Photonics PPP
Photonics21 Research and Innovation topics for the Horizon2020 PPP Work Programme 2016-2017

WORK GROUP No: 7
Research, Education, and Training

Per work group

1. Research topics: Time to market ~6-10 years
2. Innovation topic: Time to market ~3 years (optional)

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1 Number of work group proposals on research/innovation topics is not limited
I. Preamble:

There will be at least one call per year where Research and Innovation (R&I) actions under the Photonics PPP (and under the cross-cutting KETs WP) could be supported by the EC. There is therefore a need for:

1. Defining in much more detail than the level of description provided in the SRIA each of the specific R&I actions which could be candidates for inclusion in the ICT WP 2016-2017.

2. Prioritising such candidate R&I actions (incl. the definition of the respective budget figures) for their inclusion in the ICT WP 2016-2017.

The purpose of this document is therefore to request, from each of the WG, specific inputs with regard to items 1 and 2 above. Separate inputs are requested for the research actions (topics) and for the innovation actions.

II. Description of the area where Horizon2020 funding is requested (1 page max)

1. Area to be addressed
   - Application domains (e.g. “Automotive”)

   Optical technologies are increasingly used for structuring and functionalising materials and for the fabrication of micro/nanodevices and systems (including, but not limited to, photonic devices and systems). In particular 3D printing gave a strong contribution to boost this area. However, up to now rather conventional light sources and technologies have been used. Impressive improvements could be achieved through research actions targeting new approaches to multidimensional (2 and 3D) opto structuring.

   On the other side, when dealing with innovative photonic devices, new manufacturing (including, but not limited to optical technologies) materials and processes are needed to open the way to new functionalities.

   - targeted application (e.g. “Sensors for automotive safety”)

   Applications of new optical technologies as fabrication tools are practically unlimited, going from biomedical devices to sensors for environmental monitoring, transport safety, food quality assessment, etc.

2. Position of Europe in the application domain (research, industry), foreseen evolution from now to 2020+ What is the challenge (in Europe) in the respective area today?

   (e.g. The excellent results obtained by European research centers and industrial labs in the field did not give birth to any product up to now; the reason is 3-fold:

   - Some materials involved and process steps do not exist in current foundries.

   - Large investment are needed to produce this new technology in European foundries.

2 For horizontal work groups focus can be on generic technology domains
- Tier 2 suppliers in this field are quite weak in Europe; European Tier 1 suppliers currently implement Asian products in their commercial equipment.

European industry has a recognised excellence in the development of laser sources and systems for optical manufacturing. However, its position is being challenged by competitors from the rest of the world. In this frame, a stronger cooperation between research centres, universities and industrial labs would create the basis for long-term innovation. Disruptive approaches to radiation-matter interaction are the challenge that Europe is facing to overcome present limitations of optical manufacturing technologies so as to achieve unprecedented resolution and flexibility together with the capability of functionalising the surface of the materials used, thus tailoring and optimising their characteristics for the different application fields. Novelty can be related to the laser source (e.g. ultrashort pulses or non-conventional wavelengths) or to the optical system for light manipulation (e.g. non-conventional optical systems to achieve sub-micron resolution) or to radiation-matter interaction (e.g. highly nonlinear processes).

When dealing with photonic devices, Europe is again one of the major players, both at the research level and in terms of industrial competitiveness. It is a field where a lot of SMEs are operating. Also in this area, disruptive approaches to manufacturing and new materials and a strong cooperation with the most advanced research institutions are needed to maintain European industrial competitiveness on the long term.

3. What needs to be done?

*Necessary steps to overcome the problem described, including the type of activity (research, innovation, other)?* (e.g.:

a. Consolidate R&D in the field, especially regarding the validation of the technology by Tier 1 suppliers and automobile manufacturers (Research activity).

b. Set-up a pilot production line involving the technology providers as well as the potential European customers; they should be provided a free access to the products of the pilot line and integrate them in equipment pre-series (Innovation activity).

c. Explore the other potential fields of valorisation, including niche markets, where cost constraints can be relaxed (Innovation activity).

4. When should it be launched and how much funding is needed?

*In which year should the area be called: as part of WP 2016 or WP 2017?* (e.g.:

(a,c) WP2016

b. WP2017)

a. WP2016

a.2. WP2017
III. Proposal for Research or Innovation Topic(s) (2 page max) in Horizon2020 WP 2016-2017

For each Research or Innovation topic, please provide a few lines of description which comprises of at least the issues listed below under 1 to 6 (for the level of granularity of the description per R&D topic, see for example the WP text of Objective 3.2 Photonics under the ICT FP7 WP 2013). Innovation actions can be in the form of a pilot production line, a demonstration action, a combination of these or any other form of action.

Research Topic #1 (the title should specify explicitly the nature of the topic, i.e. “Research” or “Innovation”)
(proposed for WP2016):
“2&3D opto structuring: researching new approaches to optical manufacturing”

1. Description of the topic, objective: What shall be reached in concrete terms including Specs and TRL?4
2D and 3D opto structuring are being increasingly used for the fabrication of devices and systems down to the microscale. Different kind of components can be fabricated: micro-mechanical, microfluidic, photonic, etc. Opto structuring is also widely employed to modify the surface properties of materials so as to functionalise them. These technologies can be considered partially mature for industrial production, and indeed commercial fabrication facilities exist, but at the present level of advancement, they still suffer from severe limitations. For example, in the case of 3D printing, resolution is not sufficient for many applications. Exploring new laser sources and new materials, so as to exploit novel conditions in terms of radiation-matter interaction, opens the field to unprecedented perspectives in terms of resolution (down to the submicron and nano-scale), flexibility, and capability of fine tuning of the surface characteristics (e.g. wettability). Different materials can be targeted, including dielectric, metals and semiconductors, thus allowing full integration of different functionalities in the same device (e.g. micromechanical together with optofluidic). This will allow the realisation of smart sensing devices and other innovative components. TRL 3 to 5 can be targeted.

2. Relevant Research & Innovation present in Europe?
What is the positioning of EU research of this topic? With regard to the current EU industrial landscape, are the results likely to be exploited in the EU?
The EU research is very advanced and competitive, regarding all aspects involved: laser source development, optical systems to be used for light delivery, automation and control of the manufacturing, including sensing and characterisation. The industrial landscape is favourable and can surely benefit of the technological advances brought by disruptive research in terms of long-term competitiveness.

3. Impact on European economy, employment; What is/are the concrete business case(s)?
Why/how will it improve the competitiveness of the EU industry? Direct market potential [market fig.]/ impact on End user markets [market fig.]; Which value/supply chain(s) does the

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4 Note: In the particular case of a pilot production line, please define the TRL ([http://de.wikipedia.org/wiki/Technology_Readiness_Level](http://de.wikipedia.org/wiki/Technology_Readiness_Level)) of the action and whether this is an “open” access pilot or not.
product(s) address, which parts of the value/supply chain(s) are likely to be located in Europe? Creation of jobs in Europe;
The capability of fabricating small devices and microsystem, integrating different functionalities, at reasonably low cost can face the needs of several markets (e.g. point-of-care medical diagnosis, food quality assessment, environmental monitoring, gas or contaminant detection, transport security, etc.). In particular, 2 and 3D opto-structuring are very promising for the following application fields:

- Life science: by combining surface functionalization and 3D structuring a new approach to biomedical sensing can be envisaged e.g. through the realization of functionalized lab-on-chip where optical diagnostic and characterization techniques are integrated;
- Smart lighting: optical structuring has important potentials in changing material characteristics that can be beneficial for efficient lighting;
- Agrifood, food quality assessment, security and environmental sensing: as in the case of biomedical applications, the capability of fabricating through optical techniques multifunctional, highly innovative sensors will have a great impact in terms of the development of new products.

Both the development of the new technologies and their subsequent exploitation are likely to be located in Europe, with obvious positive impact in terms of job creation.

4. Impact on societal challenges
The impact on societal challenges is potentially strong although partly indirect. A first direct positive impact is related to the possibility of improving the sustainability of the manufacturing processes by reducing energy consumption, material waste, use of dangerous materials and gases, etc. The indirect impact on the long-range is related to the kind of devices and systems that will be enabled by innovative approaches, capable of addressing the main needs of smart cities protocols.

5. EU added value:
Need for EU investment rather than national or local investment? Why should it be funded at EU level?
The success of the research lies in the capability of joining different competences ranging from the development of novel laser sources, innovative approaches in terms of light delivery and radiation-matter interaction, material science. Thus the effort needs to be supported by international teams. This will also allow EU to foster synergies between the different competences, present at the local level and supported within the regional Smart Specialisation Strategies, thus increasing the final impact of EU funding on industrial development and competitiveness.

6. Funding:
What could be the share of financing requested under Horizon 2020 compared to the overall investment required (only for innovation actions)? 12 M€

Research Topic # 2 (the title should specify explicitly the nature of the topic, i.e. “Research” or “Innovation”)
(proposed for 2017):
“Research on new manufacturing and materials for novel photonic devices”

1. Description of the topic, objective: What shall be reached in concrete terms including Specs and TRL?
Photonic components and systems are nowadays widely employed both as stand-alone and as part of “non-photonic” products. However, much wider application fields and market opportunities could be reached by targeting new and better performances, higher integration, and lower production cost. Since present manufacturing technologies, materials and processes used at the industrial level have in most cases reached their limit, novel approaches have to be developed at the research level. These require a stronger interaction with other KETs, typically nanotechnologies, advanced materials, micro and nanoelectronics, and advanced manufacturing. Some targets are common to all applications (e.g. reduction in energy consumption, reduced size, integration, sustainable manufacturing techniques, and reduction in the use of toxic or rare materials), some depend on the kind of applications: sensitivity and specificity for all sensing applications, sensitivity and resolution for imaging, speed and data processing/transmission capacity for information and communication technologies, etc. New materials (e.g. 2D non-graphene materials) and manufacturing approaches need to be explored to achieve smart integration of optical and non-optical functionalities and to reach the nanoscale. New processes have to be implemented (e.g. quantum based) to obtain unprecedented performances and to address new application fields (e.g. cognitive photonics). The main target is the development of a new class of highly innovative components that can play a key role in the implementation of the smart city and smart community model, i.e. suitable for integration in systems for ambient-assisted-living, smart buildings, etc. TRL3 to TRL5 are addressed.

2. Relevant Research & Innovation present in Europe?
   What is the positioning of EU research of this topic? With regard to the current EU industrial landscape, are the results likely to be exploited in the EU?
   EU research is very active in this topic and TRL1 to TRL2 research activities are being sustained by ERC grants and Marie Curie Actions. The industrial landscape can be considered mature to be the recipient of researches extending from TRL3 to TRL5 so as to turn the research results into future market products. The results are likely to be exploited in Europe. Future innovation actions devoted to the creation of pilot lines based on the results of the proposed research activity will further contribute to consolidate the present industrial landscape.

3. Impact on European economy, employment; What is/are the concrete business case(s)?
   Why/how will it improve the competitiveness of the EU industry? Direct market potential [market fig.] / impact on End user markets [market fig.]; Which value/supply chain(s) does the product(s) address, which parts of the value/supply chain(s) are likely to be located in Europe? Creation of jobs in Europe;
   Excellent fundamental research and proof of principle demonstrations are being performed in Europe potentially enabling new technologies for novel photonic devices. Bridging the gap between fundamental material science/disruptive nanoscale technologies and materials/technologies with industrially-compatible reliability, and transforming proof of principle demonstrations into prototypes will set the basis for future innovation in the design and fabrication of novel photonic devices. This will dramatically increase the competitiveness and is mandatory to maintain the viability of SMEs in a highly demanding market. The capability of increasing the market share of photonics, and of addressing new markets, including niche markets where the capability of customising the devices is mandatory, will be of great benefit for European economy and create a large number of jobs.

4. Impact on societal challenges
   The impact on societal challenges is very high. The design and realisation of novel photonic devices with unprecedented performances will give a significant contribution to the
development of many areas related to wellbeing and to living in a better and safer society. New approaches to manufacturing and research for new materials/material engineering will allow reduction in energy consumption, material waste, use of dangerous materials and gases, etc., with a positive impact on environment-related societal challenges.

5. EU added value: *Need for EU investment rather than national or local investment? Why should it be funded at EU level?*

   The success of the research lies in the capability of joining different competences ranging from advanced manufacturing, material science, nanotechnology, quantum technologies, etc. to integrated optics, advanced photonics, design of photonic devices. Thus the effort needs to be supported by international teams. This will also allow EU to foster synergies between the different competences, present at the local level and supported within the regional Smart Specialisation Strategies, thus increasing the final impact of EU funding on industrial development and competitiveness.

7. Funding: *What could be the share of financing requested under Horizon 2020 compared to the overall investment required (only for innovation actions)?* 12 M€
Draft template

Photonics PPP
Photonics21 Coordination and Support Action (CSA) topics for the Horizon2020 PPP Work Programme 2016-2017

BoS proposals

WG7

5 Recommended by the Photonics21 secretariat
1. **Area to be addressed**

Photonics is becoming a ubiquitous technology. Many industries exhibit a large portfolio of photonic-based products and/or of products containing photonic components. End users also face the need to have some expertise in photonics. Thus a skilled workforce needs to be trained so as to maintain both the capability of developing new photonic components and systems on one side, and to make an optimal use of the existing products on the other side.

2. **What is the challenge/problem (in Europe) in the respective area today?**

Nowadays, Science and Technology studies are not sufficiently attractive for young students. Economy and business related curricula tend to be more successful. Moreover, within S&T curricula photonics does not always have the importance it deserves when considering its impact in the industrial landscape. As a result of this situation, workforce well trained and skilled in photonics is largely insufficient for the industrial needs.

3. **What needs to be done by a CSA to overcome the problem? Description of the topic.**

**What should be achieved by the CSA.**

Some CSAs have already been launched in the past to address outreach programs and they have demonstrated to be effective to attract young minds towards photonics. One of the key aspects of the success of any action, especially when they target high school students, is the possibility of performing hands-on activities. In other areas of S&T, in particular mechanics and robotics, FabLabs have demonstrated to be a perfect approach, with very high impact. A general approach of fablab can be perfectly adapted to the transversality of photonics; the use of opto and laser components to perform industrial tasks are too often restricted to 3D printing and cutting machines, although many other processes can be easily reproduced assembling opto, mechanical and material components. This approach developing open FabLabs where opto-components and equipments - photonics FabLabs- can be used not only to perform conceptual tasks (prototyping, rebuilding parts...) as in generic and historic Fablabs, but also, to assemble various components enabling participants to understand and master, at all level of education, from the principles of photonics all the way to process control. The pedagogic impact can be very high, as it may even enable innovation in photonics applications.

FabLabs are available around Europe, but very few of them include working stations related to photonics. A CSA should start from the existing FabLabs, but also extend the number of them, promoting the realization of work-stations related to photonics and/or the creation of photonics-based FabLabs. This will allow young students to get directly in touch with the fascinating possibilities offered by photonic technologies, thus most likely increasing the attractiveness of photonics as the main topic for their future studies. Upgraded workstations should also be envisaged, dedicated to higher education-level students and for the training of technicians and professionals. In the latter case, the FabLab should provide some flexible, reconfigurable workstations, where industries could temporarily implement specific additional instrumentation for training purposed. While FabLabs designed for young students and for outreach purposes should be preferentially based in easily accessible structures (e.g. science and technology museums, school-dedicated infrastructures, etc.), the higher level FabLabs would have a stronger impact when located where highly specialized trainers are present, e.g. in universities or technological infrastructures.
4. What is the expected impact?
The availability of photonic work-stations in the FabLabs will allow a large number of students to experience the potential of photonic technologies through hands-on experiments and should both increase the attractiveness of photonics in third and fourth level studies and push students to pursue a professional career in photonics. The expected impact is a significant increase in the number of students choosing S&T curricula, in particular curricula with a strong focus on photonics, and in the consistency of skilled workforce for photonic and photonics-enabled industry. Moreover, the possibility of organizing training sessions for technicians and professionals will have a great impact in maintaining SMEs’ competitiveness through the skills of employed workforce.

5. EU added value:
Need for EU investment rather than national or local investment? Why should it be funded at EU level?
By creating a European network of photonics-oriented FabLabs it will be possible to create a common background and share best practices; this will increase the impact and reduce implementation cost.

6. When should it be launched and how much funding is needed?
In which year should the area be called: as part of WP 2016 or WP 2017?
Since the CSA will give its positive impact on a medium time-range while the problem to be solved is very urgent, it should be part of WP2016.
Funding needed depends on how many FabLabs will be equipped with photonics based workstations. It goes from a minimum of 3M€ for a single project with a small number of nodes up to 9M€. The possibility of two separate calls, one per year, targeting different end-users, should be considered:
WP 2016: CSA for FabLabs for high-school students, 3 to 9M€
WP 2017: CSA for FabLabs for training of higher-education-level students, technicians and professionals employed in photonic industries or in industries employing photonic-based set-ups, 6M€

Note: if photonics Fablabs are launched as platform with various kits- optics and laser, mechanical components and characterisation tools for process control, the call of 2016 can be focused on high school students, and set the basis for the second call where the platform could be improved and upgraded, possibly in the same partnership, for higher education as well as open pedagogical resources for technicians and engineers training.