EMERGE
Emerging Printed Electronics Research Infrastructure

D5.8 1st Interim report on design and architecture of devices and systems, FLAPEP connected

WP5 – TA1: Access to design, modelling and simulatio

The EMERGE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 101008701

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List of abbreviations

C60 – Fullerene
CELIV – Charge Extraction by Linear Increasing Voltage
DCV5T – Dicyanovinyl-quinquethiophene
EQE – External Quantum Efficiency
EU – European Union
FLAPEP – Flexible Large Area Printed Electronics and Photonics
JV– Current-voltage curves
NDP9 – Proprietary p-dopant compound (Novaled p-dopant No. 9)
SME – Small & Medium Enterprise
TA – Transnational access activity
TUD – Technische Universitaet Dresden
WUT – Warsaw University of Technology

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1. Executive Summary

Deliverable **D5.8 "1st Interim report on design and architecture of devices and systems, FLAPEP connected" (M24)** provides an overview of the incoming projects that required activities on design and architecture of devices and systems offered by the EMERGE consortium. The different tools proposed by the WP5 partners are listed and briefly described in previous deliverables **D5.1 (M6)** and **D5.5 (M15)**.

2. User-projects on design and architecture of devices and systems

During the reporting period, from July 2022 to June 2023, a total of four open calls were organized, resulting in the submission of 63 projects. The collaborative efforts of 11 European partners have brought together a vibrant community of 88 participants from 26 nationalities. This multicultural and multidisciplinary approach has fueled invaluable knowledge exchange and fostered a dynamic environment within the EMERGE project.

The strong interest and involvement of research institutions in the European Union (EU) is evident, with 43 projects submitted by participants working in institutes located in EU countries. Equally remarkable is the fruitful contribution of 20 projects from industry, start-ups, and small-medium enterprises (SMEs), ensuring that the projects developed under EMERGE are both relevant and applicable in real-world contexts.

Although EMERGE has been receiving increased interest from external users as successive calls are open, only two proposals requested access to design and architecture of devices and systems activities. As identified in **Table 1**, the user-projects were submitted during the 3rd open call and have been successfully completed.

The evaluation of transnational access activity TA1 projects have shown to be the most challenging to evaluate, taking more than 90 days to collect reviewer's feedback. A possible reason for this lies in the level of specificity of the topics covered in the TA1 projects, which leads to successive refusals of evaluation by the reviewers. The turnaround time for proposal evaluation is expected to decrease with the reinforcement of the evaluation panel experts in TA1. A simplified "evaluation form" template, specific for TA1 projects, may also be prepared to address this issue.

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Table 1- Projects requesting access to design and architecture of devices and systems tools.

Projects	User's gender/ nationality	Institute	Selected installations	Selected institution	Installations used
3rd Call – 4010: Thin and flexible electrodes for capacitance measurement	Female/ Sweden	SME, Sweden	TA3 - Device preparation (*) TA2 - Chemical & physical techniques TA1 - Device design and architectures	Warsaw University of Technology (WUT)	Completed (Remote)
3rd Call: 4079: Controlled doping of the active layer as a way of enhancing performance of organic solar cells	Male/ Finland	University, Finland	TA3 - Device preparation (*) TA1 - Device design and architectures	Technische Universität Dresden (TUD)	Completed

* Non-official installation

The following section offers a comprehensive analysis of the project proposals concerning design and architecture of devices and systems.

2.1. Analysis of the stakeholder's engagement

During the course of the four open calls, a total of two projects were submitted to the EMERGE program. The current number of TA1-related projects is not enough to identify a clear trend in the stakeholders interested in modelling and simulation tools. More projects are needed to gain a comprehensive understanding of their diverse needs and interests.
In detail, these projects involved the participation of two individuals (50% female) from European institutions, whereas one is from a SME. This not only reflects the active involvement and valuable contributions from the European research community but also showcases the program's commitment to fostering collaboration between academia and industry.

2.2. Description of the publicity

As reported in deliverables **D2.4 (M4)** and **D3.1 (M12)**, a communication and dissemination strategy was designed and implemented to publicize all activities involving EMERGE participation. To achieve this, EMERGE utilizes various means of propaganda to effectively promote EMERGE project and engage with a broader audience and build a wide user

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community network with expertise on flexible large-area printed electronics and photonics (FLAPEP) materials and technologies. This includes active participation in public events, such as conferences, scientific and technological fairs, and workshops, providing valuable opportunities for EMERGE members to directly engage with potential users and establish collaborations. To expand its reach, EMERGE leverages proper online platforms, including the official website, LinkedIn, and online platforms of the EMERGE institutions. Besides, EMERGE partners also explore their internal networks to establish direct contact with potential users of EMERGE infrastructure to encourage the submission of proposals and facilitate collaboration within the project.

Regarding the participants of the projects related to design and architecture of devices and systems, both projects were proposed after discussions with involved EMERGE partners (word of mouth), while others resulted from direct contacts or conference advertising.

Throughout the EMERGE project, efforts will be carried out to advertise the offer of EMERGE institutions, also aiming to boost engagement of participants working in TA1 activities and increase the number of proposals submitted for virtual access to these facilities.

2.3. Requirements of the submitted projects

For both projects, the design and architectures activity was associated with experimental activities. Thereby, the following design methods have been requested:

- Project 4010: Computer-Aided Design of electrodes and of the corresponding screen-printing screens offered by WUT;
- Project 4074: Optical simulations for modelling ellipsometry measurements as well as the optical behavior of the fabricated organic solar cells. Note that this kind of simulations actually correspond to “modelling and simulation” activities, even though they have been registered as “design and architectures” activities.

Regarding the preferred EMERGE institution selected to develop the project activities, one project (project 4010) was submitted to WUT, and the other (project 4074) was applied to TUD. Regarding this last project, although TUD is not officially registered as a TA1 provider, it can still provide the necessay tools for the desired simulation activities. Given that these simulations are connected to experimental activities conducted at TUD, it was logical, from a participation standpoint, to perform the simulation activities at TUD as well.

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2.4. Overview of completed projects

In this section, additional details on the concluded user-projects are provided below, including main objectives, relevant results and expected/ achieved outcomes:

Project 4010: Flexible electrodes for non-invasive real-time bladder monitor (WUT)

- Objectives: The primary objective is to print and test dedicated bladder monitor electrodes using printed electronic techniques, specifically screen printing. We will collaborate with our partner, Emerge, who possesses experience in printed biomedical applications, including electrodes, to ensure we meet the technological requirements and limitations. Together, the WUT will develop the initial design, which will consist of multiple layers (conductive layer, isolation layer, etc.) printed on flexible substrates (thermoplastic polyurethane or polyethylene terephthalate foil). The electrode layer will be printed using metal-based (silver) and carbon-based paste (graphene and carbon black). A set of 50 printed electrodes will be produced. The WUT equipment will enable us to measure the thickness of the layers (using a profilometer) and the electrical parameters (using a test unit). The electrodes will be measured through cyclic voltammetry, square wave voltammetry and electrochemical impedance spectroscopy in the FeCNB buffer, which are allowing us to asses of the electric stability in the biomedical application. After the manufacturing and basic testing on the associated Emerge partner side, we will test the application of printed electronic electrodes with a non-invasive real-time bladder monitor.
- Results**:** Due to the lack of firm adhesion of commercially available simple electrodes to the abdomen, their angle can change with even small movements of the user, and they are significantly affected by accumulated sweat. Custom electrodes designed for stimulation purposes can also heat up when worn for extended periods. This can lead to interference from different layers of tissues and disturbances in the capacitance value and correlation of impedance and voltage signals. The project has identified limitations in the current performance of these electrodes. Printed electronics methods offer a low-cost and effective means of producing user-friendly electrodes. With a thickness of approximately one hundred micrometers, these electrodes will be almost imperceptible during all-day use. The biodegradable

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materials, thin layer construction, exact size and optimal placement will reduce unexpected affects by skin, moisture and heating. We will conduct performing test in the laboratory setting and a small number of field test.

- Potential use after the project: follow-up EMERGE project to extend the work with WUT on another Emerge Project and explore potential funding opportunities from the EU.

Project 4074: Controlled doping of the active layer as a way of enhancing performance of organic solar cells (TUD)

- Objectives: The main objective was to moderately dope the active layer of vacuum evaporated organic solar cells, with the aim of improving device performance in device with thick active layers. Computer simulations have shown that, especially in devices with thick active layers, there is an optimum doping concentration where devices performance is maximized. The objectives of this mini project were to dope the active layer of DCV5T-C60 (dicyanovinyl-quinquethiophene (donor material) – fulerene (acceptor material)) based vacuum evaporated organic solar cells using the p-dopant Proprietary p-dopant compound (Novaled p-dopant No. 9, NDP9), and to characterize the solar cells with current-voltage curves (JV) characterization, doping-charge extraction by linear increasing voltage (CELIV), external quantum efficiency (EQE) and sensitive-EQE. The device manufacturing was slightly delayed due to illness, and the JV-characterization took unexpectedly long due to contact issues. Therefore, some measurements are still to be completed (devices are being shipped to Turku for final measurements).
- Results: We successfully doped the active layers using NDP9, and we could demonstrate a drastic effect on device performance. However, in terms of optimizing the power conversion efficiency the resulting doping concentrations were simply too high. The reason is mainly due to the material choices we made; it turned out that choosing NDP9 as the dopant was a mistake. Due to lack of time, we were not able to conduct all measurements during the visit. These measurements are currently being completed. Based on the outcome of these measurements, a follow-up visit will be planned and applied for through the EMERGE-infrastructure.

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- Potential use after the project: follow-up EMERGE project to extend the work.

2.5. Potential difficulties of experiments

In both projects, participants have encountered some technical issues and faced time constraints that affected their ability to conduct some experiments. Specifically, in project 4010, there was a reported material shortage, particularly in the availability of carbon-based pastes, leading to delays in the process. As for project 4074, the theoretical activities have not been realized. A follow-up EMERGE project proposal will be submitted by the participant to carry out these activities in the future.

2.6. User feedbacks

The feedback on how the projects were carried out is excellent, with the participants expressing their intention to recommend access to EMERGE infrastructures to their colleagues. The participants are considering follow-up projects, which is a clear indication of their very positive experience. It is worth noting that the participants feel that the project duration offered by the EMERGE consortium could be increased.

Regarding the general EMERGE workflow for project submission, operation, and finalization, as well as the EMERGE tools, such as website and guidelines, the feedback is marked systematically as “excellent”. However, there are areas that have received "satisfactory" ratings, indicating room for improvement. These areas include enhancing logistic support at the host institution to facilitate research activities, improving the EMERGE website and guidelines to meet all users' needs effectively, and addressing occasional delays in the review process to streamline project evaluation and approval. Addressing these points will lead to a more satisfactory experience for all participants.

3. Final remarks

During the reporting period of this deliverable, a small number of projects (only two) requesting activities related to design and architecture of devices and systems have been submitted and concluded. The low number of project was to be expected in the ramp-up phase of EMERGE, however it is particularly low for TA1-related activities. This risk had also been identified, notably because the scientific community in the FLAPEP field is focused on

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experimental work. To address this issue, the report suggests active publicity efforts, relaxation of project duration limitations to facilitate the fulfillment of the scientific objectives, and the promotion of coupled theoretical-experimental approaches. Most of the TA1 projects that could be implemented would require several weeks of work to meet the scientific objectives. Implementing these recommendations will enhance the attractiveness of EMERGE for potential participants and foster further engagement in TA1 activities.

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