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SEVENTH FRAMEWORK PROGRAMME

Development of smart machines, tools and processes for the precision synthesis of nanomaterials with tailored properties for Organic Electronics

Reporting

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Smartonics

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Final Report Summary - SMARTONICS (Development of smart machines, tools and processes for the precision synthesis of nanomaterials with tailored properties for Organic Electronics)

Executive Summary:

Organic Electronics (OEs) is a rapidly emerging field that is expected to revolutionize conventional Electronics, Energy and Photonic applications. Some of the most important OE applications include flexible OPVs, OLEDs for displays & lighting, TFTs, sensors and biosensors, thin film batteries, and RFIDs to name but a few.

Smartonics (www.smartonics.eu) is a key EU Large Scale Project (FP7-NMP.2012.1.4-1 Pilot lines for precision synthesis of nanomaterials) with ambitious targets to revolutionize the Organic and Printed Electronics Industry in Europe. Its objectives are the following:
• Development of smart Nanomaterials for OEs (polymer & small molecule films, plasmonic NPs and super-barriers) by process and computational modeling optimization.
• Development of smart Technologies that include R2R printing and OVPD machines combined with precision sensing metrology tools as in-line Spectroscopic Ellipsometry and Raman Spectroscopy, and precision fabrication tools as R2R inkjet printing and in-line ultra-fast pulsed laser tools and processes.
• Integration of Nanomaterials & Technologies in unique Pilot lines for precision synthesis of Nanomaterials & OE devices (OPVs), optimization, demonstration and evaluation for Industrial applications.
Smartonics has developed three unique pilot to production lines to cover Europe's needs in Industrial leadership in Organic and Printed Electronics. These pilot lines are the following:
• R2R printing Pilot line, which will combine optical sensing (SE, RS), inkjet printing and laser processing tools
• OVPD Pilot line equipped with in-line optical sensing tools (SE, RS)
• S2S Pilot line for the precision fabrication of OE devices (e.g. OLEDs, sensors from state-of-the-art Nanomaterials) and for the evaluation of encapsulation of these devices. The above will be up-scaled in Industrial processes.
The Smartonics consortium consists of 18 European partners (Universities, Companies and Organisations). The partners cover the fields of nanomaterials & process development and optimization (AUTh, POLO, UOP, UOI, UOXF, USUR, CNRS, USTUTT, HZB, Advent, OL, CSEM), precision sensing and fabrication tools (HJY, AUTh, OL, COM, OET), industrial processes (COA, AIXTRON) and manufacturing of commercial products (CRF).

Project Context and Objectives:
Organic Electronics (OEs) is a rapidly emerging field that is expected to revolutionize conventional Electronics, Energy and Photonic applications. Some of the most important OE applications include flexible OPVs, OLEDs for displays & lighting, TFTs, sensors and biosensors, thin film batteries, and RFIDs to name but a few.
Nevertheless, the reported high performance OE devices are mainly fabricated by lab-scale processes, which are accompanied by several drawbacks. These include: a) manual lab scale processes, which require multiple process steps and material transfers between the different process steps, b) complicated procedures, that combine different technologies, such as glove boxes environment, vacuum chambers for deposition of electrodes, printing techniques, etc., c) batch configuration, with capability for only low throughput fabrication, and d) high costs and increased material consumption in order to achieve the required properties.
An additional problem is the lack of efficient synthesis approaches that would enable the control & reproducibility of nanomaterial structure, purity and agglomeration in large scale together with

the insufficient understanding of nanomaterial growth and structure-property relationships in OE hybrid organic-inorganic nanomaterials. Finally, there is a lack of intelligent Pilot lines (to cover both large area Roll-to-Roll (R2R) printing processes and highly scalable gas transport processes as organic vapour phase deposition (OVPD)) that should combine smart precision sensing tools (that would provide real-time information on properties, structure, morphology and thickness during deposition, and to correlate the growth parameters with the material structure and composition) to enable fabrication processes with high reproducibility, homogeneity production yield & throughput, ensuring the wide market implementation of OE devices.

Smartonics has addressed the above challenges and it has combined the world class expertise of its partners in order to develop three Pilot lines:
a) OVPD Pilot lines (at AUTh & AIXTRON) equipped with in-line optical sensing tools for precision synthesis of small molecule nanomaterials and OPV devices (simple and tandem architectures),
b) R2R printing Pilot line (at AUTh), which will combine optical sensing and laser processing tools (for patterning and plasmonic nanoparticle formation), and
c) S2S Pilot Line (in POLO-IAP) for the precision fabrication of OE devices (e.g. OLEDs, sensors from state-of-the-art nanomaterials) and for the evaluation of encapsulation of these devices.
The Smartonics innovative approach will develop the nanomaterials (Technology Readiness Level-TRL: 2 to 3) and the machines (TRL: 3 to 4) to integrate them and develop the Pilot lines (TRL 4 to 5) for the precision synthesis of OE nanomaterials and devices. The developed know-how approaches and methodologies will be readily available and compatible with several OE applications (e.g. OPVs, OLEDs, OTFTs, sensors) related to energy, photonics, and electronics and it can be employed in the long-term to nano-electronics, nano-medicine, etc., advancing the competitiveness of European Organic Electronics and Photonics Industry.

The scientific and technological objectives and targets achieved by Smartonics are:
1. Development of Smart Nanomaterials, which include:
• Polymer organic semiconductors such as tailored electron donors (polymer, hybrid donor-acceptor copolymers) that consist of thiophene bearing alkyl-thiophene, dithiophene & cyclopentadithiophene species, electron acceptors (fullerene derivatives, endohedral fullerenes, inorganic nanoparticles, and quinoline copolymers to increase photon absorption, charge generation and transport by upscalable techniques. The synthesis process of these nanomaterials will be developed in order to allow their upscalability to large quantities to meet the demands for high volume fabrication by pilot to production lines.
• Small Molecule organic semiconductor films and architectures (as metal phthalocyanines, phthalocyanine derivatives, thiophenes, perylenes, C60) to sequentially deposited and/or co-deposited donor acceptor device architectures (simple and tandem OPV architectures). This will be performed by deploying the high precision capability of OVPD processes. (HZB, AUTh, AIXTRON)
• Plasmonic NPs: that consist of metal NPs (e.g. Au, Ag) prepared either by evaporation methods or by laser surface structuring (USUR), wet chemistry methods and laser ablation in liquids (UOI). Also, processes for the precise control of the positioning of the NP layer in the device

architecture as well as its surface plasmon resonance by scalable in-line annealing will be developed. Such NPs will allow the tuning of scattered light, and wavelength adaptation to the active material absorption spectrum.(USUR, AUTh)
• Super-barriers for Encapsulation of flexible OE devices: The innovations include the combination of active barriers (with water vapour absorbers and oxygen scavenging capabilities) with hybrid polymer/inorganic barriers that will achieve a global barrier response of 1×10-5cm3/(m2dbar) (g/(m2d)) for O2 (H2O) permeation. The developed barrier lacquer will have high shelf lives and compatibility to large scale r2r processing. Also, ALD deposited barrier layers on the active stack will enhance the long-time stability of the devices. (POLO)
The above will be supported by computational modelling for the optimization of the growth processes, materials & device properties that includes: i) Finite Difference Time Domain Method-FDTD, classical atomistic modelling, Density Functional Theory-DFT, ab-Initio methods (UOI, AUTh, USUR) for simulation of light scattering and absorption, plasmonic effects, growth mechanisms and dynamics of small molecules, charge transfer, HOMO-LUMO gap etc. ii) OPV device modelling (CNRS), iii) modelling of gas permeation through multilayer barriers (POLO-IVV).
2. Development of Smart Technologies (production machines, precision tools and process).These encompass:
• Production Machines for OE nanomaterials & devices: Smartonics will develop: a) a novel OVPD machine for the controlled deposition of small molecule OE nanomaterials with tailored optical and electrical properties, b) a full r2r process line that will be developed from an existing r2r process already available in AUTh, and which will be upgraded to fabricate OPVs onto flexible polymer substrates.
• Precision sensing and fabrication tools: The precision optical sensing tools that will be developed combine state-of-the-art Spectroscopic Ellipsometry (SE) from Visible (Vis) to far UltraViolet (fUV) (1.5-6.5eV) and in-situ Raman Spectroscopy (RS) for the robust and accurate determination of optical and electronic properties, chemical structure, nanostructure, stoichiometry, thickness with sub-nm precision and feature size, of the OE nanomaterials. The innovations include the coupling of ultra-fast SE with RS for real-time measurement and analysis (in ms) of the optical properties from the complex structures & architectures (e.g. tandem OPVs). The precision fabrication tools include a novel R2R inkjet printing system that has been adapted on the R2R printing pilot line for high precision printing of OPV nanolayers and an ultra-fast laser for the patterning of OE nanomaterials with nm spatial resolution and plasmonic NP formation (by laser annealing of printed nanomaterials and by laser ablation in liquids).
• Processes development based on nanomaterials, machines and tools: Smartonics will develop the process for fabrication of polymer and small molecule OPVs by the combination of machines with the precision tools (for the in-line monitoring of optical & electrical properties, thickness, composition, structure, etc.), the developed smart nanomaterials and the ultrashort-pulse laser processing with high speed and high resolution for the precision patterning of nanomaterials. (HJY, OL, AUTh, AIXTRON, HZB, COM)

3. Development of Pilot Lines for OEs by integration of advances in smart Nanomaterials & Technologies. The advances on the synthesis of organic semiconductors, barrier, and plasmonic

NPs will be combined with the capabilities of the optical sensing and laser fabrication tools for the precision synthesis of OE nanomaterials and devices (OPVs in simple and tandem structures, as well as other devices, e.g. OLEDs) by three Pilot Lines:
• Pilot lines 1: OVPD Pilot lines (at AUTh & AIXTRON) equipped with in-line optical sensing tools for precision synthesis of small molecule nanomaterials and OPV devices (simple and tandem architectures)
• Pilot line 2: r2r printing Pilot line (at AUTh), which will combine optical sensing and laser processing tools (for patterning and plasmonic NP formation)
• Pilot line 3: s2s Pilot line (in POLO-IAP) for the precision fabrication of OE devices (e.g. OLEDs, sensors from state-of-the-art nanomaterials) and for the evaluation of ALD encapsulation of these devices. This Pilot line is already installed at POLO-IAP and it will be used for the evaluation of the process parameter and for the process development (by upscaling the deposition procedure) for the different type of OE devices. This will allow the adjustment of the processing parameter for the r2r processes that will save both time and material in the production development.

The market performance of OE devices will be validated by CRF in automotives applications (integration of OPV devices on the roof of automotives in combination with electronics and conformable auxiliarities, assessment in relation to the strict standards and specification of the automotive industry.
The Smartonics workplan is divided in three Project Areas (PAs), each one with a specific approach and complementary targets. The PA1 is focused on the development of the smart nanomaterial films (polymer and small molecule organic semiconductors, plasmonic NPs, super-barriers for encapsulation), (TRL 2-3) which are supported by computational modelling in order to optimize the opto-electronic properties, stability and growth parameters. The PA2 include the production OVPD & r2r printing machines (TRL 3), the precision sensing (SE & RS) and fabrication (laser) tools (TRL 4) and the deployment for process development. Finally, in the PA3 the advances in nanomaterials & technologies are integrated to three Pilot lines for fabrication of tailored OE devices (TRL 5) and transferring of results for industrial applications (TRL 6).

The expected final results of Smartonics include the following:
• Novel polymer organic semiconductors (electron donors & acceptors and copolymer structures) with tailored properties and controlled structure with high potential for upscalability for industrial applications
• Controlled small molecule layers that can be deposited by OVPD in single and multilayer form
• Plasmonic nanoparticles with controlled positioning and tunable surface plasmon resonance for the enhancement of the efficiency of OPVs
• Super barriers for the encapsulation of flexible organic electronics devices, with global barrier response of 10-5 cm3/(m2dbar) (g/(m2d)) for O2 (H2O) permeation and high shelf lives that will be compatible to large scale r2r processing
• Precision optical sensing tools, that include ultra-fast Spectroscopic Ellipsometry and Raman Spectroscopy
• Precision fabrication tools for laser patterning of nanomaterials for OEs

• Pilot lines (r2r printing & OVPD) with adapted precision sensing and fabrication tools for the precision synthesis of OE devices
• OPV devices on rigid and flexible substrates
• OPV Components for automotive applications

The proposed approach will have a major impact in Electronics, Photonics & Energy industry, it will significantly enhance the innovation and market perspectives in industry and will contribute to the increase of competitiveness, sustainability & employment of OE industrial processes, strengthening Europe’s role in OEs.
The Smartonics consortium involves 18 expert partners from 6 EU Countries, which include 7 Universities (AUTh, UOI, UOP, USUR, UOXF, USTUTT, USUR), 3 Research Institutes (CNRS, POLO-IAP-IVV-ISC-FEP, HZB), and 8 Industries (HJY, AIXTRON, CRF, OET, CSEM, Advent, COA, COM, OL) with complementary expertise on nanomaterials (polymers, small molecules, barriers, plasmonic NPs), computational modelling, device architectures, upscaling, precision tools, manufacturing equipment, and commercial applications
For more information, you can visit the official Smartonics website: http://www.smartonics.eu

Project Results:
1. Smart Nanomaterials and Plasmonic Nanoparticles (NPs)
Among the first steps for the achievement of its targets objectives, it was the establishment of the specifications of the nanomaterials and the OE devices. The establishment needs to be realized by the evaluation of the characteristics of the developed nanomaterials and OE devices and the comparison of their performance against the targets that were set in the project.
During the Smartonics project, there were several organic semiconductor nanomaterials with high upscalabilty potential, that were developed in order to be used as photoactive nanomaterials for OPV devices. These include:
• Functional P3HTs, Copolymers & Fullerene Hybrids as compatibilizers (UOP)
• Several single batch syntheses: from 1g up to 45g (168m2 film on r2r) single batches (UOP)
• Optimization of synthesis routes to optimize purity (monomer/polymer) and molecular weight (UOP)
• Synthesis of end-functionalized P3HT donors for application to OPVs
• Reproducible results of the synthesis approaches to ensure upscalability of nanomaterials to large quantities (UOP, Advent)
• Competitive price compared to big suppliers in combination to efficiency similar to commercially available materials (UOP, Advent)
• Optimization of PCDTBT preparation procedure (UOP)
• Synthesis Alternative route to the synthesis of PCDTBT via Stille Coupling (UOP)
• Preferred method via Suzuki coupling (UOP)
• Large Scale production of identified fullerene acceptor (IC70BA)
• Optimization and potential for upscaling of the acceptor: PC71BM (UOXF)
• IC70BA purification and characterization (UOXF)
• Electrochemical characterization of several fullerenes (USTUTT)
• Calculation of Acceptor Energy Levels and Comparison with HOMO/LUMO Values of P3HT

(USTUTT)

Small molecule nanomaterials and films
Smartonics has developed the processes for the deposition of thin films of small molecule organic semiconductors such as donor metal phthalocyanine and acceptor C60 onto different substrates by the use of high precision VTE and OVPD deposition methods. Applying sequences of such layers, single and tandem OPV devices have been developed by AUTh and HZB. Sequentially deposited as well as co-deposited donor acceptor systems have been implemented. Procedures for the preparation of complete solar cell devices have been realized. Endohedral fullerenes developed by UOXF with increased electron accepting properties have been tested for the application in single solar cell devices.
Organic small molecule solar cells with the device structure glass/ITO/PEDOT:PSS/ZnPc:C60/Mg:Ag and tandem structures were prepared by AUTh, HZB using the OVPD pilot line.

Plasmonic NPs: Smartonics developed the processes for the fabrication of plasmonic nanoparticles (NPs) by laser methods. The partners USUR, UOI and AUTh developed various processing conditions to produce plasmonic NP distributions with tunable sizes and distributions. USUR has developed the excimer laser process to fabricate controlled NP distributions by laser annealing from a Ag film coated glass substrate. During the project, USUR has finalized this process that can be used for the fabrication of NP solutions of any size.

Furthemore, Smartonics developed the laser ablation methods for the synthesis of Ag nanoparticles in solutions (chloroform and water) compatible with the R2R process for the fabrication of OPVs and optimization of the process (laser ablation parameters) in order to control the size and the concentration of the Ag NPs in the solution. In-situ & real-time optical transmission measurements were used to monitor the process and optical modelling was used to calculate the size and the concentration of the Ag NPs.

Modelling of OE devices
Smartonics developed its efforts to establish a multiscale modelling approach in order to provide fundamental understanding on the functionality of the developed nanomaterials in terms of their:
• Optical, electronic and structural properties by analysis of the optical measurements (AUTh)
• Interaction and bonding between different nanomaterials by Atomistic Simulations and Molecular Dynamics (UOI, AUTh)
• Nanomaterial and device simulation in the case of OPVs with embedded plasmonic NPs using Optical simulation (FDTD) and 2D finite elements electrical simulator (Silvaco ATLAS) to evaluate performance improvement in plasmonic OPVs with both optical and electrical points (USUR, UOI)
• Description of macroscopic behavior of OPVs, by Compact modelling (CNRS)
• Understanding of the permeation mechanisms of barrier nanolayers and device architectures (POLO-IVV)
2. Super-barriers for encapsulation

One of the main targets of Smartonics was to develop the super barrier nanomaterials and architectures for the encapsulation of OE devices. The partners developed the following:
• High Barrier materials for Encapsulation (WVTR 1.6 × 10-5 g/(m²d) achieved in R2R production that consist of a sophisticated combination of inorganic and hybrid polymer multilayer architectures. During the project, POLO has performed a systematic investigation of the effect of layer sequence, number of layers and layer thickness, on the final barrier performance of the whole structure. All the barrier layers have shown better optical transmittance than the commercial available barriers and they have been successfully used in OPVs encapsulation.
• ORMOCER® Barrier lacquers with long shelf-lives (storage stability), ready to use (up to 50 kg). The storage time of the interlayer lacquer system ORMOCER® was increased by POLO-ISC by developing a 3-component lacquer system. The 3-component lacquer system shows a longer shelf life. Thus the lacquers can be sent to the partners over longer distances.

• Pilot-scale Manufacturing of Barrier films available on demand
• Extensive knowledge generated on quality and reproducibility factors during R2R barrier film production
▪ TRL of 5 is reached with POLO® high barrier materials
▪ Ready-to-laminate, self adhering barrier films, successfully delivered for demonstrator production at OET
The encapsulation of the OPV modules made with flexible barriers developed in SMARTONICS project in R2R process. The encapsulation process is made by laminating the OPV device from both sides. This process is made under Nitrogen environment.

3. Smart precision sensing optical tools (SE, RS)
Smartonics developed the novel optical tools and methodologies for the in-line monitoring of the optical properties, thickness and quality of OE nanomaterials (polymers, small molecules, plasmonic NPs, barrier nanomaterials) and architectures. The partners have developed two sets of novel optical sensing tools consisting of ultra-fast Multi-Wavelength (MWL) Phase Modulated Spectroscopic Ellipsometer (SE) in 32 specific photon energies at the 1.46-6.5 eV spectral region, and a robust Raman Spectroscopy (RS) tool.
The one set of SE and RS tools has been adapted on the R2R printing pilot line in a dedicated metrology chamber using a specially designed moving platform. The both SE and RS techniques can measure at the same position at the center of the moving web, whereas the entire platform has the capability to move in the perpendicular direction and scan the entire width of the roll (30 cm). The in-line SE unit has been adapted on the r2r system on a moving stage and is focused on the polymer roll surface with an angle of incidence of 70° towards the detection head, which consists of the analyzer, the MWL unit and the detector.
During the project, the partners have faced and overcome several challenges related to the stability of the moving web roll in the measurement position, and the investigation of the effect of potential vibrations (and their elimination) in order to acquire accurate spectra from the printed nanostructures on the flexible web roll. The measurement time can be reduced to <50ms for the entire MWL spectra whereas the developed modelling and analysis algorithms, can provide information for the films thickness (with nanometer scale precision), complex refractive index

over the visible-far ultra violet spectral region, electronic transitions, blend morphology and vertical distribution of the different phases (in the case of donor:acceptor blends).
Moreover, the developed in-line RS tool can provide information on the bonding structure of the printed nanomaterials in the R2R printing pilot line after the printing process. The information from the in-line SE and RS tools is of significant importance since it can contribute to the optimization of the printing process, detecting any printing inhomogeneities and ensuring that the printed nanolayers have the same thickness, morphology and optical/electrical properties over the whole printed areas.
Also, it is clear that SE can provide information on the quality of the printed nanolayers and shows clearly the appearance of delamination areas in measured/modelled spectra. This information is crucial since it can contribute to the optimization of the process, the reduction of the source materials and waste, as well as to optimize the fabricated OPV device efficiency and lifetime.
In the case of the OVPD pilot line, the in-situ optical tools were integrated on a dedicated metrology chamber that has been connected to the handler of the OVPD pilot line. The adaptation of the SE and RS tools has been performed by attaching their optical heads on the specially designed ports of the metrology chamber.
The SE tool has been connected in two optical ports in order to measure the optical properties of the samples at an angle of incidence of 70º in reflection mode. The RS tool (that also has the capability for PL measurements) has been adapted on the top part of the metrology chamber in order to measure the bonding structure of the deposited samples by laser light of normal incidence. Both SE and RS techniques measure to the same position of the sample (center) in order to extract accurate and combined information from the same location.
4. Smart precision fabrication tools
Smartonics revolutionized the fabrication of OE device architectures by large scale fabrication processes by developing novel precision fabrication tools and adapting them on the unique pilot lines. The partners have developed the ultra-fast pulsed laser system and processes for the patterning of the printed nanolayers with nanometer scale precision. The partners have determined the best laser parameters regarding the P1, P2 and P3 laser scribing processes for manufacturing OPVs. The r2r laser system, is equipped with two scanners, one emitting at wavelength 1064nm and the second at 532nm wavelength. In order to develop a functional OPV device, 3 scribing processes are needed (P1, P2, P3). Laser scribing process P1, P2, P3 allows the development of large scale patterning of OPVs on flexible substrates. These parameters were transferred to R2R process and a R2R laser process was developed for the fabrication of larger modules.
One the main achievements of the Smartonics project is the development of a novel inkjet printing system that has been adapted on a dedicated cabinet of the R2R pilot line at AUTh in order to print customized structures with high accuracy and speed on the moving web roll. The system consists of 6 print heads that can transfer to the web roll any design from different OE nanomaterials (e.g. active layers, Ag paste, etc.), whereas it has a dedicated registration system in order to ensure that the printed patterns will be located on the pre-defined positions of the web roll over the entire length, and to avoid misalignments that would lead to not homogeneous printed areas. Furthermore, the partners have developed all the necessary instrumentation and

automatizations (e.g. ink flow sub-systems, ink management system) in order to ensure that the inkjet printer can be adapted to any large scale fabrication R2R process line.

5. Smartonics Pilot Lines

During the Smartonics project, the partners have upgraded the existing R2R printing pilot line at AUTh with smart technologies and tools to enable the effective fabrication of OPV devices. This upgrade includes the following:
• Upgrade of gas sensors, inlets, cabling to enable printing operation under nitrogen environment
• Registration methods and systems in the printing and patterning systems to enable μm lateral accuracy on the process over large areas which will be compatible with large scale fabrication and production. Also, the partners have performed engineering, Integration and Qualification of Registration camera System
• Design and adaptation of dedicated metrology cabinet for the adaptation of the in-line metrology tools
• Upgrade of R2R Pilot Line with supporting systems for the adaptation of the R2R inkjet printer together with its subsystems, electronics, software and ink management systems.
• Ultra-fast pulsed laser laser system (ps pulses) for patterning OE materials adapted on the R2R pilot line

OVPD Pilot Line
Smartonics developed a unique OVPD pilot line, which has been installed at the AUTh site for the scalable fabrication of OE devices. This include the OVPD chamber system for the thin film and device deposition, the 6 source modules for the OVPD system, the automatic vacuum handler with the pre-aligner, the flipper and the hybrid load lock. Also, a metal deposition module (EDC), a metrology chamber that includes the in-situ precision sensing tools and a glovebox are included.

The operation of the OVPD pilot line for the fabrication of organic layers has been validated by the deposition of reference organic materials. OVPD is a highly scalable and unique deposition process that can provide high quality thin films with controllable thickness, morphology, surface/interface quality and performance. The partners AIXTRON, AUTh, and HZB have collaborated for the establishment of the process for the deposition of specific small molecule nanomaterials (CuPc, ZnOc, C60, CuI, MoO3, etc.) in single and multilayer (tandem) architectures.
The Smartonics OVPD pilot line is a world point of reference for the controlled fabrication of OPVs by in-situ optical metrology. In Smartonics, the partners HJY, OET and AUTh have designed and developed the novel optical sensing tools (SE, RS) and methodologies and they have adapted them on the dedicated metrology chamber that has been connected to the handler of the OVPD pilot line. The adaptation of the SE and RS tools has been performed by attaching their optical heads on the specially designed ports of the metrology chamber. These tools have been used to assess in-situ the quality of the OVPD deposited nanolayers with the target to optimize the OPV device performance and lifetime.

Pilot line 3: s2s Pilot line (in POLO-IAP) for the precision fabrication of OE devices (e.g. OLEDs, sensors from state-of-the-art nanomaterials) and for the evaluation of ALD encapsulation of these devices. This Pilot line is already installed at POLO-IAP and it will be used for the evaluation of the process parameter and for the process development (by upscaling the deposition procedure) for the different type of OE devices. This will allow the adjustment of the processing parameter for the r2r processes that will save both time and material in the production development.

6. Integration of smart nanomaterials and technologies in Pilot Lines for OPVs fabrication

Fabrication of small scale OPV devices: Part of the development for the transfer to pilot line was to demonstrate how the efficiencies would decrease with different processing conditions on a larger device scale, as reflected in the efficiency targets. The partner USUR has developed a lab based slot die coater which is able to produce mini-modules on the scale of 40 cm2 using very small volumes of ink (<0.3 ml per module). This gives a stepping stone to realise actual potential performance parameters, more realistic to devices being produced on the pilot line and allowing for processing conditions to be optimised at a lower cost that in the pilot line. The coating parameters optimization were been completed for the production of mini-modules on glass and PET, and the associated losses compared to small devices were catalogued. This allowed for the production of modules using the up-scaled PCDTBT synthesis undertaken by UOP.

Fabrication of printed OPV devices: The polymer-based OPV devices that were developed in Smartonics have inverted architectures. Commercial available PET/ITO substrates were used for the printing of the OPV nanomaterials and devices. All layers were coated with slot die except from Ag electrode that was printed with inkjet printing.
For the patterning of the substrate, instead of chemical etching used for S2S processes, the laser scribing process has been implemented with the ps ultra-fast laser that has been installed on the R2R pilot line.
The steps for manufacturing OPVs with R2R Pilot Line are: a) Coating of ETL and simultaneously P1 laser scribing, b) Coating of photoactive layer, c) coating of HTL, d) Printing of Ag electrode. Different formulations and thicknesses were tested by AUTh for each layer separately. The different Smartonics project materials combination and commercial available materials for manufacturing the photoactive layer were tested. The materials used as photoactive layers include P3HT, PCDTBT as electron donors and PC60BM, PC70BM and ICBA as electron acceptors.

The parameters developed were transferred and tested for printing 8 stripes interconnected modules. The photoactive blend P3HT:PC60BM, has been used for the most tests with the r2r pilot line in order to ensure the stability of the process and the fabrication of devices with well-known performance. Modules of 8 stripes and ~70 cm2 native area and ~50 cm2 active area were printed in a fully R2R printed process according to the parameters that have been defined for the R2R printed single cell devices.

In the case of the small molecule OPV devices, Smartonics developed the process for OVPD fabrication of OPVs that implements the following nanomaterials: Electron Donors: CuPc, ZnPc, Acceptor: C60, HTL: MoO3, CuI, Buffer: Ca, Mg and metal Cathode: Al, Ag.
The structures for small molecule OPVs have already been investigated and optimized at the VTE system at AUTh and at the VTE & OVPD System at HZB (WP3) in lab scale with the collaboration of AUTh & members. Thanks to the high precision, uniformity and the reproducibility that the OVPD technique offers, the fabrication process becomes absolutely scalable to larger active areas.
After the first installation phase, the OVPD System at AUTh was able to deposit only single (bilayer) structure OPVs without HTL & ETL. The OPVs that were fabricated by AUTh were functional.
Finally, the Smartonics achievements in terms of the OPV device efficiency are shown in the following table.
• Best OPV Cell (s2s)= 8.01%
• Best OPV module (s2s)= 5 %
• Best OPV Cell (R2R) = 5.36%
• Best OPV Module (R2R) = 3.51%
• Best OPV Cell (OVPD) = 4.0%

7. Implementation of OPVs to Automotive applications
The performance and applicability of the Smartonics OPV devices on commercial applications has been evaluated by their implementation on automotive components, which include a semi-transparent solar roof with curved form factor adapted on a commercial Fiat car (Fiat model 500L®). The OPV modules have been developed by OET through a fully printed fabrication process using the R2R pilot line at AUTh. These were encapsulated by barrier nanolayers from POLO and were injection moulded with polymer sheets with specific interconnects and circuitry to enable combined operation of harvesting solar energy in real environment.
The main aim of this solar roof is to demonstrate the feasibility of using OPVs in automotive and increase the TRL of the technology by forcing the OPVs to face a real challenging application. The possibility for the customer to substitute the panels can compensate the limited lifetime if the cost of the solar panel can be competitive. The innovative solar roof was assembled with OPV panels manufactured by OET and installed by CRF. The system is coupled with a specific air conditioning system to demonstrate the use of the solar roof as an auxiliary energy system that can power internal components of the automotive.

The testing of the OPVs modules has been performed according to automotive requirements. The Smartonics OPVs can withstand automotive tests for exterior applications (very harsh conditions) and they show good resistance to UV and humidity environments. The delamination from the polymer sheet is greatly reduced. The extension of the OPV lifetime has been achieved thanks to the developed barrier layers, whereas the proper selection of materials have increased the OPVs lifetime.
The solar roof can deliver 12W at 18V that is enough to power the cooling device. However the

system is just the first prototype and it is not optimized. The solar modules have a PCE of 3% but OET has demonstrated that the target of 5% is achievable. Moreover the surface coverage can be largely improved. CRF calculation shows that 90W nominal power is feasible. If this target can be confirmed and the price of the solar modules can be reduced, (<150€/m2) there is room for application on electrical and hybrid vehicles, starting from 2018-2019.

Potential Impact:
1. Potential Impact
The Smartonics results and innovations are expected to have a strong impact in EU in multiple levels, including Science and Technology of OE devices, Computational Modelling approaches, Metrology tools, Manufacturing of OE-enabled innovative products for a wide range of applications, and consumer products. The expected results of Smartonics include the following:
Smart Nanomaterials
• The Smartonics nanomaterials (P3HT, PCDTBT, ICBA, ICMA) will significantly enhance the performance of OE devices (OPVs, OTFTs, OLEDs, etc.) by enabling the exact control of their functionality based on the sophisticated and effective synthesis methods, that can be upscaled in order to provide large quantities of materials for high volume and large area manufacturing processes.
• The concepts for materials synthesis have the potential to be implemented for the up-scale and versatile methodology for several other classes and combinations of functional polymer, copolymer and hybrid nanomaterials
• Availability of high volumes of electron donors and acceptors by the Smartonics partners (UOXF, Advent, UOP) for commercial exploitation
• Strongly increase of the competitiveness of the Smartonics partners to play a leading role in EU and world market as suppliers of source materials and solutions for several OE devices
• New concepts of theoretical and computational approaches (from Ab Initio and DFT to compact modelling for devices) that will strongly contribute to the establishment of structure-property relationships and the tailoring of properties, composition and nano-morphology of several nanomaterials classes. This know-how will be transferred to other nanomaterials to enable the improvement in the efficiency of OE devices of different layer architectures.
• The developed simulation and analysis tools and software have the potential to be commercialized in order to provide to Academia and Industry the tools to optimize the OE device manufacturing processes.
• The establishment and upscaling of the laser synthesis process of plasmonic NPs (excimer, ps, ns) with controllable sizes and distributions will revolutionize the availability of plasmonic NPs from different nanomaterials (e.g. metals) and will open the way for their functionalization and implementation to other OE devices. The incorporation of customized plasmonic NPs to different parts of the OE device architecture that is expected to increase the performance of the active layers and the transparent electrodes of OE devices.
• The commercial Smartonics partners will be able to demonstrate their outstanding work and become more competitive in the market.
• The developed super barriers with global barrier response of 10-5 cm3/(m2dbar) (g/(m2d)) for O2 (H2O) permeation and high shelf lives and compatibility to large scale r2r processing will

enable the encapsulation of several r2r processed OE devices (e.g. OPVs, OLEDs for display and lighting, etc.). Also, it will open new market opportunities for European manufacturers in new low cost, high volume and high throughput r2r manufacturing processes for encapsulation materials. The project partners already have explored the potentiality to provide commercially barrier nanomaterials on-demand and pilot-scale delivery of customer adapted nanomaterials and barrier films.
• The innovations of long self-life barriers will enable the long-distance shipment of large lacquer amounts to industrial partners for pilot trials or production trials, industrial consulting and will lead to know-how transfer to other lacquer systems, and their implementation in new applications (UV stabilization coatings, abrasion resistant coatings, antibacterial, etc.)
• The innovations on nanomaterials will open new scientific subjects for the optimization of the device architectures to meet the market demands for high quality OE devices. Also, the novel concepts on the materials synthesis, the understanding of the structure-properties relationships (e.g. understanding of the experimental factors that affect and define the morphology the electronic structure and the HOMO-LUMO levels) and thin film fabrication by R2R printing and OVPD techniques will enable the discovery of new nanomaterials and device concepts.
• The controlled small molecule layers in single and multilayer form by OVPD will result to the establishment of optimized process parameters for the fabrication of tailored small molecule semiconductor layers by OVPD will enable the fabrication of high performance OE devices (such as OPVs, sensors, biosensors, OLEDs for display and lighting, RFIDs, etc.) with high production yield and high reproducibility. Moreover, the results will be also extended to other vacuum processes.

Smart Tools
• The Smartonics precision optical sensing tools (SE, RS) will revolutionize the manufacturing of OEs and other devices (e.g. perovskites, electronics, sensors for IoT) by enabling robust in-situ and in-line monitoring for the precision synthesis of nanomaterials and fabrication of OE devices with tailored properties and quality control, with flexibility for adaptation in different pilot and industrial processes (large scale vacuum, R2R/S2S printing, OVPD, CVD, PVPD, ALD, liquid phase, etc). The detailed feedback such as film thickness, lateral and longitudinal uniformity, roughness with Å scale accuracy, optical characteristics (e.g. band gap value with meV accuracy) and characteristic bonding structure with ±1 cm-1 accuracy of the nanomaterials provided in ms, will enable the accurate quality control of the nanomaterials by providing information on very small deviations in nanomaterials properties during processing, which can significantly change the properties and efficiency of the whole device and the final product in industrial scale.
• The in-line and in-situ optical tools will enable the automatic feedback and control of the manufacturing processes (R2R Printing, OVPD, PVPD, CVD, ALD, etc.) in order to increase the process yield, the quality and homogeneity of the nanomaterials and devices, to significantly reduce the material and energy consumption during the processes, and to eliminate any defective batches, that could potentially jeopardize the commercialization of the products. Smartonics will have a significant impact on process control by establishing a flexible, cost-efficient, integrated sensing tool that is estimated to give yield and device efficiency improvement

of above 95% and 40%, respectively.
• Establishment of new collaborations between the Smartonics partners and other entities from the entire value chain to exploit the benefits of in-line optical metrology for manufacturing processes.
• The commercial Smartonics partners related to the optical sensing tools (HJY, OET) will be able to demonstrate their outstanding work and become more competitive in the market.
• Establishment of new H2020 and national projects with Smartonics partners and others for optical metrology of other nanomaterials and devices (e.g. perovskites), and founding of new start-up and spin-off companies specialized on optical metrology tools and methodologies.
• Release of new laser systems for nanomaterials structuring to provide nm-scale precision patterning of a huge variety of nanomaterials.
• The integration of ultra-short pulsed laser tools for patterning of OE nanolayers and devices guarantees the highest efficiency and throughput with the best possible precision and minimal material damage. Because of the very short exposure time, almost all of the energy can be used for material ablation resulting in almost non-thermal material removal. By laser patterning, very fine feature sizes and accurate edge profile control of single organic (e.g. P3HT:PCBM) and inorganic (e.g. ITO) or subsequent layers (e.g. PEDOT:PSS/P3HT:PCBM bilayer) in large areas and with high process speeds (up to 20 m/min) can be obtained. By laser processing an edge profile improvement of 30% in width and 70% in height for e.g. ITO can be achieved in comparison to the conventional wet etching process. This will ensure the elimination of defects and shorted modules fabrication and increases the efficiency.
• The Smartonics laser patterning systems and process offer an “on-the-fly” accurate patterning tool without stopping the winding process with reduced production steps supported by a fully automated control system. Therefore, the advances in precision fabrication tools for laser patterning will have a major impact to the fabrication of OE nanomaterials with customized structures, increase of the OE devices performance, and replacement of other conventional patterning techniques such as the aforementioned chemical etching. The integration of laser systems to r2r machines will lead to the reduction of production costs and to the increase of process yield.
• The Smartonics inkjet printing tool will revolutionize the R2R fabrication of OE devices by offering a robust and accurate solution for inkjet printing of customized structures in high volumes and large areas.

Pilot Lines
• The development of unique pilot lines (OVPD and r2r printing) with precision sensing and fabrication tools and processes will have a major impact to the European Industry since this know-how will be applicable to several technological and industrial sectors and will enable the penetration of flexible OEs to new markets (niche, established, high volume).
• The upgrade of the existing machines (e.g. for fabrication of displays) with precision sensing and fabrications tools will boost the product quality and the process throughput and will reduce significantly the fabrication costs. This will open the way for the precision synthesis of knowledge-based smart nanomaterials with tailored properties and superior performance for several applications in energy, electronics, photonics, nanomedicine, nanobiotechnology, etc.

That is since the deep understanding and the establishment of the structure-properties of the Smartonics nanomaterials will be also applicable to other nanomaterials. The optimization of materials which can be deposited by large-scale process with enhanced performance and stability, will lead to shorter and less-expensive R&D cycles.
• The Smartonics pilot lines will transform the EU Research and Industrial ecosystems by providing open access solutions to interested EU Industrial entities to develop OE enabled innovative products and to solve fundamental problems that currently limit their commercialization (e.g. cost, quality, lifetime, etc.). These pilot lines will become a one-stop-shop solutions for SMEs to provide services for materials and device development based on OE and other concepts.
• The Smartonics advances in precision sensing and fabrication tools and R2R printing and OVPD processes will optimize the fabrication processes that will lead to reduction of lab-to-market time of OE devices by more than 50%. Also, it will enable the more efficient source material consumption that will lead to the reduction of process costs. That is since the special design of systems and processes combined with advanced control tools, will have the potential to significantly reduce the manufacturing cost of the device relative to the conventional approaches used in the industry. This manufacturing cost reduction by adopting advanced process of both printing and vacuum technology lines could have a profound impact on the OE industry by not only transforming the manufacturing infrastructure, but also by permitting flexible electronics to penetrate new markets.

OPV devices
• The innovations of Smartonics in the fabrication of tailored OPV modules by OVPD and r2r printing processes in combination with precision sensing and fabrication tools, will extend our knowledge on the mechanisms that take place during the fabrication of simple and complex (e.g. tandem) OPV device architectures. This will enable the optimization of the device architectures and the increase of the OPV performance and stability above 15% and 15 years, respectively. The reduction of production costs and increase of production yield for OPVs will lead to their wide market exploitation contributing to the reduction of fossil fuel emissions from the industrial and domestic sections. Finally, their low-cost and large scale industrial exploitation will enable their integration to several other commercial products, improving the quality of life.
• Integrated OPVs for automotive applications are a promising market segment. Besides semi-transparency, integrated applications require a reasonable transparency perception and good color rendering properties in order to be suitable for realistic scene illumination in combination to weight reduction, reduction of fuel consumption and preservation of the environment.
• The developed OPV modules will be applicable for a huge spectra of consumer applications in buildings, agriculture and greenhouses, energy solutions, wearables, architecture, Internet of Things, portable devices, sports and leisure, aerospace, transport, food packaging, bioelectronics, medicine, etc. Already the Smartonics partners have explored most of these approaches by new collaborations, development of consumer products and new projects.
• Increase of the competence of the Smartonics SMEs, which will gain competitive advantage in their sector through the Smartonics achievements. By this way they will enter into a long-term market of several B€.

The contribution of Smartonics to wider societal aspects includes the following:
• Improvement of employment prospects: Smartonics has a strong impact in the increase of employment to many scientists across the consortium partners and to related entities. The advances of Smartonics innovations in nanomaterials, technologies, pilot lines and OE devices will contribute to the increase the employment aspects of European Industries contributing to the increase of Europe’s economic growth.
• Increase of the number of scientists & researchers: The scientific and technological subjects of Smartonics will open the way for the increased participation of a higher amount of students to work with cutting-edge subjects. Also, the extensive dissemination plan of Smartonics (that involves numerous Conferences, Workshops, Summer Schools, and training sessions) will contribute to this direction.
• Increase of the mobilization of scientists and researchers since several researchers worked in Smartonics have increased their technical - managerial skills, expertise and competences by interacting and disseminating the project results.
• Improvement of the quality of life, health and safety of EU citizens by the improvement of the industrial production processes for OEs by robust in-line metrology and computational modelling optimization, which will boost the process yield and reduce significantly the resource consumption and radiative & substance emissions. This will also will benefit the environment and will reduce the carbon fingertip of the relevant industrial sectors, in combination to the achievement of better health, safety & quality of working conditions of EU workers and citizens.
• The wide market implementation of OE devices (OPVs, OLEDs, sensors, etc.) as well as of integrated OE devices in several consumer products will improve the quality of life by the immediate availability of low-cost solar-powered portable devices (laptops, tablets, mobile phones, sensing units, displays), conformable OPV modules for adaptation onto complex shaped objects (such as roofs, tents, textiles, automotives, luxury goods), and of other OE products.

2. Main dissemination activities

The main tool for the dissemination of the project results is the Smartonics website (http://www.smartonics.eu). The website has been constructed and uploaded on-line since the beginning of the project (month 1). This website will remain on-line after the end of the project and it will maintained by the Smartonics coordinator (AUTh) with support from its own resources. It will be updated regularly, whereas it will advertised in every dissemination activity performed in order to become the point of reference for the successful activities of Smartonics in developing the smart nanomaterials, tools and unique pilot lines for Organic Electronics.
The visibility of the project website is evident by the number of the visitors that have been visiting its pages requesting for information. The visitors traffic of the website pages have been monitored since the beginning of its operation, using the commercially supplied counter service StatCounter (http://statcounter.com).
The distribution of the visitors of the website over the world countries are shown in the following figure. Although the majority of the visitors come from Europe, it is clear that the project activities have attracted the interest from visitors coming from USA, India, China, Japan and Australia.

The total numbers of visitors of the website during the recording time of the website traffic, are shown in the following figure. It is clear that almost 17.700 page loads have occurred, from 5977 unique visits, 4796 first time visits and 1613 returning visits. Finally, it has to be mentioned that the Internet Protocol addresses of the AUTh staff are excluded from the Statcounter monitoring process.
The Smartonics dissemination activities are described in detail in the Deliverable 13.4.

The ISFOE and the whole NANOTEXNOLOGY multi-event were the main means for the dissemination of the Smartonics activities, in which the partners have presented their activities and achievements related to the project. In the following figure, the numbers of participants for the different events during the duration of Smartonics are provided. The number of participants in ISFOE the period 2013-2016 are in the order of 160-207 whereas the number of the ISSON summer school students that attended the presentations from the Smartonics partners are in the range of 130 students.
3. Exploitation of Results
The Smartonics partners have performed significant activities during the implementation of the project in order to exploit the generated results and to increase the impact of the project innovations. These activities are described in detail in the previous section. In addition, the partners have prepared a strategic plan for the future exploitation of the innovations in order to ensure the sustainability of the Smartonics technologies and pilot lines, as well as to extend the developed nanomaterials, models, tools and processes to other OE devices (e.g. OLEDs, OTFTs, etc.).
The above activities will underline the partners leading position worldwide on the research and manufacturing landscape of OE devices.
Some of the aspects of the exploitation of results include the following:

Nanomaterials (polymers, small molecules, plasmonic NPs, barriers)
• Upscaling of Smartonic nanomaterials in large quantities to meet the demands for large area processing
• Up-scaled Preparation of Monomers via direct coupling and single Polymerization Batches of more than 15 g scale using larger pilot reactors
• Implementation of the up-Scalable & versatile methodology for other polymer, copolymer and hybrid nanomaterials
• Large scale fabrication of electron acceptors (ICBA, ICMA, PC71BM, etc.) for commercial exploitation
• Upscaling of the laser based synthesis of plasmonic NPs with controllable sizes and distributions and implementation to other OE devices
• Implementation of novel nanomaterials in OPVs and other OE devices (e.g. graphene)
• Further investigation will be carried out regarding the high Mn method
• The commercial partners will be able to demonstrate their outstanding work and become more competitive in the market
• The connections with international entities (e.g. Advent Technologies Inc. CT, USA) will give us the ability to approach new customers, partners for other research projects and demonstrate our

credibility in OPVs
• Scientific exploitation of results ranging from polymer semiconductors to barriers
• short Courses on Permeation Barriers, Invited Conference presentations
• new EU H2020 funded projects between Smartonics partners and others
• Pre-commercial exploitation:
• demonstration of technology (barrier performance ⇔ proof of technology),
• barrier film for device development,
• reference material for device customers and barrier film makers
• pilot-scale delivery of customer adapted nanomaterials and barrier films
• attracted interest of adhesive suppliers in EU
• Long self life barriers: long-distance shipment of large lacquer amounts to industrial partners for pilot trials or production trials, industrial consulting know-how transfer to other lacquer systems, ORMOCER® in large-area coating new applications (UV stabilization coatings, abrasion resistant coatings, antibacterial, etc.)
• Computational modelling:
• Implementation to other nanomaterials and systems
• Commercial exploitation of simulation and analysis tools and software

Precision Tools
• Optical sensing Tools
• Scientific publications, Patents, Presentations in Conferences
• Development of concepts for optical data acquisition on other manufacturing processes
• New H2020 and national projects with Smartonics partners and others for optical metrology of other nanomaterials and devices (e.g. perovskites)
• Services for SMEs and Industries
• Implementation of optical tools to other processes
• Demonstrators for customers of precision sensing tools
• Potential OEM Partnerships between the partners (OET, HJY. Aixtron, COA)
• Promote HJY capabilities of In-Situ and R2R Process control
• Provide experience on emerging nanomaterials
• Potential cooperation (for materials – machines and special tools)
• Laser patterning tool and process
• New patterning techniques and processes for OPV, OLED, OTFT device fabrication
• Scientific publications, Patents, Presentations in Conferences
• Marketing and Commercial exploitation of laser systems for nanomaterials structuring (e.g. A-Series FLEXeLASE, J-Series for ultrafast lasers)
• Networking/Promotion/Distribution channels with existing/new industrial customers RTO/academics; keeping close contact with activities of 4x UK Centres-of-Excellence Research Centres in Organic Electronics (CPI, CIMLAE, WCPC, Imperial College) and other COLAE centres Holst, IMEC/Ghent, AUTh
• Industrial partners to EPSRC, CIMLAE large area electronics centre Cambridge (5 year programme), installed laser machine major research centre in Holland
• Sales team actively promoting new technology, constantly looking for commercial opportunities.

• Inkjet printing system
• InkJet sub-system supplier to R2R machine integrators
• Scientific publications, Patents, Presentations in Conferences
• Further develop a modular system for easy and flexible setup
• Approach established Printing companies for adding smart OE in their R2R printing machines
• Collaborate with other Smartonics partners and other experts in order to propose smart packaging to selected customers
• Collaborate with a Greek toy manufacturer for the design and development of smart toys based initially on the inkjet printing of conductive ink

Pilot Lines
• Open Access of the Smartonics pilot lines to interested Industrial entities to develop OE enabled innovative products
• One-stop-shop solutions for SMEs to provide services for materials and device development based on OE and other concepts
• Participation
• Scientific publications, Patents, Presentations in Conferences
• Fabrication of printed OPV devices and modules
• New processes for other OE devices (OLEDs, OTFTs)
• Concepts for integration of optical metrology tools
• Adaptation of in-line metrology tools for quality control
• Combination with other processes for OE devices and other nanomaterials (e.g. CVD, ALD)
• Commercialization of the pilot line concept with interested customers
Devices
• Patents and Publications to be published on specific topics
• Presentations on International Scientific Journals (single, common)
• Integrated OPV Devices to consumer products (e.g. Greenhouses, Automotive, packaging, other products)
• Establishment of the Center for Organic & Printed Electronics (COPE-H)
• Collaboration with Networks, Clusters – HOPE-A (e.g. JAPEC, AFELIM, COPT, OE-A)
• NANOTEXNOLOGY Event as a platform for dissemination & networking
• Further collaborations with Smartonics academic partners for common scientific subjects
• Bilateral collaborations with Industrial partners (Greece, EU, USA, Asia)
• Further collaborations with Smartonics partners for H2020 & Bilateral projects
• Follow-up H2020 projects with other partners
• OLEDs: Technology transfer of OLED processing from pilot to industrial scale to customer
• Application evaluation services for barrier film makers, substrate makers, adhesive makers, active material producers
• Demonstrator devices for end-users
• Implementation of Smartonics solar roof in Fiat automotives
• This can be installed on specialties firstly as an optional
• Fiat has a fleet of Electric 500 has been created to connect the CRF’ s headquarter in

Orbassano and FCA Mirafiori Plant. Potential implementation in some of the fleet cars to contribute to the reduction of pollution due to the frequent movements of employees but also the collection of information on daily electrical mobility.

List of Websites:
The main tool for the dissemination of the project results is the Smartonics website (http://www.smartonics.eu). The website has been constructed and uploaded on-line since the beginning of the project (month 1). This website will remain on-line after the end of the project and it will maintained by the Smartonics coordinator (AUTh) with support from its own resources. It will be updated regularly, whereas it will advertised in every dissemination activity performed in order to become the point of reference for the successful activities of Smartonics in developing the smart nanomaterials, tools and unique pilot lines for Organic Electronics.
The main target of the website is to promote the mission and goals of the project and to inform the society on the activities and achievements of the project. The following Figure shows the main page appeared during the loading of the website. It is composed by the main logo (top part) indicating the project title and acknowledgements to EU for funding, together with the project logo and the flag of European Union.

AUTh has developed a secure area, within the website, that has been used for internal communication between the partners and for the distribution of confidential documents that are difficult to be sent by email messages. Moreover, the secure area will be used for the internal communication and announcement of confidential information regarding the activities, and the meetings.

The secure area of the Smartonics website include information on the
• Project documents (e.g. updated DoW)
• Templates/reports/presentations
• Consortium and Technical Meeting Presentations & Minutes
• Dissemination Kit (flyer, public presentation)
• Deliverables
• Reports

Related documents

final1-smartonics-photos-images.pdf

Last update: 9 May 2017
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