European Partnership on Metrology
Call 2024 –Digital Transformation, Green Deal, Normative and Research Potential

Selected Research Topic number: **SRT-n10**
Version: 1.0

Title: Accurate chemical measurements of organic based semiconductors

Abstract

Semiconductors are essential to most industries and the European Commission introduced in 2023 the "European Chips Act Regulation" to strengthen the EU's semiconductor ecosystem. An important class of these materials are organic based semiconductors, with a great global market value. However, there are challenges on accurate, sensitive, and reproducible measurements of buried organic layers, which are typical in organic based semiconductors. The proposals should aim to develop reference materials for layers less than 100 nm, establish accuracy and reproducibility in measurement via interlaboratory tests and create standards to underpin the organic semiconductors sector at various stages from R&D to manufacturing and diagnostic methods.

Keywords

Standards, Semiconductors, Organic Semiconductors, Nanoscale, Chemical Metrology, reference material, thickness measurements, interlaboratory study, amount of material, ISO, BIPM, VAMAS,

Background to the Metrological Challenges

Semiconductors are an essential underpinning part of most industries, including transport, communications, data, space, defence, and smart devices. In 2023, the European Commission introduced the "European Chips Act Regulation" to help Europe meet the target of doubling its global market share in semiconductors from 10 % to 20 % in the next decade. Semiconductors are central to the digital economy, and they are powerful enablers for the sustainability and green transition (e.g., The European Green Deal). An important class of materials within the sector are organic semiconductors as their usage has increased in the consumer electronics sector, large displays, and in electric and smart vehicles. However, there are challenges related to organic semiconductors which are hindering the potential of growth of the market. This includes for example lower stability of blue organic light-emitting diodes or environmental degradation of organic solar cells. At the core of understanding these issues and improving organic semiconductors is the challenge of achieving accurate, sensitive, and reproducible measurement of small amounts of organic materials buried as layers of typically 10 to 100 nanometres within organic hosts, which are typical in many types of organic semiconductors.

There is the need for standards to underpin the organic semiconductors sector at various stages, i) Research & development of new materials with complete understanding of organic molecules to guide formulations and organic semiconductor device architecture; ii) Reproducible manufacturing with sufficient sensitivity to different organic materials; iii) Benchmark of device performance and stability for reliable diagnostic methods to detect and localise small quantities of molecular degradation products. The establishment of a nanolayer reference material of alternating thin layers (2.5 nm and ~55 nm) served as the basis for the international standard ISO 22415:2019 (Method for determining yield volume in argon cluster sputter depth profiling of organic materials) that specifies a method for measuring and reporting argon cluster sputtering yield volumes of a specific organic material. For the effective and accurate usage of all these listed techniques in conjunction, more standards and procedures need to be developed and new reference materials must be established.

Research regarding organic molecules buried in organic hosts is suitable for standardisation within ISO TC/201 (Surface Chemical Analysis). Nevertheless, this will require the international interlaboratory

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comparisons supported by pre-normative initiatives in the Versailles Project on Advanced Materials and Standards (VAMAS). Moreover, accurate measurement of the thickness of buried organic layers is a strategic topic of the Surface Analysis Working Group (SAWG) within BIPM CCQM. The development of standards for measurement of buried organic molecules in organic based semiconductors aligns with the aims of the “European Chips Act Regulation” and has a strategic aspect of developing metrology for challenging materials that are developed at a fast pace at the fundamental science level.

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 proposal shall focus metrology research necessary to support standardisation in the organic semiconductors sector at various stages from R&D to manufacturing and diagnostic methods.

The specific objectives are

1. To develop a reference material for the standardisation of quantity and thickness measurements of buried layers in organic based semiconductors. The targeted thickness is less than 100 nm of organic molecules.
2. To establish traceable measurement capability for the real-world samples of organic based semiconductors with the goal to determine i) thickness in the nanometres range, and ii) amount of material in the volume fraction range for thickness. The target relative uncertainty is < 5 % for nanoscale buried layers of organic molecules in organic hosts.
3. To conduct an inter-laboratory study to establish metrology infrastructure to measure thickness and amount of material using the reference material developed in objective 1. The interlaboratory study will be done within BIPM CCQM and VAMAS.
4. To initiate the development of a new ISO standard using the results from the interlaboratory study for organic semiconductor measurement under the ISO TC 201 committee (Surface Chemical Analysis).
5. To contribute to the standards development work of the technical committees ISO TC 201 and BIPM CCQM SAWG to ensure that the outputs of the project are aligned with their needs, communicated quickly to those developing the standards and to those who will use them, and in a form that can be incorporated into the standards at the earliest opportunity.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art and explain how their proposed research goes beyond this.

Proposers should note that the programme funds the activity of researchers to develop the capability, not the required infrastructure and capital equipment, which must be provided from other sources.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.0 M€ and has defined an upper limit of 1.3 M€ for this proposal.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated 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 proposal's 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,
- Facilitate improved industrial capability, or improved quality of life for European citizens in terms of personal health, protection of the environment and the climate, or energy security,
- Transfer knowledge to the semiconductor and electronics sectors.

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 the Metrology Partnership 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.

Timescale

The project should be of up to 3 years duration.