EMRP Call 2013 – Energy and Environment

Selected Research Topic number: **SRT-g15**
Version: 1.0

Title: Metrology for III-V materials based high efficiency multi-junction solar cells

Abstract

III-V multi-junction solar cells under concentrating sunlight have recently reached the highest efficiencies ever achieved, up to 44 %, paving the way to bridge the enormous gap between the potential of solar energy and our current slight use of it. To support the strong efforts being undertaken to further increase the efficiency of III-V solar cells and reduce the overall system size and cost, accurate material characterisation, reference material, calibrated standards and traceable measurement methods are needed. The requirement is to develop the metrological infrastructure and facilities for traceable metrology of structural, electrical, optoelectronic and thermionic properties characterisations of III-V multi-junction cells to deliver a key competitive edge to EU companies and support large-scale manufacturing excellence.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Energy and Environment on pages 8, 11, 23, and 34.

Keywords

III-V semiconductors, multi-junction solar cell, reference material, photovoltaic, electrical transport, metrology, efficiency, heterostructure properties, quantum dots, spectral responsivity, standardisation

Background to the Metrological Challenges

Multi-junction solar cells use a combination of semiconductor materials to more efficiently capture a larger range of photon energies than similar technologies, with current state of the art devices achieving 44 % efficiency in the laboratory.

To support these developments for highly efficient III-V multi-junction cells, there is a need to build the metrological infrastructure and facilities for traceable metrology of structural, electrical, optoelectronic and thermionic properties characterisations of III-V materials, from the macro to nanoscale. The aim is to develop reference material, calibrated standards and traceable measurement methods to overcome the present lack of material data that limits the modelling capabilities and realistic simulations as well as qualified material and devices for large-scale manufacturing. These measurements are also useful to quantify process variation and optimise manufacturing process. There is also a need to develop specific procedures and standards for multi-junction solar cells, as already exist for the standard cells based on well-known technologies.

Current state of the art measurement techniques for these material stacks are mostly limited in terms of traceability, accuracy and quantification. Better resolution and low uncertainty measurements could be achieved by using powerful measurement methods based on ion beam techniques as Secondary Ion Mass Spectrometry (SIMS) or Scanning Probe Microscopy techniques as SKPM, SCM and SMM.

Scientific and Technological 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 JRP-Protocol.

The JRP shall focus on the traceable measurement and characterisation of multi-junction solar cells based on III-V material.

The specific objectives are

1. To develop methods to accurately measure electrical transport properties of III-V materials used for multi-junction solar cells including: work function; band gap; dopant; photocurrent; carrier density; diffusion length; minority carrier lifetime; recombination mechanism; series-resistances; and defects concentration.
2. To characterise nanoscale semiconductor quantum dots in terms of: structural properties; effect of size and density on effective bandgaps; electronic coupling between dots; and excitons lifetime.
3. To develop reliable tools and workflows to measure the carrier transport between interfaces in multi-junction solar cells and to characterise narrow (10 to 30 nm) tunnel-junction properties.
4. To measure thermionic and thermoelectric transport across multilayer structures.
5. To develop traceable and reliable calibration methods, and standards for determining device efficiency and linearity, as well as the development of a broadband spectrally-tuneable source for improved spectral response measurement of multi-junction devices.

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 R&D work, the involvement of the user community such as industry, and standardisation and regulatory bodies, as appropriate, is strongly recommended.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. Any links to the EMRP project NEW01 TREND should be explained in the proposal.

EURAMET expects the average size of JRPs in this call to be between 3.0 to 3.5 M€, and has defined an upper limit of 5 M€ for any project. The available budget for integral Research Excellence Grants is 30 months of effort.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the “end user” community (eg letters of support) is encouraged.

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge to the semiconductor manufacturing sector.

You should detail other impacts of your proposed JRP as detailed in the document “Guide 4: Writing a Joint Research Project”

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology and includes 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 Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.