Increasing solar cell efficiency on the laboratory scale and transferring this to large-scale production will progress solar technology particularly for high-efficiency panels used for utility power generation.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the development of more accurate and faster metrology tools for commercially available third-generation solar cells.

The specific objectives are

1. To develop measurement techniques for measuring electrical dopant activities near single junctions for multi-junction solar cells (MJSCs). These should link to short-circuit current calibration methods and have a target uncertainty of less than 10 % for a lateral resolution of 100 nm.
2. To develop an industry-level characterisation tool for early diagnosis of quality and performance of MJSC wafers. The method should be contactless, with a single spectrum acquired in less than 50 ms producing IV characteristics with ≤ 10% uncertainty.
3. To demonstrate the reliability and competitiveness of laboratory based ('synthetic') solar cell calibrations compared with balloon flight calibrations taking into account factors that influence the spectral responsivity of MJSCs. The comparability of the methods should be evaluated using the methods described by ISO/IEC 17043 / ISO 15387 with a target comparability index, E_n, < 1.
4. To develop predictive models for failure modes and life-time prediction for terrestrial applications based on existing solar space knowledge.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited laboratories), standards developing organisations and end users (solar cell manufacturers).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research, the involvement of the appropriate user community such as industry, standardisation and regulatory bodies is strongly recommended, both prior to and during methodology development.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMRP project ENG51 and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 2.0 M€, and has defined an upper limit of 2.3 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 35% of the total EU Contribution to the project.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the solar cell sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.