European Cooperation in Science and Technology - COST -

Secretariat

Brussels, 4 July 2012

COST 4153/12

MEMORANDUM OF UNDERSTANDING

Subject :	Memorandum of Understanding for the implementation of a European Concerted Research Action designated as COST Action MP1205: Advances in Optofluidics: Integration of Optical Control and Photonics with Microfluidics

Delegations will find attached the Memorandum of Understanding for COST Action as approved by the COST Committee of Senior Officials (CSO) at its 185th meeting on 6 June 2012.

MEMORANDUM OF UNDERSTANDING
For the implementation of a European Concerted Research Action designated as

COST Action MP1205
ADVANCES IN OPTOFLUIDICS: INTEGRATION OF OPTICAL CONTROL AND PHOTONICS WITH MICROFLUIDICS

The Parties to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 4154/11 "Rules and Procedures for Implementing COST Actions", or in any new document amending or replacing it, the contents of which the Parties are fully aware of.

2. The main objective of the Action is to promote interlinks among scientific and industrial bodies in order to develop alternative approaches to optofluidics to design multifunctional platforms, integrating novel photonic elements and optical control, and involving isotropic and anisotropic fluids and soft matter.

3. The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 52 million in 2012 prices.

4. The Memorandum of Understanding will take effect on being accepted by at least five Parties.

5. The Memorandum of Understanding will remain in force for a period of 4 years, calculated from the date of the first meeting of the Management Committee, unless the duration of the Action is modified according to the provisions of Chapter V of the document referred to in Point 1 above.

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A. ABSTRACT AND KEYWORDS

The aim of this COST Action is to establish active interlinks between laboratories working in the fields of micro and optofluidics, optical tweezers, nanoscience and photonics, bio and soft materials, focusing their work towards lab-on-a-chip systems and at promoting long-term development of these fields in Europe. The goal is to increase the knowledge in basic physics and biology from the micro- down to the nano-scale, and to develop the future generation of lab-on-a-chip devices for portable and inexpensive, but accurate and reliable equipments for: (i) diagnostics; (ii) detection, identification and manipulation of biomolecules and nanomaterials, (iii) biomedical and environmental microsensing, (iv) advanced imaging, (v) energy generation.

The scientific innovation concerns advanced concepts of optofluidics and a new generation of optofluidic devices integrating photonics as well as optical control. Indeed, their technologically relevant research threads are of significant interest for the academic community and industrial research and development (R&D). In order to capitalize on recent achievements and go one step forward, a platform as a COST Action, promoting interdisciplinary activities, is a relevant tool to exchange expertises and to explore new opportunities coming from each specific insights and knowledge.

The Action will focus on selected scientific challenges and will be organized in three Working Groups:

1-Integrated microfluidic photonics (new concepts of optofluidics);
2-Optical control in microfluidics;
3-Materials (soft, bio and nano) and technologies for optofluidic devices.

Keywords: Optofluidics, Optical Manipulation, Nanophotonics, Bio- and Soft-Matter, Imaging Specroscopy and Sensing in Microfluidic Environment.

B. BACKGROUND

B.1 General background

Scientific issues

Micro-optofluidics and nanophotonics have developed from basic science into cutting-edge technologies in the past twenty years. Nowadays, their technologically relevant research threads are of fundamental value to the academic community and industrial R&Ds. Substantial achievements were reached by the development of micro-fabricated systems for chemical and biological assays, driven by the need to perform fast measurements on small sample volumes, with low cost and portable devices. The ability of processing and manipulating small amount of fluids, with high degree of parallelism, using micrometric channels, has produced significant advances towards microchemical “factories” on a chip. Optofluidics originated about 10 years ago by the combination of microfluidics and optics in the same platform to leverage the specific advantages of the two disciplines. In the first approach, it referred to a class of optical systems synthesised with fluids.

Recent developments, coming from the permutations and combinations of optics, photonics, and microfluidics, demonstrate how this field is growing rapidly, also in directions that have been remarkably unexpected, such as energy applications, but is still experiencing significant revolutions. This is partly due to the number and diversity of influences, and partly due to the fact that mixing non-solid media with solid-state fluidic structures provides a nearly limitless range of combinations. Optofluidics is, then, a field in which it is essential for scientists from different communities to collaborate not only to understand how optics and fluids interacts, but also to exploit which applications and capabilities may be possible.

Simultaneously, other research fields such as optical trapping, manipulation at the nanoscale, and nanophotonics have experienced considerable and rapid progress. These areas grow very quickly driven by such notable achievements as optical tweezers for biological studies or holographic optical tweezers for hierarchical bottom-up material assembly, and an increasing number of scientists are involved in the basic aspects of light-matter interaction and their applications.

Indeed, the ability to access nanometric length scales and picoNewton forces makes optical tweezers an important tool for several branches of science. Recent progress in photonics, with a particular emphasis on plasmonics, photonic crystals, and resonators, have led to the development of devices for biochemical sensing, imaging, non invasive diagnostics, etc., opening tremendous new possibilities for the life sciences.

The parallel advances in these research areas are demanding to explore ways to combine respective strengths, capabilities and knowledge of the involved, leading researchers. In this view, the tasks of this Action are addressed to establish and promote communication links between researchers with expertises in these topics in order to improve optofluidic and photonic applications and to focus on actual selected scientific and technological challenges.

Relevance

The ability to perform laboratory operations at small scales using miniaturized devices has tremendous benefits. Designing and fabricating these systems is extremely challenging, and physicists and engineers are now beginning to construct highly integrated and compact labs-on-chips with exciting functionalities.

The ability to manipulate small volumes improves a number of features, since it is associated to low cost, short operation time, high throughput, low consumption, portability and easiness of use even in case of very sophisticated devices. Many of the novel cutting-edge technologies have been conceived and presented as proof-of-principles in European labs of groups of this COST-Action, and a number of applications have solved chemical, biological and medical issues.

As a consequence, the developments and applications of micro and optofluidic-chip-based technologies for imaging and sensing, particles control, detection of chemical and biological agents, energy production and storage, as well as for more traditional photonics devices and components, are of highest relevance for the European society and for its contribution to the medical and social contexts of the developing world. Nevertheless, a crucial task is an efficient cooperation between the various research groups and with industrial partners and end-users in order to maintain and strengthen the leading role in this field in Europe. To address such cooperation, this Action will gather the most active European research institutions and companies and also selected excellent non-European institutions.

Motivation and benefit from COST

Research activities in the fields of micro- and optofluidics, optical trapping and manipulation, and biophotonics have reached today a high level of specialization into different groups at European and global scale. These groups, facing very similar challenges, exploit frequently different types of materials, processes, methods, techniques, and diagnostics on the basis of their background. Nevertheless, the achievement of major breakthroughs is connected to effort towards integrated and interdisciplinary approaches to the problems suggesting that a platform for exchange of ideas and exploring new opportunities is essential. A COST Action is a very suitable means for stimulating and promoting collaborative programs in a multidisciplinary area. It is ideal to facilitate wide scale international collaboration, stimulating and promoting interdisciplinary research activities, and fostering next-generation interdisciplinary researchers in the field.

B.2 Current state of knowledge

The term optofluidics has been coined about ten years ago from the integration of optics and photonics with microfluidics [Nature 442, 381 (2006), Nature Photonics 1, 106 (2007)] to provide capabilities that cannot be achieved through either field alone.

However, the combination of light and fluids is looking back at a successful history that is much older than the term "optofluidics". On the basis of this approach a number of devices have been developed in which optics and fluidics are used synergistically to synthesize novel functionalities. Fluidic replacement or modification leads to reconfigurable optical systems, whereas the implementation of optics through the microfluidic toolkit gives highly compact and integrated devices. Since the first approach, it has evolved significantly.

Researchers are now developing applications that range from imaging and sensing, particle control, and plasmonics to energy applications through the enhancement of photonic circuits and energy generation [Nature Photonics, 5, pagg.583, 591, 598, (2011) and references therein].

At an early stage, it became evident that microfluidics could bring a wide range of advantages to the field of optofluidics, including the ability to change the optical properties of an optofluidic device changing the fluid contained within, developing optically smooth interfaces between fluids to reduce scattering losses, and the ability to create gradients in optical properties using streams of miscible fluids. Optofluidics has now evolved to include biosensing platforms, in which microfluidics is used to deliver biomolecules to novel functionalised optical and nanophotonic sensing devices and structures, addressed to technology for biomedical sensing.

Optofluidics has also enabled the realization of a new class of photonic elements. These devices have provided new techniques for light generation, shaping, routing and switching [Lab Chip 9, 2767, (2009), Lab Chip 8, 395, (2008), Lab Chip 9, 2050, (2009)] as well as for optical manipulation and analysis of particles in liquids [Nature 426, 421, (2003), Nature Phys. 5, 915, (2009), Nature 457, 71, (2009)]. Devices for refractive index-based detection, fluorescence based cell sending and optofluidic surface enhanced Raman spectroscopy [Lab Chip 7, 630, (2007), Nature Photonics, 5, 598 (2011) and references] are prominent and successful examples of actual developments. Some emerging opportunities for optofluidics encourage the application of the same approach to energy fields, as demonstrated by recent optofluidic investigations addressing issues of energy production and storage [Nature Photonics, 5, 583, (2011)].

The use of light to control and manipulate objects from the micro to the nanoscale is also a topic that has grown strongly during the last years and has reached a very high level of performance that offers by now most attractive opportunities for optofluidic applications. Since their inceptions [Opt. Lett. 11, 288 (1986)] optical tweezers have reached notable achievements for the applications to biological studies [Annual Review of Biochemistry 77, 205 (2008)]. Indeed, the ability of optical tweezers to access nanometre length scale distances and picoNewton forces developed them into one of the most important tools for biophysicists. They have also contributed significantly to the understanding of the mechanochemistry of molecular motors.

Although most optical traps exploit standard Gaussian beams, shaping the phase and amplitude of the optical field can create complex, but highly beneficial light patterns to perform multi particle trapping [Nature Photonics 5, 335 (2011) and references therein]. Complex beams can also be used to improve manipulation performances exploiting their unique intensity, polarization, and phase structures.

Therefore, optical manipulation can be tailored by sculpting the shape or the optical properties of the light field in order to perform dynamic trapping in three dimensions in arbitrary configurations [Nature Photonics 5, 343 (2011) and references therein]. Another aspect of innovation in the future of optical manipulation and its applications relies on nonlinear optics. One issue is the nonlinear optical response of materials in light-driven nano-motors, or the mediation of electrically-based techniques by nonlinear light-matter interaction.

Moreover, the latest advances in nano-optics, in particular in the field of plasmonics, now allows low-intensity evanescent optical fields to achieve in-plane, parallel, and selective manipulation of nanoparticles, heading towards potential applications of these plasmonic tweezers [Nature Photon. 5, 349 (2011)] to the fields of biosciences and quantum optics. Another emerging technique is the use of optoelectronic tweezers, a manipulation approach that exploits both optical and electrical fields to make use of benefits from both regimes [Nature Photonics 5, 322 (2011)].

Based on the presented state of the art, the main objective of this Action is to establish active links between European laboratories working in the field of microfluidics, optofluidics, materials sciences, optical trapping and manipulations, and related applications in order to foster and accelerate long-term successful developments of these fields in Europe. Research activities in these fields are generally fragmented into several groups. Because of the multidisciplinary fundamental feature of most of these topics, these groups have to address common fundamental issues and analogous scientific and technical challenges, however, are working with specific materials and using different methods and techniques often related to their background. This limitation becomes a source of cultural enrichment and ideas if shared in an exchange platform promoting an integrating approach both to the fundamental issues and innovative applications. Naturally, optofluidics is an interdisciplinary field in which it is absolutely essential for scientists and engineers with different expertises to collaborate not only to understand the fundamental processes but also conceive novel applications and capabilities in a common effort.

In spite of the great potential of optofluidics in its “dynamical meaning” that deals with the redefinition of the term connected to the fast and impressive advancements of the last few years, not much exchange has happened between various trendsetter groups in Europe. On the other hand, a thematic network to be built in the frame of the forthcoming European Framework Programme can address only specific aspects of this field, while the mentioned potential of optofluidic methods can find higher chances of success by joining in the same Action groups with different expertise and skills. On the other hand, the field of the present Action is by itself very interdisciplinary covering optics, electronics, micro and nano-photonics, materials science (including nano and bio materials), microfluidics, microlithography, imaging spectroscopy, and sensing, just to mention a few. Moreover, the methods developed can be applied in almost any field of physics, chemistry, biology, or medicine, and are important therefore for future advances in devices usable in everyday life. Therefore, the best way to put together different specific projects is a network and, among the possible network structures, a COST Action is the most suitable one, since:

(i) it is wider in scope than a thematic network implemented through the Framework Programme, including participation of a large number of countries and different groups for each country, and opens the possibility for additional partners to join the Action during its lifetime;

(ii) it does not require a huge investment to support a number of national delegates participating in the meetings and to support a program of Short-Term Scientific Missions (STSMs), but allows a tremendous impact on cooperation and interaction of the participating groups;

(iii) the specific research activities of the participating groups are supported in each country by other agencies.

The adequacy of the COST Action in favouring and improving research activities that need strong collaborations between researches with very high-level expertises in specific research fields has been demonstrated especially within the COST Action MP0604 “Optical Micro-Manipulation by Nonlinear Nanophotonics” that was recently completed extremely successfully, and which created a new core interdisciplinary scientific community of highly qualified partners that can be considered as the nucleus of the present Action.

B.3 Reasons for the Action

Developing new directions of optofluidic technologies requires scientific and technological advances that need a strong interdisciplinary and international effort. Europe has a rich community of scientists operating in both academic and research institutions with a well consolidated and recognized expertise in all the research fields involved in the Action (optofluidics, materials sciences, micro and nanophotonics, optical tweezers), that have developed important tools for applications within the bio and life sciences. Additionally, it is evident from recent literature that highly attractive developments can be obtained by transferring the optofluidic approach to other fields. In the same way, one of the Actions aims is to investigate contributions coming from optical control strategies and materials assembling methods as well as micro and nano-photonics in order to develop new strategies in optofluidics..

The COST Action is the most suitable mechanism to coordinate and aggregate the presently widely distributed resources, linking the activities to a global level, while the presence of industrial partners drives the technological developments. The specific benefits of the COST Action are related to: i) dynamic networking during four years; ii) WGs activities and meetings that unify diversified and complementary expertises on focused tasks; iii) developments of innovation and emerging tools; iv) international training of young researchers for careers in high-level science and R&D management, or even to promote an international network of young scientists that is of great relevance for such a vivid research field; v) a COST Action provides an ideal platform for initiating and coordinating joint EU research proposals.

The scientific, social and industrial benefits of the Action are described more extensively in section C4.

The Action is mostly aimed at European scientific and technological advances in optofluidics integrating innovative aspects of the optical control and photonics to the microfluidics. Its focus will be on the development of compact and integrated devices for optical sorting, colloidal and biomedical manipulation and detection, microsensors, light sources, energy production and storage, light-controlled lab-on-a-chip devices and analysis instruments for biomedical, environmental or industrial applications. The means that will be used to reach the scientific and technological goals are detailed in the section D.

B.4 Complementarity with other research programmes

Most participants of this COST Action have currently active research projects which are financially supported from national institutions, public or private, with limited means for international networking.

Some researchers interested in the present Action are involved in the following European or International projects:

- ERC Advanced Grant, CATCHIT - Coherently Advanced Tissue and Cell Holographic Imaging and Trapping (2010-2015).
- STREP, Surface Plasmon Early Detection of Circulation Heat Shock Proteins (SPEDOC) (2010).
- European Commission Marie Curie Intra-European Fellowship (FP7-MC-IEF), Contract No. PIEF-GA-2009-252579, MICRODROPLETS (Characterizing Surface-Supported Microdroplets for Optofluidics Applications) (2010-2012)
- Photonics4Life: Network of Excellence in Biophotonics,2008-2012, funded by the European Commission, FP7.
- Optical vortices in periodic and chiral nonlinear photonic structures, 2012-2014, co-funded by the German Academic Exchange Service and the Group Of Eight (Go8) (Australia).
- Collaborative Research Centre Transregio 61: Multilevel Molecular Assemblies: Structure, Dynamics and Function, 2008-2012 co-funded by the Deutsche Forschungsgemeinschaft and the National Natural Science Foundation of China.
- Alliance: Franco-British Research Partnership Programme (“Ferroelectric nanocrystals”).
- Royal Society International Joint Project (UK and Ukraine) “Nanoengineering of liquid crystals”.
- Marie Curie Reintegration Grant - PERG06-GA-2009-256526 "Fuel making algae".

Therefore no overlapping exists with other initiatives in the European area, and due to the increasing number of groups working in these fields it is timely to start a COST Action aimed at establishing a wide forum to improve the collaboration among them.

C. OBJECTIVES AND BENEFITS

C.1 Aim

The aim of this Action is to establish active links between European laboratories active in the field of optofluidics, microfluidics, optical manipulations, micro and nanophotonics, soft materials science including bio materials and related applications, to improve the interdisciplinary effort as suggested by recent research trends and to foster and accelerate long-term development of these fields in Europe. The goals are to increase knowledge about the basic mechanisms involved in opto-fluidics, and optical control; to develop novel photonic devices to be exploited in the future bio-medical, materials and energy technologies; to attract interest of new generation of scientists; to become competitive in the global landscape; to promote industrial activities and small companies for the development of a user-friendly technology that could constitute a solid and real support for Europe and the developing world.

C.2 Objectives

The objectives of the Action are both of networking and scientific character enhancing each other in symbiotic manner. The specific objectives of the Action are:

- to establish international relations at European and global level within the fields of optofluidics, optical trapping and manipulation, microfluidics and photonics,
- to stimulate and promote collaborative research addressing an increasing interdisciplinary approach,
- to identify proper funding schemes for collaborative research projects at European and global level,
- to promote interdisciplinary links between unrelated research groups in academia and industry,
- to implement an effective and sustained programme of short term scientific missions (STSM),
- to support the career developments of Early Stage Researchers (ESR),
- to strengthen linkage with companies interested in technological transfer of the scientific results,
- to extend knowledge and user friendly technology towards developing countries.

From a quantitative point of view the achievement of these specific objectives can be evaluated by the following parameters: number of transnational **c**ollaborative **r**esearch **p**roposals prepared including groups participating in the Action (CRP); number of All Impacted Publications (AIP) and publications in Conference Proceedings (ACP) published by groups participating in the Action and focused on the Action topics with a special attention to outputs coming from Collaborative researches among partners of the Action (CIP,CCP); number of Short-Term Scientific Missions (STSMs) supported by the Action ; number of Participants from Industries in the Action outputs or meetings (PI); number of Training Schools (TS) (open to company members and also aimed at the formation of high level student for future R&D developments of European companies) organised in the dissemination plan; number of participants from Groups Outside Europe (GOE). A similar criterion will be used to evaluate the success in the Technological Objectives, taking into account patents pending, new apparatus or prototypes realised, new software developed, etc. coming out of Collaborative researches within the Action topics (CTO).

The Action will be considered successful with the achievements of the goals listed below.

	CRP	CIP/AIP	CCP/ACP	STSM	PI	TS	GOE	CTO
Year 1	0	2/30	3/15	10	1-2	0	1	5
Year 2	1	3/33	7/18	10	2-3	1	2-3	5
Year 3	2	4/35	6/20	10	2-3	0	2-3	5
Year 4	2	5/40	7/23	10	3-4	1	3-4	5

C.3 How networking within the Action will yield the objectives?

The scientific objectives will be achieved by the participation of the leading European groups from all scientific areas covering the topics of this Action. Some of them have already established fruitful cooperation in the past but for majority of the groups invited talks and the presence of the leading scientists at the regular general meetings, workshops or training schools will promote active exchanges of expertises and form a platform of common knowledge. A continuous update of the Action web site will offer an access to data and general information through online documents related to the Action activity, references, links to participating groups, etc. Between the structured meetings and workshops, informal collaboration and discussions will be maintained via the usual routes such as email and voice over Internet Protocol (VoIP) utilities.

Transfer of knowledge from academia to industry will be stimulated by including specialists from industry for task-oriented discussions and investigations. Selected partners from the industry will be also invited to the general meetings, workshops or training schools to present their interests and unsolved problems. Exploitation and Intellectual Property (IP) issues arising as a result of the network's research will be explored in consultation with the partners' IP development offices, with patents submitted where appropriate. Each partner will have the responsibility to protect confidential information.

The highest benefit from existing complementarities can be drawn through exploitation of the STSMs offered by the COST framework. Workshops and scientific retreats will be crucial to promote cooperative and effective collaboration. Through the Action website and local advertising the Action partners will encourage interest and participation from other scientists, both from academic and industry. The networking objectives will be achieved also by the arrangement of annual general meetings, workshops and biannual training schools with invited contributions of internationally leading experts. Participation at the Training School for ESRs will be supported by travel grants. The programme of the School will include lectures with clear focus on interdisciplinary aspects of the field, interactive discussion based on workshop sessions with the experts as well as short presentations by the ESRs on their research projects to pave the way for more efficient sharing of ideas.

C.4 Potential impact of the Action

The expected impacts of this COST Action concern science, technology and society and they include: establishing efficient interlinks among the participating European laboratories (both academic and industrial) active in the fields of microfluidics and optofluidics, optical micromanipulation, nanophotonics and bio and soft-matter , increasing knowledge in basic physics and related areas of biomedicine from micro- to the nano-scale; facilitating the development of a new generation of lab-on-a-chip devices for portable and inexpensive, but accurate and reliable, components suitable for 1) diagnostics, 2) detection, identification, and manipulation of biomolecules and nanomaterials, 3) microsensor development for biomedical and environmental applications, 4) advanced biological imaging.

The activities will lead to novel techniques contributing to the miniaturization in systems used in chemistry, physics, biology, and bioengineering, strengthening the European position in all these fields.

An appropriate training plan for young academic researchers and company members, realised through a programme of short-term scientific missions linked to training schools and organised in the frame of the Action, can strengthen academic research and the resulting technological issues, and strengthen the linkage between academic and industrial institutions, improving Europe's strength in the field.

For ESRs, an adequate training in fundamentals topics as well as applications and technological approaches is a relevant opportunity to support career development, get access to an international network of experienced senior scientists, and obtain informal contacts with the scientific communities and other ESRs. ESRs will therefore take active part in the networking activities of the entire COST Action, being supported as well as being a vital part of it.

For industrial partners, the Action will be a source of inspiration for new technologies applicable to large areas of global interest, such as bio and life sciences, environment, energy production and storage. Because of the small footprint, low cost and material consumption, it will offer suggestions for the development of user-friendly technologies especially in biomedicine. Finally, this technology will aid to translate sophisticated diagnostic tools out of the laboratory to develop accurate, robust and inexpensive systems, well-suited for the medical and social contexts of the developing world.

C.5 Target groups/end users

1. The academic sector within the topics listed above will enhance its research profile and will find new routes for research activities and scientific cooperation. 26 groups from 13 different COST countries have already expressed their interest in the Action. Nevertheless, there are several other groups working in the areas of interest of the present Action which are expected to join subsequent to the start of the Action.

2. Industrial partners active in the above listed topics will have direct access to new technologies and will be able to establish links with highly qualified research laboratories. Several companies have expressed an interest in the Action. Additionally the industrial partners have the opportunity to employ young researchers involved in the Action (trained within the Action) with indispensable interdisciplinary expertise in the relevant fields.
3. The ESRs will benefit for their scientific careers and employment opportunities from the international training within a wide range of interdisciplinary topics of the Action.
4. The general public will have access to the website of the Action displaying its activities and long term consequences concerning industrial, medical, environmental, energy applications. Moreover, several general meetings will have public presentations of novel results in cooperation with the partner institutions press agencies, allowing to present new developments with interest for society in a more general way. In the same direction, public awareness of the most exciting achievements will be realized together with the press offices of the partner institutions.

Academic and industrial partners have been both involved in the preparation of this Action to create a smooth interface among target groups.

D. SCIENTIFIC PROGRAMME

D.1 Scientific focus

The present Action attempts to combine European expertise on the micro and optofluidics, optical tweezers, photonics and materials science in order to develop new directions of cross-disciplinary research and technology. The Action is not restricted to a particular research field but needs to exploit knowledge and expertise across several disciplines connecting different views and scientific languages to "dynamically guide" developing directions of research and technology. The scientific programme of this Action will be developed along three main horizontal lines, given by the working groups, each addressing new concepts in optofluidics with respect to photonics, optical control and materials science. The vertical topics of these lines do not represent different sub areas of optofluidics but rather alternative ways to consider the different research fields for technological exploitation of the results of the Action.

The most important research tasks to be carried out in the frame of the Action are the following:

- to improve the understanding of processes involving fluids (isotropic and anisotropic), soft matter (including bio materials) and optics at/down to micron scale;
- to improve the understanding and integration of complex light beams generation and performances in the frame of objects and particles manipulation;
- to deep the understanding of light-matter interaction for the case of complex light fields and the role of polarization patterns;
- to develop novel approaches to microfluidics integrating novel photonic elements (guiding light in isotropic and anisotropic fluids by microoptical elements, i.e. integrating light sources, detectors, nanoscale photonic structures and systems within microfluidics platforms);
- to develop photonic devices (with enhanced performances like tunability and reconfigurability, small scale size integration, etc.) exploiting microfluidic techniques: laser sources, fluid-fluid and fluid-solid waveguides, fluidic lenses, light switching and spectral discrimination devices, fluidically reconfigurable devices, systems for optical signal processing and communications, etc.;
- to develop photonic devices for optofluidics integrating micro-optics and soft matter: lens arrays, diffractive elements, adaptive optical elements, microresonators, etc.;
- to investigate novel optofluidic capabilities exploiting optical trapping and manipulation approaches, i.e. use of light beams with proper shaped intensity, polarization, and phase structures, as well as complex light patterns; exploitation of nonlinear optical response of materials; particles control and sorting in microfluidics channels; etc.);
- to investigate novel interactions induced by radiation forces in soft entangled matter and develop new approaches for micro- and nano-sculpturing and three-dimensional microfabrication technologies and their applications;
- to develop new methods for combining optical manipulation tools to nonlinear optical microscopy and spectroscopy in order to create multipurpose workstations for analysis of microfluidic devices;
- to investigate nonlinear optical schemes in the structured optical environment for advanced sensing applications;
- to investigate optofluidics capabilities involving anisotropic fluids (liquid crystals);
- to investigate combinations of optofluidic functionalities with electric and magnetic features;

- to investigate novel approaches to microfluidic channel and circuit fabrication (micropatterning and templating);
- to synthesize and to integrate novel soft-matter-inorganic composites embracing quantum (dots, rods, and the like) semiconductor entities and plasmonics in the optofluidic environment for applications in chemical- and bio-sensing;
- to develop potential of hybrid optical materials including nanocomposites for fabrication of microfluidic devices and sensors;
- to develop new soft and composite materials (even micro and nanostructured) exploiting microfluidic and optofluidic methods.

The technological impact of these investigations will be the following:

- implementation of non-invasive tools for bio and life sciences applications;
- implementation of advanced optical microscopy / manipulator apparatus for bio-medical applications;
- implementation of an optical tool box (or kit) for sorting, stretching, squeezing, trapping, mixing at the microscale and nanoscale;
- realization of photonic devices (lasers sources, detectors, spectral discriminators, switches, polarimeters, etc.) and definition of architectures for their integrations in microfluidic platforms;
- realization of advanced systems for large area micropatterning and templating;
- realization of light-driven micromechanic and microfluidic devices;
- definition of methodological approaches for micro and optofluidics-assisted materials structuring;
- implementation of multifunctional platforms for biomedicine;
- definition of novel methodological approaches for integrated multifunctional lab-on-a-chip systems for bio-medical and technological applications;
- implementation of electrically and optically controlled, inexpensive, compact devices for optical signal processing and limiting;
- definition of new approaches for user-friendly techniques and devices that have outstanding capabilities as high throughput, small amounts of agents, and very cheap fabrication;
- definition of novel approaches for energy production at small scale.

The Action will coordinate these different tasks to achieve the objectives described in section C. The workplan is organized in three complementary Working Groups, each devoted to a progressive development of characterization, integration and modelling aspects, technological transfer, and prototyping, thus building the horizontal level of organization and a number of research and technology issues that represent the vertical level of organization, as it is shown in Table 1.

Project Structure	**Photonics**	**Nonlinear Optics**	**Materials Science**	**Fluidics**	**Applications, Technological Transfer and Prototyping**
WG1 Integrated microfluidic photonics	Microfluidics for photonics devices.	Nanowave - guides. Nonlinear photonic crystals.	Materials characterization, imaging sensing and spectroscopic investigations.	Photonics devices for microfluidics.	Multifunctional platforms for biomedicine (diagnosis, drug testing, cell interrogation, sorting and/or isolation of control populations of cells, microdissection, data acquisition and processing)
WG2 Optical control in microfluidics	Light controlled photonics devices (sources, switches, light activated modulators, etc.); low-NA optical trapping (macro-tweezers) in microfluidic devices.	Plasmonic tweezers. Nonlinear optical manipulation and control in nano- and micro-scale systems.	Complex fields patterns for materials structuring soft materials at micro and nanoscales.	Hydrodynamics, optical forces coupling for optical manipulations and control. Anisotropic fluid environment. Combined optical and acoustic trapping.	Optical control in multifunctional platforms for biomedicine providing contactless diagnostics, sensing in food and drink/agriculture
WG3 Materials (soft, bio and nano) and technologies for optofluidic devices	Soft multifunctional materials for reconfigurable, tunable, etc. photonics devices.	Nonlinear optical patterning for structured materials (metamaterials , etc.). Cell nanosurgery	Novel architectures in microfluidics involving soft materials (polymers, liquid crystals, glass hybrid soft matter-inorganic nanomaterials, soft matter with plasmonic nanoparticles, etc.).	Interface interactions. Soft matter objects with anisotropic optical properties.	Novel approaches for integrated multifunctional lab-on-a-chip systems for biomedical applications. Novel approaches for integrated multifunctional optofluidic systems for sensor applications. Development of new sources (lasing materials). Self assembling materials for photonic crystals and metamaterials

Table1. Structure of the programme showing the horizontal and vertical levels of organization.

Since the scientific programme of a COST Action must provide an open and flexible framework making it possible for other interested countries or groups in the field to join the Action, it will be presented in a schematic way to define on the one hand the main frames of the activity which include the projects to be carried out by the participating groups, and on the other hand leave enough freedom for the integration of novel, upcoming topics and new groups.

D.2 Scientific workplan - methods and means

The action will achieve its scientific objectives through three inter-related working groups (WGs). The scientific workplan for each WG including methods and means is the following:

WG1. Integrated microfluidic photonics (new concepts of optofluidics)

This WG will concentrate on the investigation of light guiding, routing and shaping in isotropic and anisotropic fluids, both from the fundamental point of view and applicative aspects, respectively. The key innovation will be the development of new strategies inspired by different fluidic systems, aimed to improve performances and overcome limitations of present microfluidics and optofluidics devices. Nanophotonics approaches to engineer light sources, detectors, optical elements, devices for high resolution imaging, spectroscopy, and sensing in microfluidic environment will be developed. From the point of view of photonics, this WG will concentrate on developing new devices for optofluidics following cutting-edge emerging trends. Among these, reconfigurability that some fluids can add to the design of photonic devices, ranging from a complete exchange of media assets to the dynamic control of optical functions, will have strong priority.

The scientific workplan for WG1 activities will include:

- Photonics for microfluidics (i.e., creating structures, channels and other microfluidic chip configurations in 2D and 3D by direct laser writing, soft lithography, e-beam, etc.).
- Microfluidics for photonics (i.e., rapid tunability of resonator devices; development of an optofluidics platform containing microfluidic channels, optical waveguides, and electrical contacts for development of novel applications in photonics).
- High resolution imaging, spectroscopy and sensing in microfluidic environment.
- Optofluidics for nonlinear optics (i.e. nonlinear interactions in nano-waveguides and photonic crystals, nonlinear optical phenomena of anisotropic media in microfluidics environment, etc.).
- Electric field effects coupled to optofluidics (i.e., opto-electric tweezers for microfluidic applications).
- Multifunctional platforms for biomedicine (i.e., single-use chips, standardized systems for easy connection).

This WG will contribute to all objectives mentioned in part C which are related to its research topics.

Main expected achievements: new concepts for the fabrication of photonic key elements such as splitters, routers, switches, possibly fabricated by nonlinear fluids, optofluidic light sources.

WG2. Optical control in microfluidics

This WG will concentrate on the investigations both fundamental and applicative aspects of optical control of micro and nano particles and drops in isotropic and anisotropic fluidic environment. The approaches deal with the use of complex light beams, hydrodynamic and thermophoretic forces, optical and shape anisotropies of the objects. Innovative approaches to optofluidic trapping and manipulation will be investigated making use of the integrated photonic elements developed in WG1. New possibilities will be explored for the life sciences, particularly biomedical and chemical diagnostics based on the analysis and manipulation of particles in a fluidic environment.

The scientific workplan and achievements for WG2 activities will include:

- Complex light fields (i.e. spatially structured beams with intensity, phase and polarization management) to exert forces and torques at the micro and nano scale for complex control of motion and position of nano and micro-objects. The specific capabilities of light beams with tailored intensity, phase and/or polarization distributions will be exploited to perform ad hoc tasks within integrated optofluidic devices. In addition, the use of reconfigurable devices, like spatial light modulators, can be incorporated to achieve specific light beam structures and switch among them at will.
- Optical tool-kit for sorting, stretching, squeezing, trapping, mixing of emulsion droplets for digital microfluidic applications (i.e., according to the optical beams configuration and to the element under testing, trapping and dragging of selected particles in specific positions of the microfluidic chip, mechanically stretching them, and exciting fluorescence and Raman signals from them will be explored).
- Optical forces for the development of tunable photonic devices in optofluidics platforms.

- Optical activation of chemical, physical and biological processes for contactless and sterile control and initiation of processes (i.e., novel strategies to trigger specific chemical reactions, or for the selective killing of cells, or for the stimulation of cell proliferation; micro-optofluidic implementation of systems to finely control the cell environment and to monitor the cell evaluation; etc.).
- Optically driven micro-flows. Light-driven micromechanics and microfluidics devices (i.e. optically guided micromotors, micropumps).
- Optical control in multifunctional platforms for biomedicine providing contactless diagnostics.

This WG will contribute to all objectives mentioned in part C which are related to its research topics.

Main expected achievements: Integration of optical manipulation concepts into exchangeable and portable microfluidic platforms. Prototypes of integrated optofluidic devices. Elemental and integrated bricks to build transportable optical lab-on-a-chip.

WG3. Materials (soft, bio and nano) and technologies for optofluidic devices.

This WG deals with the study of methodological approaches for the assembling of micro and nano structured materials and devices. The microfluidics and optofluidics will be used to create hybrid solid-fluid materials and systems and the optofluidic design principles will be explored for detecting, diffracting and collecting light.

The scientific workplan for WG3 activities will include:

- Integrated micro-optics and soft matter: lenses arrays, diffractive elements, adaptive optical elements, microresonators (i.e., microdroplets on a superhydrophobic surface or emulsion microdroplets in microfluidic channels can be used as microresonators integrated with other components in future optofluidics chips).
- Novel ways to manipulate matter with optical fields: micro and nano fabrication with structured light for microfluidics (i.e., micropatterning and templating by means optical and nonlinear optical processes).

- Microfluidics for materials science: structured materials, nanomaterials (i.e., microfluidic approaches for assembling of colloidal particles, microfluidics chemical reactors, discriminator systems; etc).
- Optofluidics with liquid crystals and unconventional fluids: high birefringence of liquid crystal mesophases and their high sensitivity to external fields (optical, electrical, magnetic, thermal, hydrodynamical, chemical) will be exploited to develop sensitive sensing devices (chemical and bio-recognition), tunable microphotonic passive and active devices, long-range order assisted assembling of materials.
- Novel approaches for integrated multifunctional lab-on-a-chip systems for biomedical and sensor applications.

This WG will contribute to all objectives mentioned in part C which are related to its research topics.

Main expected achievements: Novel materials for microfluidic chips and applications, novel materials for reconfigurable and tunable optofluidic devices addressed to develop multifunctional lab on a chip systems. Microfluidic and optofluidic technologies for soft materials structuring and assembling.

E. ORGANISATION

E.1 Coordination and organisation

In the kick-off meeting, after fulfilling the requirements established in the “Rules and Procedures” (election of Chairperson), the Management Committee (MC) of the Action will address the basic issues for the Action organisation concerning:

1. Selection of projects to be accepted as activities of the Action,
2. Establishment of Working Groups (WG) and sorting projects accordingly,
3. Election of coordinators of each WG,
4. Introducing collaboration and communication tools,
5. Election of a responsible for Short-Term Scientific Missions (STSM) programme.

As basic communication tool among the partners and between the Action and other parties a website will be planned and set-up shortly after the kick-off meeting. The MC will elect a responsible for the website management. It will include a “static” section concerning (i) general information on the Action programme and objectives; (ii) basic information on participating groups with a link to the group websites; (iii) information and forms to be used for STSM applications; (iv) information for scientists willing to join the Action. A “dynamic” section will provide information on: (i) up-dated timetable of the Action activities (planned workshops, meeting, etc.); (ii) recent scientific and technical achievements and related links; (iii) filed reporting of past activities and achievements.

In the regular annual meeting of the MC, a plan for the co-ordination activity will be approved for the coming year consisting of: organisation of the annual general meeting, proposals for STSMs, proposals for WG workshops on specific topics. The organization of workshops and general meeting in conjunction with other international topical meetings will be encouraged. Planning of the activity for the year will be based on the available budget and considering as milestone the organisation of the general meeting. The committee programme of the general meeting will include the local organiser, the Action Chair and Vice-Chair and the WG Co-ordinators. According to the available budget, before each meeting the maximum number of participants supported by the Action will be determined and the MC will communicate to the local organiser and to the Action Chair the names of scientists to be reimbursed.

If necessary, additional extraordinary MC meetings will be organised. However, as far as possible electronic communication will be used among its members. It is foreseen that such a procedure will be necessary for approval of a number of STSMs in case of available budget to be used within a restricted time period.

Electronic communication will be also used within the MC for preparation of the activity reports which will be delivered at end of each year.

Attention will be paid to improve the collaborations by encouraging the formation of consortia able to prepare proposals under specific calls launched in the forthcoming Framework Programme of the European Commission or launched by other national and international agencies. To this aim, information on new calls of possible interest for the Action activities will be given through the website and possible invitation to participate in a project proposal will circulate.

A plan will be made for the organisation of training schools, with the aim of organising three schools during the Action lifetime. The schools should be open for company members and provide basic information on knowledge, methods, devices and applications in all involved disciplines and research fields. For students the schools will be complimented by STSMs: after the school, a number of missions will be planned as final stages in laboratories participating in the Action.

Provisions will be made for gender balance in the election of the Chairpersons (Chair and Vice-Chair), of the coordinators of WGs and of any special committees formed to address specific issues (e.g. for standardisation measurements of specific equipment).

The involvement of young people will be a basic characteristic of the Action and will be implemented through the STSM programme essentially devoted to the exchange of PhD students or Post-Doc between the participating laboratories and through the organisation of training schools.

E.2 Working Groups

This Action will be organized in three Working Groups (WGs):

WG1 - Integrated microfluidic photonics,
WG2 - Optical control in microfluidics,
WG3 – Materials (soft, bio and nano) and technologies for optofluidic devices.

This scheme will be checked after the first year and adapted if necessary upon agreement with the COST Office and the Domain committee, as well as to the scientific and technological development of the topic. All the participating groups will be invited to provide basic information on their research projects (title, abstract, preference on WG, scientists involved, etc.) and a list of projects for each WG will be prepared.

The horizontal level of the workplan promotes the interaction of researchers working in each discipline (vertical level) within each WG, strengthening the Action networking capacity.

Additionally, under the MC coordination and in cooperation with the WGs leaders a separate group of ESR will be formed (ESRG), with the aim to maximise a) the transfer of knowledge from senior scientists to ESR (teaching training and supervisors activity); b) the active involvement of ESR in all Action activities (scientific, organisation, networking, reporting, dissemination, publicity, etc.)

Each WG and ESRG will be led jointly by leading experts in each of the involved fields who will be selected by, and report to the MC. They will coordinate the WG and ESRG, organize workshops and training schools and promote interaction with the other WGs. They will also provide their WG and ESRG contribution to the annual reports (annual milestone) via reporting on activities within the WG and ESRG.

Each WG and ESRG will meet at least once per year. One of the meetings may be organized jointly with a larger international conference to allow substantial dissemination of the Action results. During this meeting, at least one “brain storming” discussion will be scheduled to support the emergence of novel research approaches, experiment and applications; a round table with an evaluation of past activities and addressing future tasks will be organized.

E.3 Liaison and interaction with other research programmes

Liaisons and interactions with other international research programmes as well as with company members will be pursued by inviting international experts as guests to each meeting to present work from other programmes and actual hot developments in the fields of the Action.

In case of other running COST Actions whose objectives are complementary to the ones of the present Action, effort will be made in agreement with the corresponding MC to organise common workshops in order to identify and strengthen possible areas of multi-disciplinary collaborations.

The interaction with other COST Actions and other European and International programmes will be maintained throughout the duration of the programme.

These will be achieved via:

1. Fostering links with other relevant EU programmes;
2. Organisation of joint workshops and seminars with other COST Actions on interdisciplinary areas;
3. Organisation of annual WG meetings together with activities (conferences/meetings) of other relevant Actions;
4. Invitation of Marie-Curie Fellows to Training Schools;
5. Invitation of European Research Council (ERC) grantees in the areas of optofluidics, optical tweezers, photonics and soft matter research to participate actively in the Action. Several partners of this Action already participate in other European programmes and bilateral actions between European countries and some non European countries.

E.4 Gender balance and involvement of early-stage researchers

This COST Action will respect an appropriate gender balance in all its activities and the Management Committee will place this as a standard item on all its MC agendas. The Action will also be committed to considerably involve early-stage researchers. This item will also be placed as a standard item on all MC agendas.

The MC will consider a step-model, considering at each career stage the same percentage of women as in the career step before. This item will also be placed as a standard item on all MC agendas.

This COST Action will encourage and promote a gender balance in all its activities. For this purpose, the following measures will be taken:

1. All of the groups of the Action will be encouraged to promote the involvement of female professionals during the following activities: (i) selection of new research recruits (e.g. by hiring female undergraduate students), (ii) selection of personnel for short-term scientific missions, (iii) selection of personnel to attend scientific conferences.
2. Care will be taken to involve in the Action groups with leaders of the two genders, accordingly effort will be made to respect a gender balance in the election of Chairpersons (Chair and Vice-Chair of the Action) and of the co-ordinators of WGs.

3. An MC member will be specifically appointed for taking responsibility of gender balance issues.
4. The participation of females in Action conference/workshops and training schools will be promoted. For instance, preference for hosts with available childcare will be adopted to facilitate participation of mothers accompanied by children.
5. Best practise gender balance measures from the participating institutions will be examined and adapted to the Action where viewed as supporting gender issues.

Involvement of early-stage researchers.

The Action will be committed to considerably involve early-stage researchers. With respect to this, the specific means listed below will be a central pillar of the Action:

1. Organization of annual training schools and seminars for young researchers;
2. Support of STSMs of young researchers between research groups and industries;
3. Exchanges of young researchers between groups;
4. Dissemination, promotion and support of specific opportunities for early-stage scientists (e.g. PhD and post-doc open positions, calls for grants, awards, etc.);
5. Support of young researchers to attend international conferences.

F. TIMETABLE

This Action is supposed to run for four years in order to create an efficient interaction between the groups, build contacts with the many industrial partners, allow Working Groups to work efficiently and schedule Training events which profit especially to early-stage researchers. Frequent monitoring will encourage emerging innovations and possibly re-orientate certain tasks where it appears to be necessary.

The provisional timetable includes the Kick-off meeting at the beginning and one general meeting of the Action each year. The general meeting in the second and the fourth year may be organised in conjunction with an International Topical Meeting in optofluidics, photonics, optical tweezers and related subjects. During each year it is foreseen to organize small workshops of each Working Group, defined by the needs of the participants. Starting from the second year, an international school devoted to PhD students and young researchers and open to company members will be organized each year. The School will also be implemented through the STSM programme. At this preliminary stage the organisation of three schools is envisaged.

The annual General Meeting is considered a Milestone of the Action.

A summary of the provisional timetable is presented in the table below.

Time	Month	Kick-off Meeting and set up of the Working Groups	
Year 1	3 6 9 12	WG/ESRG Workshops General Meeting +MC	Milestone #1
Year 2	3 6 9 12	WG/ESRG Workshops Training school, STSMs General Meeting(with International Topical Meeting) + MC	Milestone #2
Year 3	3 6 9 12	WG/ESRG Workshops Training school, STSMs General Meeting + MC	Milestone #3
Year 4	3 6 9 12	WG/ESRG Workshops Training school, STSMs General Meeting (with International Topical Meeting) + MC	Milestone #4

G. ECONOMIC DIMENSION

The following COST countries have actively participated in the preparation of the Action or otherwise indicated their interest: AT, CZ, DE, DK, EL, ES, FR, HU, IE, IL, IT, TR, UK. On the basis of national estimates, the economic dimension of the activities to be carried out under the Action has been estimated at 52 Million € for the total duration of the Action. This estimate is valid under the assumption that all the countries mentioned above but no other countries will participate in the Action. Any departure from this will change the total cost accordingly.

H. DISSEMINATION PLAN

H.1 Who?

In general the dissemination will have two aspects: internal and external. The internal dissemination is straightforward and will be realised through the regular activities of the Action as meetings, workshops, and schools, as well as by up-dating the website that will include news, timetables of the activities, and an area restricted to the Action partners with “work in progress” documents.

However, it is important to underline the external dissemination plan.

The Action will use a dissemination plan adapted to each category of its target audience. The MC will establish at the beginning of the Action the dissemination strategic plan and will address internal (belonging to the Action) and external target groups by specific instruments. The list of target groups will be discussed and regularly updated. The following target groups have been identified:

- Universities/Research Institutions/Academies working in topics related to the Action;
- Industries in related fields to the Action;
- National and European Research funding agencies;
- Other European projects (COST, FP7, EUREKA, RTN, etc.);
- Research funding/performing organisation;
- Opinion formers, European-level and regional-level Research Policy decision-makers;
- Media: scientific and non-scientific press, digital media ,etc. in order to explain to the public at large the results that may have the strongest impact on everyday life or can be of general interest (in particular concerning biomedical applications).;
- Early Stage Researchers (graduates, PhD students, young researchers working in the field of the Action).

H.2 What?

The dissemination plan is designed to achieve a maximum transfer of new knowledge. To maximise the dissemination of the results and progress of this Action several distinct routes will be used:

1. A dedicated interactive website will be set up. The website will be maintained by the Dissemination Manager appointed by the MC and supported by the CG. It allows broad dissemination of the Action outcomes in form of common scientific publication database and information on past and upcoming events. It will contain information about the management structure, contact points and activities of the Action including conferences, workshops, symposia, training schools, training events (both within the network and worldwide), list of potential host groups for technical visits and training. Links to publications, proceedings, job opportunities, project opportunities, PhD and MSc studentships will also be available. In order to reach a broad target group, this website should be open to the public, while critical information about the Action and MC actions in general will be available to the partners in a password-secured area.

   This access-level will allow private-type information exchange about available facilities and non-published work in progress for members in WGs and ESRG of this COST Action only. It will contain supplementary, disclosed information about MC meetings, scientific reports, non-technical interim and annual reports, STSM reports, financial reports, working papers, guidelines and manuals.
2. Shared electronic documents and an e-mail network will be established for the whole Action.
3. Scheduled meetings will be established: workshops, seminars, retreats and conferences will be organized by the MC, in parallel with national and international conferences and symposia.
4. Regular researcher exchanges between sites especially of ESRs.
5. Participation in industrial forums.
6. Training schools and training events will be organized, as well as lectures by leading scientists and engineers from both academia and industry.
7. Links with others Actions, NoE, ITN-MC, NMPs - links will be established with the most relevant funded projects with proximity and/or complementary objectives.

8. Joint publications in high impact peer-reviewed scientific journals, books and proceedings and presentations to the Action workshops and Conferences.
9. Visits to the laboratories of partner groups and industries; this is realizable mainly in the host locations of specific Action meetings or Conferences.

H.3 How?

The dissemination strategy follows the integrated communications approach:

- Innovative yet appropriate: messages and communications activities will be aligned with the promise they will deliver.
- Feedback-oriented: Feedback tools will be implemented in all applicable dissemination activities.

The dissemination strategy will be adapted to arising needs and internal and external communication processes can be improved.

The following selected routes will contribute to dissemination activities:

1. The website will be a vital point for dissemination by providing information about the Action, including the management structure and contact points as well as its activities including conferences, workshops, symposia, training schools, publications, proceedings, patents, job opportunities, project opportunities, PhD and MSc studentships, access to scientific, interim and annual reports, case study and STSM reports, device/sample exchange, financial reports, working papers guidelines and manuals.
2. Mailing lists for the committees and members of WGs and the ESRG will allow coordination and information exchange at each level.
3. Workshops, seminars and conference organised by the MC will also be key dissemination points to other research groups and industrial players. Particular attention will be paid to organization of such events in conjunction with other international activities to enable dissemination to broader audiences.

4. Training schools, training events as well as lectures given by leading researchers from both academia and industry will enable dissemination primarily to ESRs and PhD students. The progress of the Action as well as the results of its evaluation will feed into updating the dissemination plan during the course of the Action.
5. Training in advanced techniques of science communication will be included in the training activities targeting ESRs.
6. Subject to copyright and licensing arrangements, a copy of publications arising from and supported by this COST Action (including journal articles, books and conference and workshop proceedings) will be deposited in the e-print repository of the COST Office.
7. The Final Evaluation Report will cover the dissemination and exploitation of the results in line with the DC's Terms of Reference.

The MC will produce, following the DC's Terms of Reference requirements, a revised dissemination plan and will include it in the annual report to be approved by the DC. Therefore, once the Action begins, there will be a continuous monitoring of the dissemination by checking the following indicators:

(i) Increased number of European scientific workshops and conferences in the field by scientists in the Action.
(ii) Increase in the collaborative work and joint publications between partners of the network.
(iii) Increase in distribution of information and documentation of scientific data and materials via the dedicated Web site.
(iv) Increased number of available PhD and MSc in the Action field.
(v) Increased number of STSMs and participants of training schools, workshops and training events.