EMRP Call 2012 – Open Excellence, Industry and SI Broader Scope

Selected Research Topic number: **SRT-i23**
Version: 1.0

Title: Metrology for surface waves and surface state-assisted devices

Abstract

The increasing demand of current society for security, early disease detection or, more generally, for improved life standards asks for devices and sensors with extremely high accuracy and predictable low uncertainties. Surface waves and plasmons-assisted devices are currently seen as the responses to such need. However, the increased sensitivity comes at the cost of low output signals and complex structures at the nanoscale level. This makes the corresponding quantification of the uncertainty associated to the measurand difficult. Novel metrological methodologies are needed to characterise the optical functionalities of these devices as well as their physical and geometrical properties that strongly affect such functionalities.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Industry & Fundamental Metrology on pages 33 and 42.

Keywords

Surface plasmon resonance, plasmonics, biosensing, metamaterials, absolute optical radiometry, optical cloaking, superresolution microscopy, perfect lenses, surface waves, frustrated total internal reflection, surface states.

Background to the Metrological Challenges

Surface waves and surface states-assisted devices are currently considered as the answer to the increasing demand for extremely sensitive physical sensors in industry and current society in general. They exploit the special coupling that takes place, under specific conditions, between an evanescent electromagnetic surface wave (in most cases in the visible range) and a sample (possibly of nanoscale size) that needs to be measured or detected. This can be achieved by building novel nanostructures that can support the generation of Surface Plasmons Resonances or by other means like Frustrated Total Internal Reflection, Surface Phonon Resonances, etc. Another important tool for nanosensing is surface states when the field exponentially attenuates versus the distance from the surface without excitation of surface waves. This is possible e.g. at the interface of a periodic medium (so-called Tamm’s and Shokley’s states), however it is also possible in optically thin structures with resonant response (e.g. so-called perfect plasmonic absorbers). This results into a class of devices that are extremely sensitive to changes in the conditions of the surrounding environment. Prospective applications are biosensing, safety, optical cloaking for stealth technology. For example, devices designed to measure concentrations of biological markers in human blood for early detection of cardiovascular diseases can have output optical signals as small as one picowatt, or even less, unless smart methods to enhance the emitted signal are introduced.

Considering the large impact that metamaterials-based sensors are expected to have in the future, radiometric, dimensional and physical metrology need to develop relevant capabilities to foster these new technological advances.

EURAMET, EMRP-MSU
National Physical Laboratory
Hampton Road, Teddington,
Middlesex, TW11 0LW, UK

Phone: +44 20 8943 6666
emrpA169@npl.co.uk
www.euramet.org

EMRP
European Metrology Research Programme
Programme of EURAMET

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

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 surface waves and surface state-assisted devices and sensors in absolute terms for optical power and for wavelength.

The specific objectives are

1. To develop and validate methods for the measurement of optical power reflected or transmitted by surface wave and surface state-assisted devices within the spectral range of interest (between 200 nm to 2.5 µm).
2. To define and achieve absolute calibrations of these devices for wavelength in the same spectral range.
3. To perform a lifetime analysis of the devices to study ageing effects on performance.
4. To develop dimensional and physical measurements and theoretical models that allow the prediction of the optical power reflected or transmitted by the surface wave and surface state-assisted devices for comparison with the measurements made above.
5. To develop and validate methods for electromagnetic (optical) characterisation of surfaces supporting surface waves and states in the same spectral range, particularly structured surfaces which possess surface polarisation different from that of the substrate.

The devices under investigation must be carefully prioritised along documented industrial needs and economic impact and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected.

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

The total eligible cost of any proposal received for this SRT is expected to be around the 2.7 M€ guideline for proposals in this call. The available budget for integral Research Excellence Grants is 42 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 sensors 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.