Title: Metrology for complex thin film materials with energy applications

Abstract

The future landscape of Energy in Europe will be dominated by a diverse number of technologies in order to ensure security of supply, energy efficiency and cost competitiveness. In parallel, EU regulations for the use of renewable energies and energy efficient products are stimulating multibillion Euro business opportunities related to the development of advanced materials and technologies. Cross-cutting metrology research can lead to wide impact across different energy sectors, minimising the risk of research investment. Traditionally, metrology for energy technologies develop individually, with little crosstalk, leading to duplication of efforts. To increase European competitiveness a new approach is needed that combines knowledge from different metrology areas into a common solution.

Keywords

Nano-structured energy materials, complex thin films, power-electronics, thin film photovoltaics, solid state lighting, combined metrology, hybrid metrology

Background to the Metrological Challenges

Complex thin films are key components of numerous energy technologies including power electronics, solid state lighting, solar energy and energy efficient windows. These technologies share common challenges related to performance, stability and cost-effective manufacturing.

To optimise complex thin films for energy applications, developers rely on different measurement methods, including:

- optical methods used for dimensional measurements, characterisation of semiconductor properties and detection of defects
- x-ray and ion beam methods used for structural or chemical characterisation
- electrical / electronic measurements used to investigate the performance of the energy devices.

However, the current trend of using multiple methods does not reduce uncertainty as it could, due to the lack of a unification effort into a unique complex physical model. An indication of the feasibility and benefits from such an approach has recently been demonstrated in the JRP ENG53 ThinErgy project where a hybrid analysis of X-ray fluorescence, X-ray diffraction and combined optical and X-ray analysis were used to reduce the uncertainty in structural characterisation of thin films. Nevertheless, correlating different methods remains an open challenge due to the lack of mathematical models that can link the different traceability chains from the VUV to the hard X-ray.

JRP ENG53 ThinErgy has also demonstrated new x-ray methods for reliable depth profiling of complex thin films and high resolution optoelectronic 2D mapping methods that allow the identification of functional defects in the thin films used for photovoltaic and power electronics applications. In parallel, next generation secondary ion mass spectrometry (SIMS) instrumentation opens the possibility of 3D chemical mapping with increased spatial and mass resolution. Combination of these 2D and 3D methods is not yet possible and extending it to the study of degradation of thin film materials used in energy applications would generate reliable datasets for optimisation of manufacturing towards more reliable products.

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 traceable measurement and characterisation of complex thin film materials with energy applications.

The specific objectives are

1. To develop hybrid experimental methods (i.e. simultaneous measurements of 2 or more measurands) for improved analysis of complex energy thin film material properties and study their impact on the performance of energy products.
2. To develop data analysis, data fusion and mathematical models to take advantage of hybrid metrology methods.
3. To develop measurement methods for 2D and 3D chemical, structural, optical, thermal and transient optoelectronic properties of nano-structured thin film energy materials and devices capable of identifying inhomogeneities at multiple scales. Methods should demonstrate a spatial resolution better than 200 nm.
4. Identification of key measurement parameters for improved stability of thin film energy products and generation of new materials datasets as a function of aging, to allow reliable modelling/simulation of product degradation/lifetime prediction.
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (accredited laboratories, instrument manufacturers), standards developing organisations (DIN, ISO) and engage with industries that exploit thin films in energy applications to support the development of new, innovative products, thereby enhancing the competitiveness of EU industry.

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 ENG53 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 Energy 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.