

# i-FLEXIS NEWSLETTER

# 5.



march 2016

## i-FLEXIS

Integrated flexible photonic sensor system for a large spectrum of applications: from health to security

[www.iflexis.eu](http://www.iflexis.eu)



The project is co-funded by the European Community under the Information and Communication Technologies (ICT)



# 1. SCIENTIFIC CORNER

Scientific results and deliverables between October 2015 and March 2016

i-FLEXIS is at its final stretch and in this last period the combined efforts of all partners are focused on the integration of the different building blocks and overcoming the difficulties of combining organic and oxide materials to allow the effective demonstration of the i-FLEXIS system for luggage ID tags, health radiation dosimeter and bone density analyzer applications.

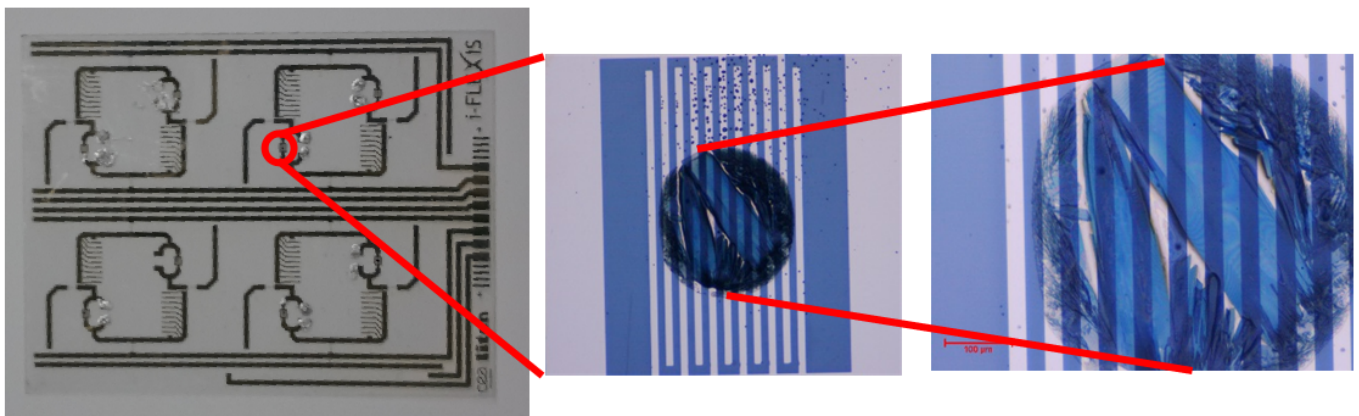
## 1.1 Scientific Results

### OSSCs

Organic semiconducting single crystals (OSSCs) represent the active core of the X-ray sensing concept of i-FLEXIS. Having these materials deposited by additive methods as printing enables a more controlled deposition and low-cost upscaling of the technology.

### Printing processes

Thanks to a printing technology currently filed for patent by UNITS, it is possible to inkjet print ink formulations that originate TIPS-Pentacene crystals directly onto interdigitated electrodes and active matrices prepared by CEA, with a positioning precision of a few tens of microns. The printed crystals are currently being tested for X-rays response at UNIBO.



*Figure 1: Inkjet printed TIPS-Pentacene crystals on the interdigitated electrodes of an active matrix.*

### Inkjet printable inks upscale

Scaling up of well-established laboratory experiments is a fundamental step in the realization and optimization of an idea. In this view UNITS and NANO collaborated to develop a scale up process, based on the know-how accumulated in the various phases of the i-FLEXIS project related to the formulation of the inks to be used as precursors of the crystals. This happened by a constant exchange of materials and information between consortium partners, in charge of crystal growth, inks development, preparation and their scale up.

In particular, the scale up procedures regarded printable inks containing the precursors of OSSCs and inorganic nanoparticles (NPs) suitable for coupling to the OSSCs, with the objective of increasing the X-rays detection performances of the OSSCs-NPs assembly. The inks preparation was carried out keeping in mind the final potential uses in industry, hence pre-industrial approaches (i.e. a large lab scale of several 100 g of product) have been considered. For the design of the scale up and the production at pre-industrial level so called "move tickets", were prepared, and prospected production costs were calculated. With this WP2 developments i-FLEXIS is ready for ink production at pre-industrial scale and it would be possible to produce first test batches with larger amounts.

### Active matrices for HD Sensor

Active matrices and readout circuits are another fundamental component of the i-FLEXIS demonstrators and their first generations using organic and oxide electronics were already developed by CEA and UNINOVA, respectively, both on glass and foil. Integration tests with OSSCs are ongoing, in parallel with the design of new generation matrices for improved performance levels.

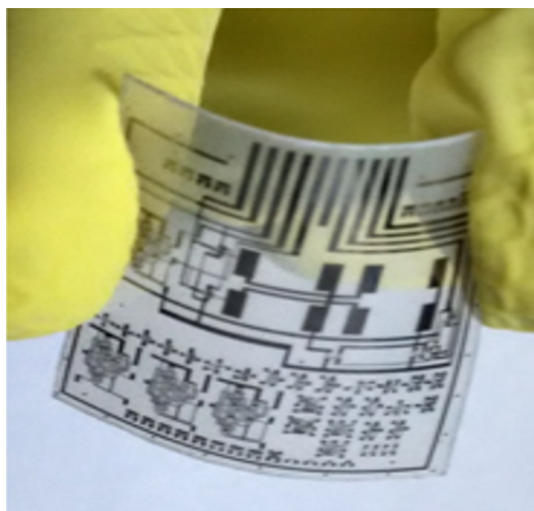


Figure 2: 1<sup>st</sup> gen flexible oxide-based backplane fabricated by sputtering

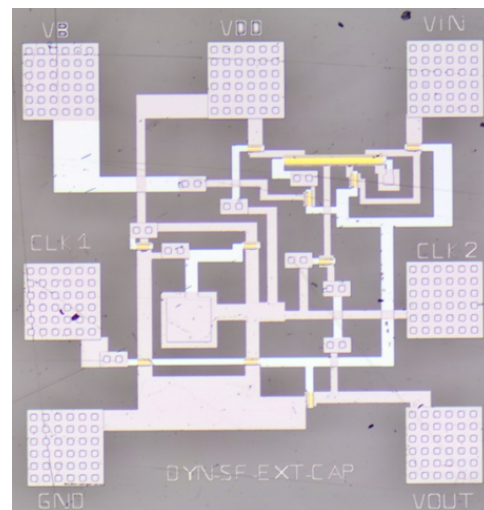


Figure 3: Micrograph of a building block of an oxide-based backplane

### IDtag test vehicle

UniCA is responsible for the fabrication of an active pixel, providing

- i) polarization of the i-FLEXIS plastic X-Rays sensor,
  - ii) memorization of one bit, indicating the occurrence of the X-Ray exposure event,
  - iii) generation of a related signal driving the TAGSYS RFID Tag (figure 4-5).
- The circuit, which employs the standardized TIPS-pentacene based OFETs developed by UniCA, has been completely designed and simulated, thus proving the effectiveness of the results. First prototypes have been fabricated and tested in collaboration with UNIBO. Preliminary results demonstrated that the proposed approach is feasible; assessment of the circuit performance in terms of retention time is currently ongoing.

In parallel, a Printed Board Circuit microcontroller card was developed and manufactured by TAGSYS to demonstrate the feasibility of the integration of the i-FLEXIS X-Rays sensors with TAGSYS RFID technology. The PCB IDTAG can:

1. Condition and amplify the electrical signal delivered by the organic crystals sensor under exposure to X-Ray photons in order to digitize it;
2. Digitize the analogue low-impedance signal in the range 0 to 3 V;
3. Backscatter the incident RFID interrogation signal using the digitized sensor signal.

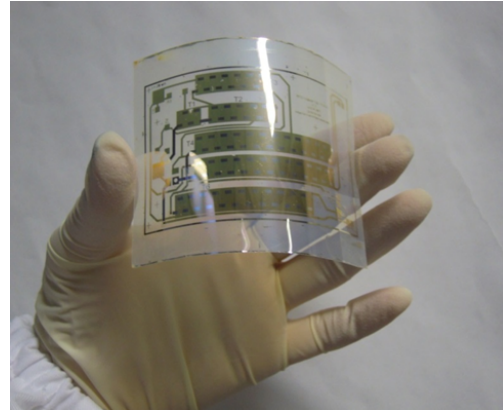
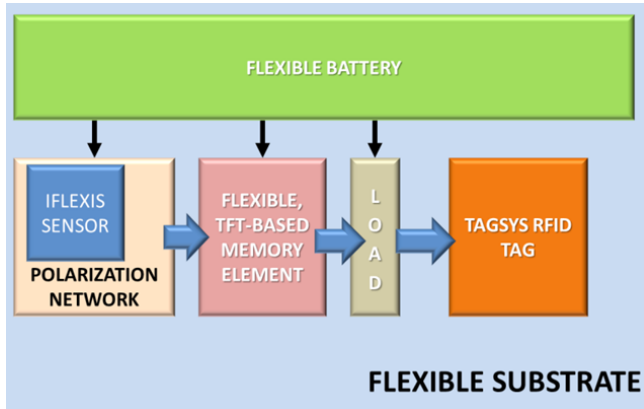


Figure 4: Block diagram of the flexible IDTAG      Figure 5: Fabricated IDTAG prototype

## Wearable X-ray detector

*Wearable X-Ray detector* is a new demonstrator developed by BIOAGE in the i-Flexis research project. It reads the signal of the crystal used to detect the X-ray magnitude, the acquired measurements are transmitted by means of a 2.4GHz RF wireless transceiver to a remote receiver that is connected by USB to a PC for data reading, saving and processing. The wearable tiny demonstrator can be placed on the user's arm. The electronic circuit is flexible and can be folded back on itself. Thanks to this approach the geometrical space required by the electronic circuits has been halved. The result is a wearable plastic case very similar to a technological armband, as it is possible to see in the pictures below. The demonstrator is powered by an internal tiny Li-Ion rechargeable battery, this battery can be wireless charged by means of a RF field.



Figure 6: Circuit folded inside the case



Figure 7: Wearable X-Ray detector



Figure 8: Device worn on arm



## 1.2 Deliverables and Milestones

Now that WP2 (OSSCs growth and characterization) and WP3 (Building the Photonic sensor unit subsystem) were finalized, three new deliverables were submitted and one milestone was reached, between month 24 and 30:

- D2.3 – Report on the characterization of inkjet printed OSSCs photoresponse (M28)
- D2.4 – Protocol for pre-industrial inks formulations for OSSCs direct printing processes (M30)
- D6.2 – Design and Integration of the iFLEXIS system into the IDtag application. Report on the test vehicle characterization and technical specifications (M26)
- MS6 – i FLEXIS technology test vehicle for application 1: luggage ID tags (M26)

## 2. MEETINGS

Main outcomes from 5<sup>th</sup> GA, announcements for 6<sup>th</sup> GA

### 5<sup>th</sup> General Assembly, October 2015

The 5<sup>th</sup> general assembly was held in Trieste, Italy, during October 15<sup>th</sup> and 16<sup>th</sup> 2015. It was hosted in the Savoia Excelsior Palace Hotel by UNITS. A significant progress towards reaching the specifications of the final OSSCs to be used in the demonstrators was shown, which was imperative to adjust all the electronics design. First generation addressing and readout electronics were presented and modifications required for next generations were defined. Structure, topics and organization of the 2<sup>nd</sup> workshop and school of the i-FLEXIS project were defined.



### Upcoming meetings

Given the focus on integration and electronic test of the i-FLEXIS demonstrators in this last period, the 6<sup>th</sup> GA will be hosted by Bioage in Lamezia on April 14-15<sup>th</sup> 2016.



Our final newsletter, out in October 2016, will describe conclusions from this meeting and summarize the main achievements of the i-Flexis project. A final project review meeting will be held in Brussels at the end of the project (date TBA).

## 3. TRAINING ACTIVITIES

### Student and researcher exchange program

As in the other periods of i-FLEXIS project, a very active exchange program between researchers and students from the different partners has been taking place during M24 and M30. At this stage, and extending towards the last 6 months of the project, the activity has been mostly focused on the improvement of solution processed oxide layers for integration in the last generation of an i-FLEXIS demonstrator. Envisaging the application of the x-ray sensors platform in real-world environments, detailed stress measurements under illumination of the oxide electronics was also investigated under this exchange program. Work being developed under this period is integrated on three MsC and one PhD dissertations.

- 1 – UNIBO to UNOVA (December 2015-February 2016) – Illumination and hot carrier stress on IGZO and ZTO TFTs
- 2 – UNIBO to UNOVA (February-July 2016): Synthesis of solution based tin oxide for semiconductor layer in TFTs
- 3 – UNITS to UNOVA (February-July 2016): Development of GIZO semiconductor ink formulation and printing
- 4 – UNITS to UNOVA (March-July 2016): Development of AlO<sub>x</sub> dielectric ink formulation and printing

## 4. DISSEMINATION

### 4.1 Workshops and Schools

#### **2<sup>nd</sup> i-FLEXIS Workshop and Spring School at E-MRS Fall 2016**

Having in mind the success of the 1<sup>st</sup> i-FLEXIS Workshop and Spring School at E-MRS Spring 2015 due to the numerous audience and wide range of research fields covered by E-MRS Spring Meetings, the 2<sup>nd</sup> workshop and the 2<sup>nd</sup> spring school of i-FLEXIS will be held in this year's Fall event, between September 19<sup>th</sup> – 22<sup>th</sup> 2016 in Warsaw, Poland.

More information on these events can be found at

<http://www.european-mrs.com/meetings/2016-fall> and

<http://www.iflexis.eu/index.html>

## 2<sup>nd</sup> i-FLEXIS workshop

The workshop will be in the form of a symposium entitled “Flexible Electronic Sensors”

Hot topics to be covered:

- novel materials synthesis
- novel device architectures
- novel sensing applications
- device modelling
- device biasing and readout circuitry
- sensor systems

### Organizers:

- Beatrice Fraboni
- Annalisa Bonfiglio
- Elvira Fortunato
- Roisin Owens

Selected papers from the symposium will be published in special issue of a prestigious journal, to be defined shortly.

## 2<sup>nd</sup> i-FLEXIS spring school on “Organic Semiconducting Single Crystals: from fundamentals to advanced devices”

The spring school will be held during E-MRS Fall 2016. It aims to provide an introduction on the fundamental aspects and a broad overview on the major issues related to material synthesis, crystal growth, device fabrication, various experimental characterization methods and modeling that reveal the intrinsic electronic and photonic properties of organic semiconductors. Speakers from the consortium and also some external invited speakers will cover topics ranging from materials and devices to fabrication and applications.

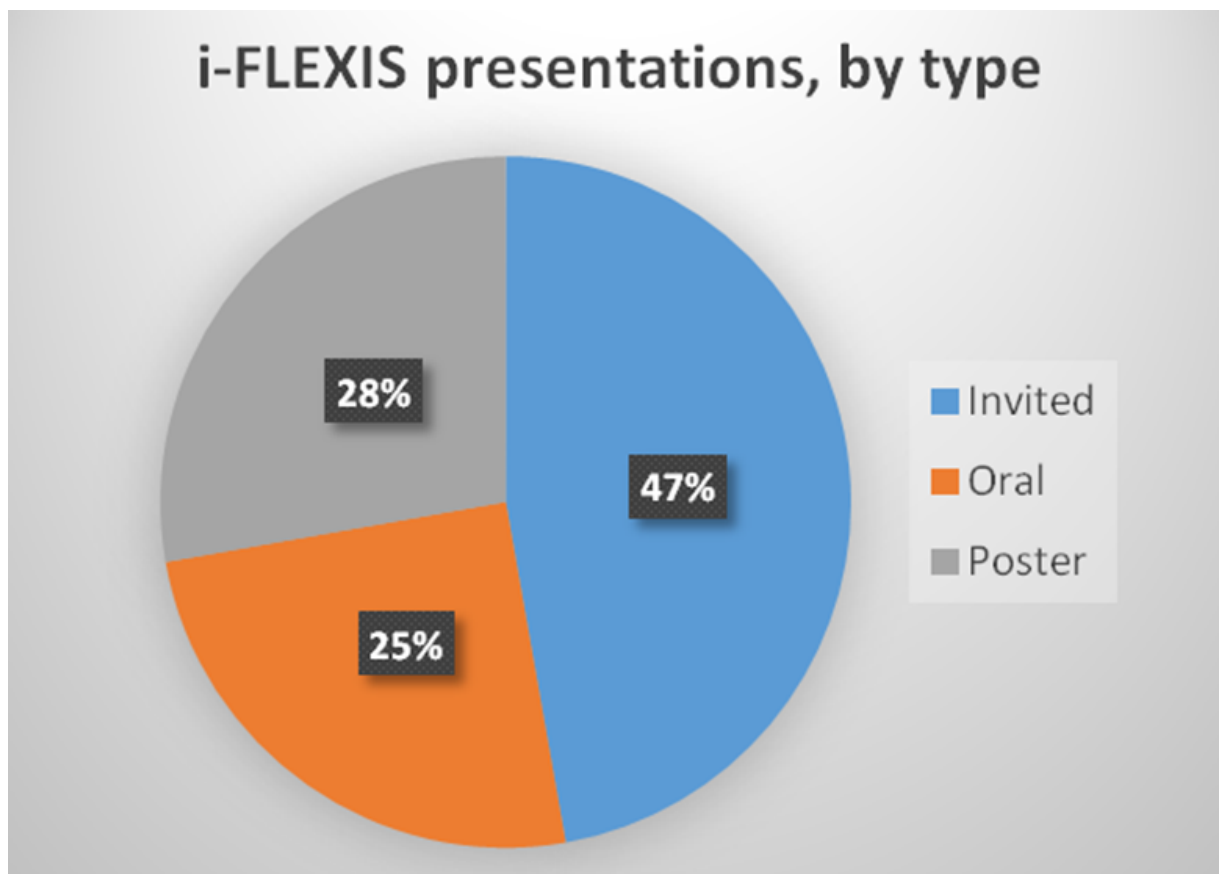
The school welcomes attendees who are new to the topic as well as researchers who may not be fully aware of some of the new materials, techniques and devices available. This school is open to the all E-MRS participants upon registration, by completing an online form which will be made available at the conference website. Further details on the 2<sup>nd</sup> i-FLEXIS Spring School will be updated soon at i-FLEXIS website.



## 4.2. Participation in conferences and publications

Being such a multidisciplinary project, topics such as OSSCs processing and characterization, organic and oxide TFTs, and radiation detectors have been intensively disseminated by i-FLEXIS partners. Since the beginning of the project 36 presentations have been given in international scientific conferences in Europe, Asia and USA, being almost half of them invited contributions.

This clearly demonstrates the relevance of the topics and the recognition of the scientific community regarding the excellence of the work developed within i-FLEXIS.



At this stage of the project results are consolidated and scientific articles are thus being published. Until March 2016, a total of 10 articles in prestigious journals such as Faraday Discussions, Journal of Applied Physics and IEEE Electron Device Letters, as well as one book chapter and one book have been published. A complete list of these publications can be found at i-FLEXIS website.