Project no.: 15SIB01
Provider: **European Metrology Programme for Innovation and Research (EMPIR)**
Realization period: 1st June 2016 – 31st May 2019

Project Title:

Reference algorithms and metrology on aspheric and freeform lenses - FreeFORM

Aspheric and freeform surfaces are a very challenging class of optical element. Their application has grown considerably in the last few years in areas such as imaging systems, lithography, automotive, etc. The reason for this growth is that aspheres and freeform surfaces are superior to classical spherical optics due to their additional degrees of freedom of geometry. Optical systems that employ aspheric or freeform surfaces have fewer optical elements and higher imaging quality.

The strength of Europe in optics is not the mass market, but high quality optical systems, with superior imaging quality. This means that the surface quality of the optical elements must be better than 30 nm, and this requires the accuracy of the metrology to be even better than this.

The most critical and immediate need of research institutes and industry is the capability of form metrology for optical aspheres and freeforms, below the 30 nm uncertainty level. This need to develop accurate form metrology for asphere and freeform optics. Such ambitious goals can only be achieved in the context of intensive international cooperation between top-class workplaces. This cooperation is covered by European Metrology Programme for Innovation and Research (EMPIR) within the project FreeFORM (15SIB01) where the TOPTEC Centre plays a significant role.

Project outputs:

a. Robust reference algorithms and softgauges

To realize a reference metrology chain for aspheres and freeforms, robust and deterministic reference algorithms will be developed, which have the calculation uncertainty at the sub-nanometre level. Furthermore, several reference softgauges, also not existing at present, will be developed to ensure the traceability of the developed algorithms for asphere and freeform analyses. To combine measurements made by different instruments, robust algorithms for data fusion, stitching, interpolation and filtering will be developed. TOPTEC is responsible for the development of stitching algorithms for all kinds of optical surfaces.

b. Thermo-invariant asphere and freeform reference standards

Innovative reference surfaces from thermo-invariant materials will be realized for the first time. Surface forms suitable for new traceability routes will be investigated and their design will be optimized for ease of manufacturability. This will lead to suitable and affordable reference surfaces

for different types of aspheres and freeforms that will be useful to enhance the traceability of metrology instrumentation manufacturers and optics manufacturers to below 30 nm. Due to the high level of knowledge and experience, TOPTEC plays an important role in the complex design of reference elements (material, optical and mechanical properties). TOPTEC is also responsible for manufacturing the freeform reference surfaces and their measurements. Results of measurements serve as reference data to other partners.

c. High accuracy reference measurement systems

The uncertainty for form measurements will be reduced to less than 30 nm for aspheres and freeform surfaces with dimensions between 10 mm and 200 mm and slopes of up to 20°. This objective will be achieved by improvements to specific measurement instruments and statistical methods for the calibration of measurement devices, where appropriate. TOPTEC also develops measurement systems based on multi-wavelength approach.