PHOSFOS

Photonic Skins for Optical Sensing

Grant Agreement number: 224058

Deliverable Report

Work Package 6

D6.15 **Final Press Release**

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Annexes:	ANNEX I – Opticalfibersensors.org article ANNEX II – Laser Focus World article ANNEX III – Optics and Photonics News article

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1. Deliverable Objectives

This deliverables is part of WP 6 on Dissemination and Exploitation. It fits into Task 6.1 as specified in Annex II to the Grant Agreement – Description of Work (DoW). This Task involves for example the support of joint publications as well as the follow-up of the participation to events at which the research conducted can be presented.

The goal of this particular deliverable was to draw the attention of:

- a fairly general public;
- a technically educated audience active in the technological field covered by PHOSFOS;
- a scientifically educated audience active in the broader field of photonics;

by means of an adequate distribution of a final press release.

2. Final press release processing

A first version of the final press release was drafted by the coordinator in collaboration with FOS and AS. This text is shown in the box below.

European PHOSFOS project consortium presents final results.

PHOSFOS implemented new approaches to optical sensing, flexible materials, embedding technologies and integration concepts.

Since its start in 2008, the PHOSFOS project funded by the European Commission's 7th Framework Programme has created a new paradigm for flexible optical sensors integrated with electronic modules and control circuitry. Its aim was to develop a generic technology that offers an integrated solution to embedded optoelectronic circuits. The PHOSFOS project is now completed and several breakthroughs in the field of optical sensing, flexible materials, embedding technologies and integration concepts have been achieved which may be used in a wide range of applications.
A first highlight of the research involves the development of a new pressure sensitive and temperature insensitive sensor. The pressure sensitivity of the new sensor exceeds the state-of-the-art by a factor of 20, whilst being truly temperature insensitive. The technology enables accurate pressure measurements in the presence of temperature gradients as required in the field of oil and gas exploration. The pressure sensitivity comes from the inherent properties of the fibre rather than any external mechanical housing which means that the sensor is very compact.
The sensor is based on a novel design of a highly birefringent microstructured optical glass fibre that features a high pressure sensitivity a negligible temperature sensitivity and that is compatible with conventional ultraviolet Bragg grating inscription setups. This fibre is known as the "Butterfly" fibre owing to the shape of the layout of air holes in its cross section (see inset). The temperature insensitivity was achieved by carefully tailoring the design of the doped region in the core of the microstructure.
The sensor has also been used as an embedded sensor in composite materials. The measurement capabilities exceeded previously demonstrated transverse strain sensitivities by an order of magnitude. The sensor can therefore contribute vital information about the structural health of composite materials by following the mechanical strain in its most vulnerable direction as required in the field of aeronautics.
A second highlight involves Bragg grating sensors in polymer optical fibres. Prior to the commencement of PHOSFOS, gratings in polymer optical fibre (POF) only existed in the 1550 nm spectral region where the large fibre loss only permitted very short fibre lengths to be used and the devices had to be butt coupled to a silica fibre lead on the optical bench. The PHOSFOS consortium has developed a means for reliably splicing POF to silica fibre and produced the first gratings in the 800 nm spectral region where losses are almost 2 orders of

magnitude less than at 1550 nm. These developments have allowed POF grating sensors to be used outside the laboratory for the first time.
Fibre Bragg grating sensors in POF have potential advantages over their silica counterparts in applications that require very large strains (> 5%) to be monitored. Also POF sensors are beneficial where the structure to be monitored is very compliant and the silica fibre would simply reinforce the structure. When embedded in flexible tubing for example the strain transfer from the flexible outer tube is higher for POF than with silica fibres. Also, the sensor is safer than one containing glass fibre. This is especially important for medical applications since should any breaks occur all of the material used is biocompatible.
One of the limitations on the volume of commercial uptake of fibre Bragg grating (FBG) technology is cost. The PHOSFOS consortium developed a new low cost POF sensor interrogator designed to work with polymer optical fibres. The sensor interrogator has been designed to operate at a wavelength around 850 nm to match the low loss transmission window of POF and to significantly reduce component costs. It is designed to monitor a multimode fibre which increases the optical power of the signal coming back from the sensors.
Using this technology a new polymer multipoint FBG sensor that can measure the pressure in various medical applications has been demonstrated. A POF sensor array has been embedded in a biocompatible polymer tube that can be used to measure pressure within the body, for example in the throat during swallowing. The system has been designed to give a graphical representation of pressure to make interpretation of the data straightforward for clinicians
More PHOSFOS results and contact information can be obtained on the website of the project www.phosfos.eu. An introductory video about the project is available on YouTube at http://www.youtube.com/watch?v=pGpL_icFn1c.

Contact:
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First, to achieve the objective on reaching a fairly general public, the text was first transmitted to the Press Office of VUB on 24th August 2011. The press officer, Mr. Sicco Wittermans, has scheduled the launch to the press contact list of VUB on 15th September 2011 at 10:00 AM. In the meantime the text is being adapted and re-written by the press office in collaboration with the coordinator to attract interest from the broadest possible audience. This approach had proven to be successful with the issuing of the first press communication about PHOSFOS (see Deliverable D6.1, PHOSFOS Doc. No. 2008-022) as the first press release was, at that time, picked up immediately by the Belga Press Agency.

This release will then also be provided to IMEC for processing by its press office and for wide distribution. Previous PHOSFOS related releases from IMEC were also picked up rapidly.

Second, to achieve the objective on reaching an audience active in the technological field of PHOSFOS, the press release was transmitted to the opticalfibersensors.org platform with support of Johan Vlekken (FOS and VUB) and immediately published on-line in the News and Analysis section (see ANNEX I). This platform receives 50 visits per day on average and targets about 200 companies active in the optical fibre sensing field. The release will also be part of the newsletter of opticalfibersensors.org platform which is distributed to a mailing list with over 4000 addresses. In addition the press release has been transmitted to a number of technical magazines as listed in Table 1 below. This also proved to be a successful approach at the time of Deliverable D6.1.

Title	Type	Info
Optics.org	Web Portal for photonics community	90000 visitors per month 44000 e-mail alert subscribers
Photonics.com	Web Portal and technical magazines	Covers “Photonics Spectra” and “EuroPhotonics”
LaserFocusWorld.com	Web Portal and magazine	Reaches nearly 70000 qualified optoelectronics professionals from around the world
SPIE Newsroom	Technical society web portal	Specific target is the Sensing & Measurement Community

Table 1. List of Technical Magazines contacted for the final press release.

Finally, to achieve the objective to reach a scientifically educated audience, Kate Sugden has contacted Mrs. Rachel Won, Associate Editor of Nature Photonics. Discussions are currently on-going as to the publication of a PHOSFOS article on developments in this very high impact journal.

3. Results

At the stage of writing this report it is too early to report on the number of final press publications (with exception of the immediate echoing on opticalfibersensors.org) since the final press release text has only been processed recently. The PHOSFOS consortium will nevertheless continuously monitor publications related to PHOSFOS developments and report on these on the www.phosfos.eu website in the Press section.

It is worthwhile noticing that PHOSFOS was highlighted twice in international magazines in the final reporting period of the project. This first highlight is the article by Jason Palmer in Laser Focus World (issue July 2010) on “Fiber-Sensor Technology is Thin Skinned but Robust” that was published following an interview with the coordinator (see ANNEX II). The second highlight is the reference to PHOSFOS in the “Photonics in Europe” article by Silke Kramprich in the Global Optics section of Optics and Photonics News (issues December 2010, see ANNEX III).

4. Conclusion

According to the DoW, deliverable D6.15 was due T0+41 (31st August 2011). The actual release was made available to press in time using different channels and was already published for the first time on 31st August 2011 by the opticalfibesensors.org platform. A broader launch by the central VUB press office will happen on 15th September 2011. In the meantime PHOSFOS appeared twice in international magazines during the final reporting period. We therefore believe that this deliverable was successfully achieved in time. The consortium commits to continuously monitor the publication of the final PHOSFOS press release and to report on this in the press section of its website.

5. Use of resources

The only resources planned for this deliverable consist of personnel effort. Table 2 provides an overview of the planned and used resources for this deliverable.

Beneficiary	Planned PM	Used PM	¨People Involved
VUB	0.5	0.5	F. Berghmans J. Vlekken S. Wittermans
Total	0.5	0.5	

Table 2. Planned and used resources for deliverable D6.15.

6. Deviations and corrective actions

No deviations have been encountered and consequently no corrective actions need to be foreseen.

ANNEX I – Opticalfibersensors.org article

Optical Fiber Sensor News & Analyses RSS

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AUGUST 31, 2011

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ANNEX II – Laser Focus World article

0.04 cm^2, consisted of a tin phthalocyanine (SnPc)-based bulk heterostructure layer as a near-IR (NIR) sensitizer and an iridium-doped biphenyl OLED layer as a phosphorescent emitter—one of the most efficient OLED materials in use today. In photovoltaic mode, the EQE of the NIR sensitizer layer can be higher than 20%, while the EQE for the OLED emitter layer is close to 20% (compared to typical EQE values of less than 5% for most conventional fluorescent OLEDs).

In the absence of IR radiation, the poor-hole-transport NIR sensitizer keeps the OLED layer in the off state. But upon photoexcitation, photogenerated holes are injected into the OLED layer and recombine with electrons injected from a cathode layer to emit visible light. The 100 nm thick NIR sensitizer layer or film has strong NIR absorption up to 1000 nm, with a peak at 740 nm. Using an 830 nm, 14.1 mW/cm^2 NIR source, green light emission began at 2.7 V and reached a luminance of 853 cd/m^2 at 15 V. At 12.7 V, the on/off ratio of luminescence intensity was about 1400 (see figure).

Even though maximum photon-to-photon conversion efficiency was only 2.7% for this device, the researchers say that this value represents an order-of-magnitude increase compared to conventional (and more expensive and complicated) hybrid organic/inorganic devices. "Since OLEDs are being used for flat-panel displays, the costs of making these organic devices are expected to be low because they can use the existing OLED manufacturing infrastructure," says Franky So, associate professor of materials science and engineering at the University of Florida.—*Gail Overton*

REFERENCE
1. D.Y. Kim et al., *Adv. Mat.* 22, 1–4 (2010).

MICROSTRUCTURED FIBER

Fiber-sensor technology is thin-skinned but robust

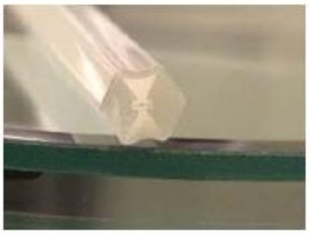
Progress continues apace for a European project aiming to create a fully integrated photonic sensing "skin" that can be used anywhere that requires close monitoring of mechanical properties. The three-year European Commission-funded project, known as "photonic skins for optical sensing" (PHOSFOS), has now perfected its fiber-production methods and has its sights set largely on medical applications.

The 2.5-million-Euro PHOSFOS project is being led by Francis Berghmans of the Free University Brussels in Belgium, in collaboration with a number of European universities and the nanotechnology firm IMEC (Leuven, Belgium). At the project's heart is the use of fiber Bragg gratings created in silica fibers, microstructured fibers, or exotic plastic optical fibers. Those in turn are to be embedded in a thin foil or skin which the team envisions could be put to uses ranging from dentistry to civil engineering.

Key to the whole enterprise, Berghmans says, is the integration of the elements—the ability to integrate the optical sensing functionality with on-board signal processing, a power source, and even wireless communication inside the flexible polymer skin. The skin can then be tacked to, wrapped around, or built into any shape the application requires.

"There are other ways to do it but not in such an integrated manner," he says. "You're getting your complete system inside a flexible material that can be attached to anything you would like. It's applicable in many different cases, whether you're thinking of medical applications or of structural health monitoring—since everything is embedded and comes in a single system, you're not limited."

The idea for PHOSFOS came from a longstanding collaboration. "We were working with microstructured fibers and had collaborations with the University of Ghent and IMEC," Berghmans says. "They had the microsystems technology, thinning diodes down until they were flexible. We said it would be great if we could combine everything to achieve these fully fledged integrated sensor systems."



A PHOSFOS photonic-crystal fiber (shown here as a preform) will be patterned with Bragg gratings and be embedded in a flexible polymer skin for sensing (top). An experimental polymer skin, illuminated with a supercontinuum source, is wrapped around a surface to be monitored (bottom). (*Courtesy of Vrije Universiteit Brussel*)

Insensitive to temperature

But making fiber Bragg gratings in a number of types of fibers while maintaining optical performance wasn't—and still isn't—a straightforward business. One principal problem was limiting the temperature sensitivity of the photonic skins; they should measure the same mechanical properties regardless of the ambient temperature. Berghmans is somewhat guarded about the secret but says that the team now has fibers with a temperature sensitivity so low as to be unmeasurable.

"You have to take advantage of the thermal properties of the polymer fiber; normally these things are quite sensitive to temperature, but if you thermally treat them in a proper way, you can achieve writing multiplex gratings."

Most recently, the team pulled off a landmark result: fiber Bragg gratings with features smaller than ever before, made point by point with an ultrafast near-IR laser.[1] Each period of the grating is made with a single pulse, and the grating is built up by translating the fiber through the focused spot. The team's method is simple—their optical setup doesn't even attempt to account for the curvature of the fiber, for instance—so it bodes well for large-scale manufacturing in the future.

For now, the team is working to make the production of the fibers reliable and repeatable. The European-funded part of the project finishes early next year and potential uses for the skins are already mounting up.

"The killer applications are definitely in the medical field," Berghmans notes. "We're now working toward a demonstrator for respiratory monitoring, and there's another project in artificial limbs or 'smart prosthetics.'"—*Jason Palmer*

REFERENCE

1. T. Geernaert et al., *Opt. Lett.* *35*, p. 1647 (2010).

Photonic Skins For Optical Sensing

ANNEX III – Optics and Photonics News article

GLOBAL | OPTICS

The Brussels Photonics Team at Vrije Universiteit Brussel.

Vrije Universiteit Brussel, Belgium

Photonics in Europe

Silke Kramprich

Photonics has been officially acknowledged as a key enabling technology in Europe. Driven by global trends and growing awareness, Europe is experiencing industry growth and an increase in the number of optical societies and public-private partnerships that promote photonics applications.

Optical scientists and engineers have always known that photonics drives modern applications—and now global governments are recognizing it as well. In late 2009, for example, the European Commission named photonics as one of the European Union's key enabling technologies. The other four include advanced materials, nano- and micro-electronics, biotechnology and nanotechnology.

As a starting point, several European Union (EU) member states have identified enabling technologies and targeted their R&D spending accordingly. It goes without saying that, given the unique strengths and limitations of the research and industrial landscape in various European countries, the 27 EU member states have taken different positions on which areas they regard as most important.

However, based upon reports by a key technologies expert group, the German Federal Ministry of Education and Research, the French Ministry of Economy, Finance and Industry and the U.K. Technology Strategy Board, there is strong support for photonics in France, Germany and the United Kingdom. Other EU countries are not necessarily less active, but they cannot always easily foster photonics, particularly in the absence of big optics industries.

Nevertheless, looking at the 22 national optical societies united in the European Optical Society (EOS), it is obvious that optics and photonics play an important role in smaller EU member states too. The recent formation of new national optical societies in Portugal, Latvia, the Ukraine and Greece shows that photonics stakeholders are uniting to gain more visibility.

EOS participating countries.

In order to boost research and development, the European Commission has encouraged the formation of technology platforms, which are public-private partnerships aimed at developing sectoral R&D programs rapidly and effectively. On the model of a European technology platform called Photonics21, many national platforms have been established, and more are under way. One example is PHORIT, an Italian technological platform, which is a voluntary association of industrial enterprises, academics and other stakeholders.

In previous years, European stakeholders were not able to reach agreement about which technologies need more strategic cooperation to improve industrial competitiveness. These days, however, photonics is emerging as a critical technological area, thanks to global trends, increased awareness due to strategic partnerships, and some very clear facts and figures. Consider the following, for example.

- The European photonics industry accounted for revenues of about $65 billion in 2006, and it is continuing to grow rapidly.
- In particular, the green photonics share is expected to grow from some 8 percent to more than 50 percent in 2020.
- There are about 5,000 photonics manufacturers in Europe that employ around 246,000 people (excluding subcontractors). In addition, the jobs of more than 2 million more employees in the EU's manufacturing sector depend directly on photonic products.

The 7th Framework Program of the European Union (FP7) is the EU's main instrument for funding research from 2007 until 2013, with the goal of encouraging growth, competitiveness and employment. According to the new Information and Communication Technologies work program within FP7, about $156 million will be budgeted for research on "core and disruptive photonic technologies" for the years 2011 and 2012.

Most current and future photonics research projects in FP7 are carried out by cross-national teams from industry and academia. In fact, when it comes to applications-oriented research, such collaborations are mandated. The table to the right shows different types of projects (which in EU terminology are called "funding schemes") applied by FP7.

An example of an EU-funded collaborative project is PHOSFOS—photonic skins for optical sensing, which was started in April 2008 and will run through March 2011. PHOSFOS aims to develop a flexible and stretchable foil that integrates optical sensing elements. These skins can be used to continuously monitor the integrity and behavior of civil engineering structures and energy production facilities. The Brussels Photonics Team at Vrije Universiteit Brussel, led by Hugo Thienpont and Francis Berghmans, carries out the project with partners from Poland, the United Kingdom and Cyprus.

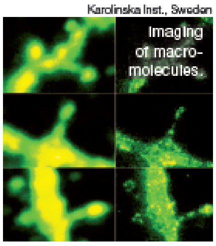
One of the strongest growing fields is photovoltaics. According to the 9th annual Photovoltaics Report of the European Commission's Joint Research Centre, which was released on 6 September 2010, newly installed PV cells generated 7.4 GW of power globally in 2009, of which 5.8 were produced in Europe. The EU covered 75 percent of PV cells installed in 2009. The market reporting the biggest growth was Germany's, with 3.8 GW. Italy ranked second with 0.73 GW, followed by Japan (0.48 GW), the United States (0.46 GW), the Czech Republic (0.41 GW) and Belgium (0.3 GW).

Europe's leading position in photovoltaics is the result of its long-term strategy of promoting collaboration between scientists, industry professionals and administrations. Many research projects across Europe are focusing on increasing the energy efficiency of photovoltaic systems.

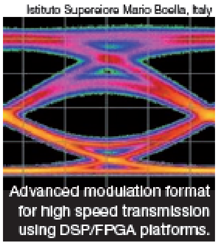
Laser Zentrum Hannover e.V.


Laser welding of glass tubes for solar collectors.

Karolinska Inst., Sweden


Imaging of macro-molecules.

Istituto Superiore Mario Boella, Italy


Advanced modulation format for high speed transmission using DSP/FPGA platforms.

Types of European Research Projects	
Collaborative projects	Focused projects carried out by consortia from different countries and from industry and academia.
Networks of excellence	Designed for research institutions willing to combine and functionally integrate a substantial part of their activities and capacities in a given field, in order to create a European "virtual research centre."
Coordination and support actions	Coordination and networking of projects, programs and policies.
Individual projects	Individual national or multinational research teams funded by the European Research Council.
Support for training and career development	For researchers from the EU and its research partners.
Research for the benefit of specific groups, in particular small and medium-sized enterprises (SMEs)	Projects where the bulk of the research is carried out by universities, research centers or other legal entities, for the benefit of specific groups, in particular SMEs, or for civil society organizations and their networks.

The LasSol project, for instance—which is funded by the German Federal Ministry of Education and Research—is looking to increase the efficiency of solar cells through selective emitter structures with higher doping concentration. The $4.3 million project runs from September 2009 until August 2012 and consists of a consortium of partners from industry and research.

EOS has recently produced an overview of current European research projects in a brochure and Web gallery. These communications tools describe how optics and photonics are addressing Europe's challenges of the 21st century and reflects key areas and applications. They are aimed at scientists, policymakers and the public, with the goal of increasing awareness about the solutions that photonics provide for 21st century challenges in health, energy, the environment, information technology, and more. You can access them using the first link in the References and Resources section. Thanks to growth and collaboration, the light of photonics is shining bright in Europe. ▲

Silke Kramprich (kramprich@myeos.org) is the deputy executive director of the European Optical Society in Hannover, Germany.

[References and Resources]

>> European Optical Society (EOS) brochure and web gallery: www.myeos.org/how_optics_and_photonics_address_europes_challenges_of_the_21_century).
>> EOS: www.myeos.org.
>> Photonics21 technology platform: www.photonics21.org.
>> Photonics Unit of the European Commission: http://cordis.europa.eu/fp7/ict/photonics/home_en.html.
>> European Commission's Joint Research Centre: http://ec.europa.eu/dgs/jrc/index.cfm.
>> The 7th Framework Program of the European Union in brief: http://ec.europa.eu/research/fp7/understanding/fp7inbrief/home_en.html.
>> Photonics in Italy technological platform: www.phorit.it.
>> PHOSFOS—Photonic skins for optical sensing: www.phosfos.eu.
>> The LasSol project: www.ct-mabrilas.de/en/lassol.