Partners description

Partner 1 - VSL (Coordinator, Internal Funded Partner)

VSL is the national metrology institute of the Netherlands and makes measurements results of companies, laboratories and organizations directly traceable to international standards. The Dutch government has appointed VSL to maintain and develop the national measurement standards. VSL uses its knowledge and unique facilities to ensure the reliability of measurements in industry, society and science, contributing to better products, quality of life and scientific knowledge.

VSL participates or participated in more than 65 international research projects in the European Metrology Program for Innovation and Research (EMPIR) and its predecessor the European Metrology research Program (EMRP), in fifteen of which acting as coordinator.

Partner 2 - CMI (Internal Funded Partner)

The Czech Metrology Institute (CMI) is the National Metrology Institute of the Czech Republic. Since 1998, the Department of Nanometrology has focused on the development of scanning probe microscopy metrology and related methods. This includes providing traceability for scanning probe microscopy methods (metrology SPM), developing methods for quantitative analysis of different physical quantities with nanometer resolution and numerical analysis. The main effort of the Department is equally distributed between scientific projects, instrumentation development and publication activities.

Partner 3 - DFM (Internal Funded Partner)

DFM is the Danish national metrological institute and possesses the highest level of measurement competences in Denmark within a range of key measurement capabilities. DFM provides critical infrastructure to the European industry by providing traceability at the highest possible international level within metrology. DFM's scientific research results in new knowledge, measurement techniques and standards, which support the need for accurate measurements required by European industry and authorities. The services offered are high level calibrations and reference materials traceable to national primary or reference standards, courses related to metrology and consultancy services.

DFM has a special role in developing measurement capabilities needed by small and medium sized high-tech companies in order for them to evolve and prosper. DFM works to ensure global confidence in European metrological services, which is critical for competing in the global market place.

DFM is a non-profit university-owned subsidiary, with a high degree of solidity. DFM is part of the national technology infrastructure with task of maintaining core competences in the field of metrology. The main income (approx. 14 mi. DKK per annum) is a government contract for the operation of the national metrology institute, i.e., the maintenance, operation and dissemination of measurements from national standards, participation in the global metrology community, representing Denmark, and for research and development of standards, measurement methods and calibration services for the benefit of Danish industry and as contributions to the international development of a global coherent metrology system. The latter is cofounded by national and regional (e.g. EU) projects participation.

A certain amount of funds allocated in the government contract is for cofounding of participation in research and development projects. Furthermore, as a non-profit organisation, income from commercial services is used for co-funding. The nanometrology team has a profound experience in design and development of instruments for characterization of surface structures and materials. These services are offered both as consultancy for Danish and European companies and as part of international funded research projects. The team always aims to be at the frontier of the research in surface and material characterization in order to provide the best and newest solutions for our partners. The team is very active in communication of the new characterization methods and publish several papers every year in international peer-reviewed journals. The team also has recently developed the novel 'imaging

scatterometry" method, which can be used for simultaneous defect detection and topography analysis of nanostructures.

Partner 4 INRIM (Internal Funded Partner)

INRIM is a national research institute devoted to research in metrology and innovative technologies (Quantum Information, nanotechnologies, ferromagnetic materials, artificial vision etc.). The quantum optics research program of INRIM, led by M. Genovese, has developed large experience in the field of quantum technologies and in particular in quantum imaging & metrology and, generally, well established international experience in quantum optics. It disposes of eight laboratories equipped with various laser sources and optical and electronic equipment, which will represent the basis for developing the present work. Another fundamental resource is represented by the young and motivated people working in these labs (7 permanent researchers, of which 6 under 45 and 6 non-permanent staff researchers under 40). It has several collaborations with European and foreign institutions: some group members have been organisers of various international workshops and are editors of international journals. In the last years the group was involved into many international and national joint projects.

Partner 5 - NPL (External Funded Partner)

The National Physical Laboratory (NPL) is the National Measurement Institute for the UK and is a world-leading centre of excellence in developing and applying the most accurate measurement standards, to science and technology. The Dimensional group at NPL is devoted to the development and dissemination of new standards, instruments and techniques covering geometry, form and surface topography measurement at length scales from nanometres to tens of metres, to support and enhance the UK's engineering and manufacturing industries. The group is supported by a complementary range of mathematics, modelling and analytical skills from the Data Science department for advanced uncertainty analysis.

Partner 6 - PTB (External Funded Partner)

The Physikalisch-Technische Bundesanstalt (PTB) is the national metrology institute of Germany and the highest technical authority for the field of metrology and certain sectors of safety engineering. PTB comes under the auspices of the Federal Ministry of Economics and Technology. It meets the requirements for calibration and testing laboratories as defined in the EN ISO/IEC 17025. It has a staff of about 1900 employees of whom more than 500 are graduates. It is fundamental task of PTB to realize and maintain the legal units in compliance with the International System of Units (SI) and to disseminate them, above all within the framework of legal and industrial metrology.

The working group Optical Nanometrology of PTB's optics division develops methods for the measurement of the size of surface structures in the µm to few nm range using optical methods. Important applications are the development of dimensional optical measuring techniques for current and future manufacturing technologies for semiconductor industry, for nanotechnologies and (diffractive) optical components. The group is developing and investigating state-of-the-art and novel optical nanometrology methods based mainly on optical microscopy, scatterometry and (Mueller) ellipsometry, strongly supported by work on modelling and data analysis methods including rigorous field modelling, sophisticated inverse solvers, modelling of optical imaging and hybrid metrology.

Partner 7 - Aalto (External Funded Partner)

Aalto University is the leading institution of Finland in micro and nanoelectronics. In this proposal Aalto university is represented by the research group of Const. Simovski, professor of the Dept. Electronics and Nanoengineering. This department comprises Micronova, centre of micro- and nanofabrication with its largest in Nordic countries cleanroom. In total, the cleanroom covers an area of 2 600 m2. It is a clean bay – service chase type of cleanroom, with clean areas dedicated to various processing and analysis activities. The classification ranges from ISO4 in lithography and CMOS-sections, ISO5 in most processing areas to ISO6 in areas dedicated to measurements and gowning. In addition to this main cleanroom there are laboratories with built-in cleanrooms for micropackaging and back-end processes

as well as well-equipped and controlled labs for MOVPE, MBE and other thin film processes. The research field of Micronova spans from microfluidics to single-electron devices. The techniques used range from deposition of atomic layers and nanometer sized structures to devices that utilize structures up to hundreds of microns.

Partner 8 - FSUJ (External Funded Partner)

The Institute of Applied Physics (IAP) of the Friedrich-Schiller-University Jena (FSU) has more than 25 years of experience in the field of micro- and nano-structured optics. Starting with the realization of integrated optical devices in the 1980, the research focus has evolved via diffractive optical elements, sub-wavelength and effective refractive index structures, photonic crystals, plasmonic elements towards meta-materials. Expertise consists in the optical modelling and designs of such structures as well as in their fabrication by lithographic technologies. For that, an extensive clean-room facility is available, containing infrastructure for electron-beam lithography, focused ion-beam etching, Helium-Ion microscopy, various reactive ion-etching tools, and the related characterization equipment (SEM, AFM, dual-beam SEM/FIB, various interferometers). Examples of elements realized in the past comprises diffractive beam-splitters and shapers, high performance diffraction gratings for ultra-short-pulse laser compression and space spectrometers, micro-structured polarizers and retarder structures, nano-antennas and a lot more.

Partner 9 - ICFO (External Funded Partner)

ICFO-The Institute of Photonic Sciences (http://www.icfo.eu) is a research institution founded in 2002 with the aim to become a leading, world-class, wide-scope research center that focuses on photonics for advancing knowledge and technology. Research at ICFO is carried out by means of medium term programs and short term projects in a variety of fields that include including quantum information technologies, health, environment, safety, energy, nano-photonic devices, remote sensors, optoelectronics, integrated optics, ultrafast optics, bio-photonics and biomedical optics.

The center's double mission is to push the frontiers of research and to train technologists by equipping them with unique technical and personal skills. ICFO actively collaborates with many leading research centers, universities, hospitals and a variety of private corporations worldwide. ICFO hosts a variety of research groups working in 45 laboratories and a nanofabrication clean-room, all of which are located in a 9'000 m2 building, located in the Mediterranean Technology Park, in the Barcelona metropolitan area. ICFO researchers participate very actively in research projects and networks funded by national and international funding agencies.

Know-how available includes novel laser sources, nanotechnology, OLEDs, light harvesting and solar cells, remote and harsh environment sensors, different advanced imaging techniques, near-field-optical methods, optoelectronics, solar cells, single-molecule detection, light-matter and light-tissue interactions, and ultra- secure communications, among others. ICFO has a strong in-house Knowledge & Technology Transfer (KTT) Team, through which it conducts many relevant research collaborations with industrial partners. ICFO holds a portfolio of more than 60 patent families and has relevant experience in more than 50 industrial projects with different corporations, as for example IBM, Graphenea, Procter & Gamble, Puig, Zeiss, TFM Solar, BASF, Seat, Ficosa**,** Monocrom, B. Braun, Leica Microsystems, Alter Technologies, Thales Alenia Space, Emxys, Time Bandwidth, and Nokia.

Partner 10 – TUBS (External Funded Partner)

The Technical University of Braunschweig (TUBS) belongs to the 9 most important technically oriented universities of Germany (TU9 German Institutes of Technology). TUBS has 20,000 students and offers more than 70 different courses. Metrology is one of the four main research foci of TUBS. Currently, TUBS establishes the LENA Laboratory for Emerging Nanometrology as a joint research initiative together with PTB. The LENA Lab aims at the precise and quantitative measurement of nanoscale structures with special focus on three-dimensional structures. The goal is lay the foundation for a better understanding of smallest structures and pave the way for an improved standardization and finally industrial use.

The research group “Metrology for functional nanosystems” located at the LENA Laboratory for Emerging Nanometrology carries out research on nanooptical surfaces for high-precision metrology and sensing applications and investigates methods for optical characterization of bulk materials as well as of micro- and nanoscale optical and opto-mechanical systems. Beside tailoring light-matter interaction for high-precision optical metrology and characterization of relevant material properties (e.g. mechanical losses, photoelasticity, photothermal properties), the group’s research focus is nanooptical polarizers for application wavelengths in the ultraviolet spectral range. To achieve a high performance in this spectral range, structure accuracies in the range of a few nanometers are necessary. The research group theoretically and experimentally investigates optical methods to characterize the nanostructures at this scale. Therefore, the group has optical facilities for the optical characterization of nanostructures (laser sources, spectrometer, polarimeter) and additionally has access to sophisticated instruments for the characterization of nanooptical functional surfaces (e.g. high resolution TEM, FIB-SEM, THz microscope, 3D AFM and SAXS) at the LENA laboratory.

Partner 11 – TUDelft (External Funded Partner)

Delft University of Technology provides top-level technical and scientific education in a great number of disciplines. In order to do so, high-quality and innovative research is a pre-requisite. The research conducted by TUDelft is internationally renowned and recognized by the scientific community as well as the business community. It is research that has determined the image of technical and scientific developments in the Netherlands since 1842. The Master of Science International Programme of TUDelft offers ten condensed engineering courses in the English language.

The Optics Research Group is part of the Department of Imaging Physics which, in turn, is part of the Faculty of Applied Sciences of TU Delft. The group focuses on teaching and research in various fields of applied optics. The aim is to pursue high-level research in the field of optical instrumentation and optical technology. Key areas are of research are: metrology for the next-generation lithography, surface inspection using optical techniques for solar cells and OLEDs, sub-wavelength optics and plasmonics, sensor solutions using integrated photonics, advanced optical design, applications of femtosecond technology for length metrology and breath analysis, research in the terahertz wavelengths.

These projects are sponsored by national institutions, European Union and industry (C. Zeiss, ASML, Philips), and the Dutch Science and Industry Institute (TNO). Furthermore, we are also involved in projects together with the metrology institutes VSL (Netherlands) and PTB (Germany).

The Optics Group also participates actively in teaching for undergraduate and graduate courses in Applied Physics. It participates in the Erasmus Mundus program Optics Science and Technology of the European Union at master level and coordinates *SMETHODS*, a EU-Support Action for training in optical design for European SME’s.
In the last few years, the Optics group of TU Delft has also organised summer schools inside the Marie Curie training programs and topical meetings of the European Optical Society.

Partner 12 – UniTo (External Funded Partner)

The UNITO team members are affiliated to the Physics Department of the University of Torino, which operates since many years within the “Nanostructured Interfaces and Surfaces” inter-departmental centre of the University of Torino (NIS) [http://www.nis.unito.it/]. The UNITO team [http://www.solid.unito.it/] has an experience dating back from early 90’s on the science and technology of artificial diamond [https://goo.gl/xDVHqn]. Both at its home laboratories and within the above-mentioned NIS inter-departmental centre, the group has well-established expertise and experimental facilities for the processing (annealing chambers, …) and the characterization of the optical, electrical and structural properties of artificial diamond (Raman and photoluminescence spectroscopies, scanning probe microscopies, …). This recently included a class 10,000 cleanroom and a state-of-the-art single-photon-sensitive confocal luminescence microscope equipped to perform Hanbury-Brown-Twiss interferometry and Optically Detected Magnetic Resonance. UNITO participates to WP4, bringing its expertise on artificial diamond processing and opto-physical characterization.

Partner 13 - SU (External Funded Partner)

Swansea University (SU) is the second largest university in Wales, and invested in major nanotechnology infrastructures through the Centre for Nano Health, Welsh Centre for Printing and Coating, advanced electron microscopy and fabrication facilities. The facilities relevant for the project include a tip-enhanced Raman spectrometer (TERS) with equipped with multiple lasers including 532nm, 633nm and 785 nm lasers, JEOL 7800F high resolution FEG SEM and a Zeiss Cross Beam 540 focused ion beam (FIB) system attached with a high resolution SEM. US is a research led university and runs a number of courses including core subjects such as physics, chemistry, biology and engineering as well as interdisciplinary courses including biomedical engineering and nanomedicine where this research topic will be very relevant.

Partner 14 – ZIB (External Funded Partner)

Konrad Zuse Zentrum für Informationstechnik Berlin (Zuse Institute Berlin, ZIB) is a mathematical research institute funded by the state of Berlin. The Computational Nano Optics (CNO) group at ZIB has a long standing history in developing numerical methods for simulating light-matter interactions on a nanoscale. An emphasis of research is on adaptive finite-element methods for solving Maxwell's equations. These developments are strongly interlinked to various collaborations with partners from academic, fundamental research and with partners from the industry.

On the numerical side, our research includes h- and p-adaptive higher-order finite-element methods, reduced basis methods, and application of methods for design optimization and parameter retrieval. On the nano optical application side, our research includes metamaterials, optical chirality, plasmonics, nano-structured fibers, photovoltaics, optical nano-metrology, design of light emitting devices like nano-lasers and quantum dot based devices.

In the past, several algorithmic developments at ZIB have had an impact on commercial software products and are now used in academic and industrial research and development around the globe

Partner 15 – DTU (Unfunded Partner)

Technical University of Denmark (DTU) is an international elite technical university that delivers excellent innovation and education founded in world-class research. Number 1 in the Nordic countries on 'Reuters Top 100 World's Most Innovative Universities 2016,' and number 10 in 'Global Ranking of Academic Subjects: Engineering Top 20' (as of 4 May 2017), DTU is a Scandinavian and a European academic leader in multidisciplinary technical and natural sciences. In addition to having several ERC Advanced Grant holders, the University participates in numerous European innovation networks and clusters, sector development projects, and collaborations including the European Space Agency and the European Food Safety Authority. Globally, DTU serves NASA, WHO, the World Bank, the UN Environmental Programme and other research programs. DTU is widely recognized for its ability to transfer research into technology in close collaboration with academic, commercial and public partners.

Department of Applied Mathematics and Computer Science (DTU Compute) is DTU's competence hub for modern mathematical modelling and computation within engineering and the natural sciences. It is the largest environment for mathematics and computer science in Denmark. The Department, with its 11 research sections and 9 research centers, covers a wide spectrum of mathematical, statistical and computational subjects, from in-depth theory to concrete applications. In addition to research and teaching, DTU Compute undertakes large-scale commissioned research assignments and provides research-based consultancy of both the public and the private sectors. The Department's 3D Imaging Center is the new Danish national research flagship, integrated into a research alliance with the coming European Spallation Source (ESS) and the MAX IV synchrotron in Lund, Sweden.