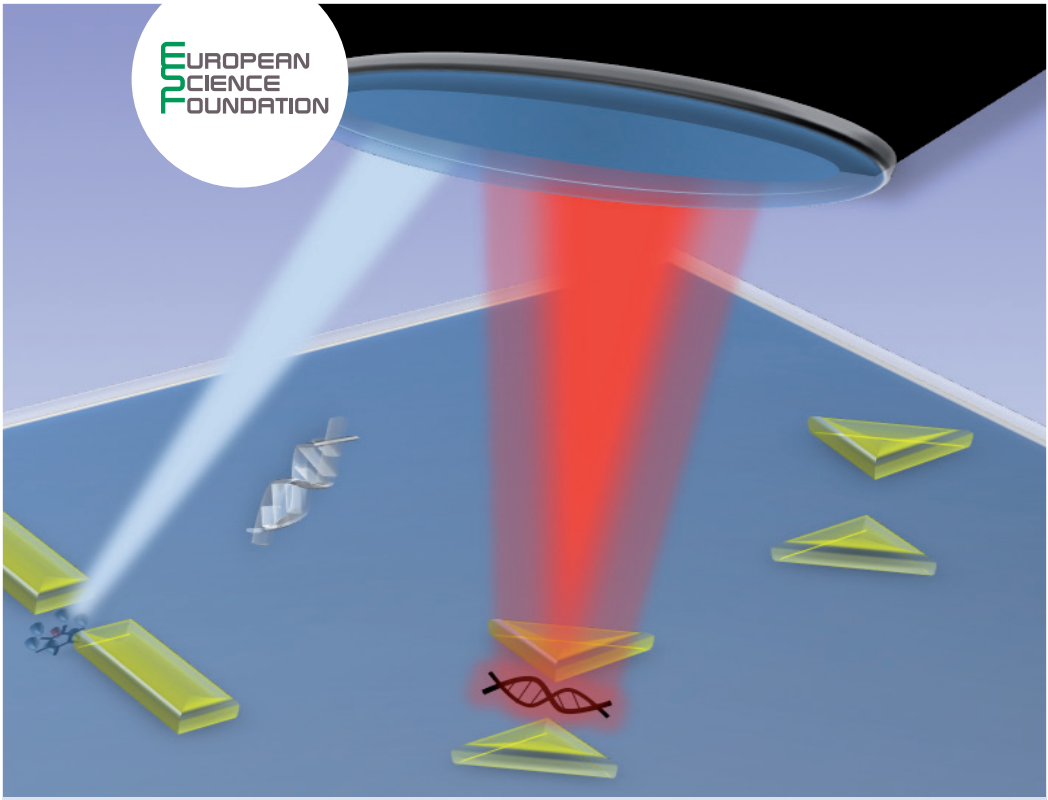


Research Networking Programme

New Approaches to Biochemical Sensing with Plasmonic Nanobiophotonics (Plasmon-BioNanoSense)

Standing Committee for Physical and Engineering Sciences (PESC)

The advent of nanotechnology has opened up the fascinating possibility to interface (bio)molecules with designed nanostructures, thereby creating new functionality for photonic, electronic and health-care applications in a highly integrated environment. At the same time, the recent fast development of plasmonics is providing clear guidelines to focus light to the nanometre scale, i.e., true nano-optics, far beyond the diffraction limit of conventional optics.

The aim of this ESF Research Networking Programme Plasmon-BioNanoSense is to exploit the unique potential of combining nano-optical technology with plasmonics and initiate a decisive advance in European-wide research in nanotechnology at the biological interface, with a focus on the development of truly nanoscale optical biosensors *allowing ultimately routine detection and recognition of single molecules in their natural environment*.

Given the significant European expertise in the areas of nanotechnology, single-molecule science, biophysics and plasmonics, the essential infrastructure for the development of easy-to-use highly integrated biosensors is present. Still, focused action is required, together with the inclusion of concrete end-users, to generate a multidisciplinary interface of the physical and engineering sciences with chemistry and biology. The ESF Research Networking Programme Plasmon-BioNanoSense, including both the European academic key players in the field and one internationally leading nanotech company (Oxonica), aims to create such synergy in order to establish Europe as a leader in photonic bionanotechnology.

The major action of this network will involve an intensive training and education programme: open workshops, schools and exchange visits between leading European groups and end-users on the international arena, and interfaces with clusters of excellence in North America and far-East Asia.

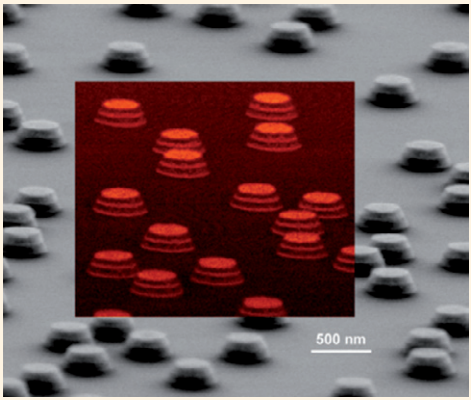
The running period of the ESF Research Networking Programme Plasmon-BioNanoSense is five years from April 2010 to April 2015.

Nano-Bio-Plasmonics

Nanoscience is a widely expanding research field, yet developments towards technological applications are occurring at a much slower pace. Fruitful interaction is found at the interface between (bio) molecules and inorganic, artificial (nano) structures with a given functionality. Here, the development of *an integrated nanobiosensor* has the clear potential to act as a focal point for achieving synergy in nanotechnology, which is exactly the *aim of Plasmon-BioNanoSense*.

The current capacity to nanostructure and engineer a dedicated photonic response has catalysed a revolution in science and technology, with the advent of *nanophotonics* and *plasmonics*. Nowadays truly nanoscale light volumes can be created, breaking the classical diffraction barrier and enhancing dramatically the light/molecule interaction. As such, plasmonics constitutes an ideal platform for surface-enhanced optical bio-sensing. The field is now at the critical stage for the development of functional nanobioplasmonic devices, taking advantage of the level of integration, parallel and fast operation afforded by nanotechnology and plasmonics. We will develop devices exploiting two key technologies:

- *Nanoplasmonics* – high-level integration of photonic and sensing functionality. Various nanoscale waveguide architectures offer true nanophotonic integration: nanowires, metal-insulator-metal heterostructures, nanoscale wedges (or edges) and single (or arrays) of metal nanoparticles, typically acting as refractive index sensors. Alternatively, the optical near field is optimised for fluorescence, surface enhanced Raman spectroscopy, or vibrational infrared spectroscopy, adding chemical specificity independent of functionalisation for agent binding.



Hole-mask colloidal lithography-produced ultracompact nanoantennas for visible light

- *Single molecule detection and spectroscopy* – the ultimate sensitivity. Single molecule fluorescence detection provides the ultimate limit in sensing. Here a nanoscale interaction volume is essential to discriminate rare species against high background, to waste less material and improve spatial resolution. Encouraging demonstrations of single molecule sensing in nanometric volumes have been reported. Once nanocontrol and functional integration are mastered, a vital combination for sensing will be achieved: chemical specificity and ultimately sensitivity at the level of single analytes.

Aims and Objectives

The main objective is the creation of a well-established interdisciplinary research network in nanotechnology, self-sustainable after the initial five-year funding period, and crossing boundaries between engineering, nanophotonics and nanoplasmonics, nanofabrication, single molecule science and plasmonic biosensing, all aimed towards concrete applications. Our activities will focus on combining expertise in these areas to develop, fabricate and test designs of nanoscale integrated nanobiosensors allowing single-molecule sensitivity and recognition, applicable in a variety of general, non-specialist contexts. General objectives:

- Integrate and align research efforts of European researchers;
- Create a technology platform for an integrated photonic nanobiosensor;
- Develop a model network for training of young researchers (PhD students, postdocs);
- Interface with key groupings in the US and Japan;
- Foster increasing connections to end-user level to aid technology transitions.

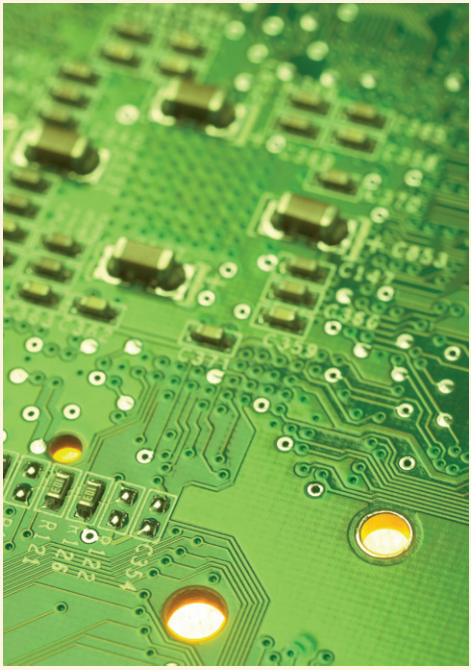
Challenges

The envisioned technology platform for *an integrated photonic nanobiosensor* provides a perfect target to confront aspects of novelty and performance. Compared to existing (plasmonic) sensing modalities the aim is to strive for the ultimate limits in:

- *sensitivity*, also at high background concentration;
- *parallel integration* of agent-specific sensing sites for assay-studies;
- *chemical specificity* (particularly based on Raman spectroscopy);
- *biological relevance* (guidance from biologists/biochemists and end users).

In terms of integration, the challenge is to achieve:

- *ultimate degree of integration* (truly nanoscale);
- *speed, flexibility, user-friendliness*.



Research Themes

The network partners range from biologists, biochemists to physicists, engineers and theoreticians. During the duration of the Research Networking Programme we will be facing the challenges of and developing the following research themes:

Theme 1: Sensing site and functionalisation

- Electromagnetic design, i.e., the development of design criteria for plasmonic sensing sites based on refractive index sensing, fluorescence excitation or quenching, and vibrational Raman or IR spectroscopy, adding chemical specificity.
- Implementation of sensing sites consisting of one or multiple metallic nanostructures optimised for achieving large electromagnetic field enhancement, and designed field gradients for trapping.
- Functionalisation of sensing sites for chemical specificity: surface modifications with antibodies and binding ligands.

Theme 2: Agent delivery

- Integration of continuous flow micro-channels with sensing structures.
- Development of opto-fluidic chip-technology.
- Development of optical schemes for molecular trapping and transport to sensing sites.

Theme 3: Nanoscale waveguide backbone

- Design, fabrication and testing of nanoscale plasmon waveguides for delivery of electromagnetic radiation to sensing sites, at visible or infrared frequencies.
- Design of focusing structures interfaced with sensing sites acting as hot-spots.
- Identification and development of suitable coupling schemes to on-chip light sources (quantum dots, LED, IR quantum well lasers).
- Development of coupling schemes to the outside world, i.e., interfaces to dielectric waveguides.

Theme 4: Optical and electrical read-out

- Integration of sensing platforms with microscopy-based optical detection techniques, both far-field and near-field.
- Development of on-chip optical detection schemes, fibre read-out, micro-spectrometer.
- Development of electrical read-out and interfacing with semiconductor-based electronic structures.

Theme 5: Packaging criteria and end-user technology transition

- Development of a packaged low-cost user-friendly sensing device. Input here from industrial partners Oxonica and Philips will be essential.

Close up of microchip

European Context

The initial network includes 28 groups from 23 institutions in 11 European countries, reflecting the wide range of expertise present within the European community in the areas of (nano)photonics, molecular science and micro- and nanotechnology, and one of the internationally leading nanotechnology companies. Furthermore, the network Plasmon-BioNanoSense will ensure the building of a new generation of highly trained scientists in interdisciplinary nanotechnology.

Activities

Science meetings: workshops, schools, conferences

All guidelines for candidate science meetings organisers can be found on the ESF PIBNS website (www.esf.org/plasmon), including the application form and deadlines for application. Applications for science meetings should be submitted online to the ESF website. The same application form is valid for workshops, training schools and conferences.

Grants for short visits and exchange

Two types of grants are available:

- Short visits of up to 15 days;
- Exchange grants, from 15 days to four months.

Eligibility criteria:

1. Undertake work applicable to the ESF PIBNS Research Networking Programme;
2. Apply to stay in a European country other than the country of origin;
3. Return to the institute of origin upon termination, so that the applicant's institution may also benefit from the broadened knowledge of the scientist;
4. Acknowledge ESF in publications resulting from the grantee's work in relation with the grant.

Priority will be given to applications where the institutions involved are in countries that financially support the programme.

Level of the grant:

Short visit grants are reimbursed on a per diem basis of 85 € plus actual travel expenses up to a maximum of 500 € after the visit on submission of a completed balance payment form accompanied by the original travel tickets. No payment will be made without the scientific report.

Exchange grants are reimbursed on the basis of an allowance of 1,600 € per month / 400 € per week / 57 € per day plus actual costs for travel, up to a maximum of 500 €.

Funding

Applications providing a short description of the proposed project work (about 1,000 words for exchange grants and 250 words for short visit grants) and the duration of the stay should be submitted using the online forms on the ESF website.

➔ Please note that exchange grants should be supported by a letter of recommendation from someone familiar with the applicant's work (if appropriate), a letter of acceptance from the receiving institution and a curriculum vitae of two A4 pages.

Assessment

Applications will be selected according to scientific excellence and assessed by a sub-group of the Steering Committee in agreement with the public ESF guidelines concerning assessment of applications for funding (www.esf.org/RNP-guidelines).

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- **Engineering and Physical Sciences Research Council (EPSRC)**
  United Kingdom

Throughout the duration of the network we will strive to involve yet more Member Organisations.

Plasmon-BioNanoSense Steering Committee

- **Professor Stefan Maier** (Chair)
  Department of Physics, Experimental Solid State Group, Imperial College, London • United Kingdom
  Email: S.Maier@imperial.ac.uk
- **Professor Niek van Hulst** (Co-Chair)
  ICFO – The Institute of Photonic Sciences, Castelldefels, Barcelona • Spain
  Email: niek.vanhulst@icfo.es
- **Professor Jouni Ahopelto**
  VTT Technical Research Centre of Finland • Finland
  Email: jouni.ahopelto@vtt.fi
- **Professor Gustaaf Borghs**
  Interuniversity Micro-Electronics Centre (IMEC), Leuven • Belgium
  Email: borghs@imec.be
- **Dr Wolfgang Fritzsche**
  Department of Nanobiophotonics, Institute of Photonic Technology (IPHT), Jena • Germany
  Email: wolfgang.fritzsche@ipht-jena.de
- **Dr Jirí Homola**
  Institute of Photonics and Electronics, Academy of Sciences of the Czech Republic, Prague • Czech Republic
  Email: homola@ufe.cz
- **Professor Mikael Käll**
  Division of Bionanophotonics, Department of Applied Physics, Chalmers University of Technology, Göteborg • Sweden
  Email: kall@chalmers.se
- **Professor Joachim Krenn**
  Institute of Physics, Karl-Franzens University of Graz, Graz • Austria
  Email: joachim.krenn@uni-graz.at
- **Dr Liberato Manna**
  Istituto Nazionale de Fisica Della Materia, Lecce • Italy
  Email: liberato.manna@iit.it
- **Professor Vahid Sandoghdar**
  Max Planck Institute for the Science of Light, Erlangen • Germany
  Email: vahid.sandoghdar@mpl.mpg.de
- **Professor Aasmund Sudbø**
  Department of Physics, University of Oslo, Kjeller • Norway
  Email: aas@unik.no

ESF Liaison

Dr Thibaut Lery
Science
Ms Catherine Werner
Administration

Physical, Engineering and Space Sciences Unit
European Science Foundation
1 quai Lezay-Marnésia
BP 90015
67080 Strasbourg cedex
France
Tel: +33 (0)3 88 76 71 28
Fax: +33 (0)3 88 37 05 32
Email: cwerner@esf.org

For the latest information on this Research Networking Programme consult the Plasmon-BioNanoSense website: **www.esf.org/plasmon**

Cover picture: Schematic of a plasmon bionanosensor consisting of designed metallic nano structures

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