EMPIR Call 2014 – Industry and Research Potential

Selected Research Topic number: **SRT-i10**
Version: 1.0

Title: Traceable asphere and freeform metrology

Abstract

High quality optical surfaces are an enabling factor for many scientific and industrial applications, from precision engineering to the optical and semiconductor industries. Most challenging are aspheres and freeform surfaces; and in the high-quality manufacturing and metrology of these surfaces, Europe has a leading role. Various metrological capabilities need to be advanced to guarantee the traceability of asphere and freeform metrology; and the dissemination must be continued to metrology in industry. The complete calibration chain must be realised and to enable stakeholders to measure and manufacture optical surfaces at a higher quality and with lower costs.

Keywords

Optical surfaces, aspheres, freeform, traceability, optimal calibration strategies & design of experiment, interferometry, CMM

Background to the Metrological Challenges

According to an analysis published by the European Commission [1], the computers, electronic and optical products sector is characterised by a strong global competition and a comparatively strong emphasis on R&D. The global market of the photonic industry is estimated to be €615 billion in 2020, based on a market volume of €350 billion in 2011 [2]. The core sectors are lighting, production technology, medical technology, defence photonics and optical components and systems; with the photonics sector projected to almost double by 2020 [3]. However, to foster and strengthen this margin, several metrological activities are mandatory.

Highly accurate optical elements and systems are a key technology for modern production in the photonics industry. The applications range from automotive detectors and cameras, cell/smart phones, glasses, photography, astronomy, up to the semiconductor production. The surfaces of the elements are of “optical quality”, i.e. smooth with low roughness and waviness, with the characteristic property to describe these surfaces known as the ‘form’. The most challenging class of optical surfaces are aspheres and freeform surfaces; and in the manufacturing and metrology for these surfaces, Europe has a leading role.

Prior to their application, asphere and freeform measurement devices need to be calibrated. The accuracy and the reliability of subsequent measurements rely heavily on how the calibration has been performed; but optimal calibration strategies, reducing the amount of effort needed to achieve a required accuracy, are currently lacking.

An effective chain of traceability is urgently needed the stakeholders, which use different asphere and freeform metrology systems in their specific production environment to improve the accuracy of the surfaces. For this chain, the uncertainty at the NMIs also has to be reduced. Reference specimens must be made available to the stakeholders; and on the workshop level, there is still not sufficient information on the behaviour of the instruments typically used.

Ongoing discussions at the High Level Expert Meetings and workshops of the Competence Centre for Ultra Precise Surface Manufacturing (UPOB) [4] on “asphere metrology” have strongly emphasised the urgent needs of industry for more accurate form measurement and improved asphere standards.

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 proposal.

The JRP shall focus on establish the calibration chain from metrology institutes to industry for aspherical and freeform optics. The specific objectives are:

1. To improve the metrological capabilities for aspherical and freeform optical surfaces and to develop statistical methods for the calibration of measurement devices. The required uncertainty for form measurements is significantly less than 50 nm over dimensions between 10 mm and 200 mm.
2. To realise reference aspheres and freeforms for the calibration and quality control of metrology systems and to develop traceable calibration of these references capable of an uncertainty significantly better than 50 nm. The calibration systems must include high precision alignment methods, different (i.e. optical, tactile) measuring systems and highly sloped surfaces in order to achieve comparability.
3. To investigate the traceability and measurement capabilities of asphere and freeform metrology systems in the production environment. This investigation must include fast and flexible asphere and freeform metrology systems, fast alignments of the surface under test, speed-optimised data analysis and optimised marker structures. Advanced techniques for industrial application must be developed.
4. To develop a method for the comparison of measurement data from different measurement instruments. This must include the interpolation between different surface representations, the capability of rotating surfaces, the calculation of the absolute radii, the development of robust and fast algorithms to solve min-max problems, the solution of vertical and orthogonal least-square problems.
5. To engage with industry that manufactures and or / exploits aspherical and freeform optics to facilitate the take up of the technology and measurement infrastructure developed by the project, to support the development of new, innovative products, thereby enhancing the competitiveness of EU industry

Proposers shall give priority to work that meets documented industrial needs and include measures to support transfer into industry by cooperation and by standardisation. An active involvement of industrial stakeholders is expected in order to align the project with their needs – both through project steering boards and participation in the research activities.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this and EMRP JRP IND10 (Form metrology) ‘Optical and tactile metrology for absolute form characterisation’.

EURAMET expects the average EU Contribution for the selected JRPs to be 1.5 M€, and has defined an upper limit of 1.8 M€ for any project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution to the project. Any deviation from this must be justified.

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,
- Drive innovation in industrial production and facilitate new or significantly improved products through exploiting top-level metrological technology,
- Improve the competitiveness of EU industry,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the optical surfaces sector.

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

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.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] European Commission: Computers, electronic and optical products, Comprehensive sectoral analysis of emerging competences and economic activities in the European Union, http://ec.europa.eu/restructuringandjobs

[2] Optech Consulting Study, Industry Report of Photonic 2013, http://www.spectaris.de/photonik-praezisionstechnik/presse/artikel/seite/branchenreport-photonik-2013-wirtschaftsdaten-einer-schluesseltechnologie/presse-1.html

[3] Towards 2020, Photonics Driving Economic Growth in Europe, Multiannual Strategic Roadmap 2014, published by: European Technology Platform Photonics21, http://www.photonics21.org/download/Brochures/Photonics_Roadmap_final_lowres.pdf

[4] Competence Centre for Ultra Precise Surface Manufacturing (UPOB), http://www.upob.de/