DOI 10.5162/SMSI2025/A6.2

Flexible , Printed Sensors research in Joanneum Reasearch and access through INFRACHIP

Oliver Werzer[1], *Gregor Scheipl*[1], *Barbara Stadlober*[1]
[1]*Joanneum Research Forschungsgesellschaft mbH/Department Materials, Franz-Pichler-Str. Nr. 30, 8160 Weiz, Austria*
Mail: oliver.werzer@joanneum.at

Summary:
Realizing ideas is challenging especially if dedicated experimental stations or machinery are missing. INFRACHIP provides free access to state-of-the-art technologies in many fields so that fundamental research, feasibility or even prototypes can be achieved. As JOANNEUM RSEARCH (JOR) we are a partner in the project consortium. In this context, we present some of the technological focal points that we contribute to this project to give the reader an impression of how their own research/development ideas might benefit from collaborating with JOR via INFRACHIP.

Keywords: Infrastructure, functional printing, flexible electronics, sensors, R2R, high resolution structures & patterns, lab-on-chip, piezoelectric, PVDF-TrFE

Introduction

Technology is advancing rapidly, yet innovative ideas often face roadblocks due to limited access to state-of-the-art technologies or delays in securing funding - if funding is granted at all. EU-sponsored infrastructure projects are crucial for maintaining Europe's competitive edge in science and research. The INFRACHIP project addresses these challenges by offering a streamlined proposal process and rapid access to cutting-edge technologies. This initiative is funded by the European Union's Horizon Europe research and innovation program under Grant Agreement No. 101131822.

Joanneum Research (JOR), a non-profit RTO based in Austria, is a proud partner in this project. The department Materials holds extensive expertise in a wide range of advanced technologies. Highlights of our offerings are detailed in the following chapters, with additional resources available online [1].

Printed Sensor Fab (PrintSENS)

In recent decades, sensors have become indispensable in our everyday lives, with an ever-expanding array of innovative variants. At JOR, we host a comprehensive development chain for flexible, printed sensors, placing a strong emphasis on those based on the ferroelectric polymer P(VDF-TrFE) (poly(vinylidene fluoride trifluoroethylene). P(VDF-TrFE) has become very attractive as functional material for high-tech applications due to inherent physical properties like high piezo- and pyroelectric coefficients (up to 40 µC/K*m2) [2]. This material forms the core of a printed sensor technology (PyzoFlex®) which are able to measure slightest pressure changes (piezoelectric sensing) in a wide frequency range. At low frequencies, the sensor does force sensing, pressure distribution measurement or impact monitoring; at higher frequencies it can detect structure born sound, and vibration patterns. The sensor reacts to changes in temperature as by pyroelectric sensing and usable as touchless interaction or proximity sensing, among others.

PyzoFlex® technology enables the utilization of screen- or inkjet printing techniques and can be used to add new sensory functions to almost any surface. By leveraging CAD tools and finite element modelling, we achieve optimized sensor design to realize customized solutions for each given application. Tailored material selection ensures peak performance during printing, while post-processing techniques, such as high-voltage electrical poling, align the polymer's dipoles to enhance application-specific performance.

The development process is comprehensive, encompassing morphological and electrical characterization, followed by the assembly of complete sensor systems. This includes the integration of off-the-shelf components, electronic readouts, and custom software development, completing the value chain for printed sensor solutions (Fig.1).

Recent breakthroughs highlight the technology's versatility: measuring large-area pressure distributions in smart surfaces [3], realizing fully

DOI 10.5162/SMSI2025/A6.2

organic pyroelectric sensor arrays by integrating P(VDF-TrFE) with organic thin-film transistors [4], monitoring the bending of alpine skis during downhill performance [5], and creating ultra-flexible organic active-matrix sensor sheets for bio-signal monitoring [6].

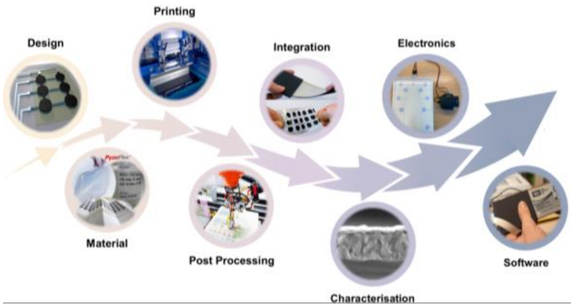

Fig. 1. Development path of PyzoFlex® sensor solutions covering the value chain up to prototype level.

Beyond sensing, this technology also unlocks opportunities for energy harvesting. Examples include ultra-thin, 1 mm floor tiles with bendable cantilevers [7], vibrating structures [8], and deformable elements within bicycle tubes or on wind turbine blated [9]—all capable of generating energy through mechanical deformation.

Roll-to-roll imprinting

Mass production of advanced tools and devices requires scalable manufacturing solutions. Roll-to-Roll (R2R) technology, long utilized in paper printing, offers fast, continuous production capabilities. In recent years, R2R technology has been adapted for the large-scale production of functional devices, including organic electronics, flexible micro-optics, and microfluidic systems. While some R2R developments facilitate just printing, additional capabilities arise from mechanically imprinting structures onto flexible substrates.

Using precision-engineered stamps, high-resolution structures can be transferred directly onto flexible foils, which are coated, for example with high-viscosity liquid resins in which the structure is embossed. These resins harden under UV exposure, capturing the desired features and enable the fabrication of high-resolution textures with a very high throughput (several m/minute). Key challenges in this process include designing and originating the stamp via maskless lithography, optimizing the stamp's surface chemistry, and tailoring the imprint resin. At JOR, proprietary technologies like NIL® and bioNIL® enable advanced customization of these resins, meeting diverse application requirements.

Flexible Microfluidics Fab (FLEXµFLU)

R2R imprinting enables the fabrication of sophisticated devices which enable applications like point-of-care diagnostics, organ-on-chip, mixing, crystallization amongst many more. For their realization many aspects need consideration starting from simulation of fluidics or reaction chemistry, over imprinting, lamination and more (see Fig. 2). At the FLEXµFLU all steps can be taken care of for achieving best functional devices.

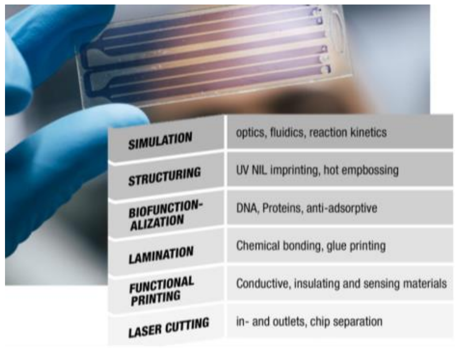

Fig. 2. Example of a Lab-on-chip produced in a R2R process at Joanneum Research and an explanation of the entire development and production chain offered.

Flexible Microoptics Fab (FLEXµOPT)

Microoptical elements are integral to various applications, including lighting, optical communications, camera lenses, and even decorative designs. While injection molding is commonly used for large-scale production, R2R processing offers a faster, more cost-effective, and adaptable alternative.

At JOR, the FLEXµOPT facility supports the entire development chain for 2D and 2.5D freeform microoptical elements. This includes raytracing, lithography up to small-scale production using step-and-repeat imprinting technology and high-throughput manufacturing explained above.

References

[1] https://infrachip.eu/showroom/access_provider__facility-joanneum/

[2] N. Neumann, et. Al. Ferroelectrics 1991, 118(319- 324)

[3] Asier Alvarez Rueda, et. al. *Sensors* **2023**, *23*(2)

[4] Marco Fattori, et. al. Nature Electronics 2022, 5(289–299)

[5] Christoph Thorwartl, et. al. *Sensors* **2022**, *22*(15), 5768

[6] Esther Karner-Petritz, et. al. Adv. Electron. Mater. 2023, 9, 2201333

[7] Asier Alvarez Rueda, et. al. Nano Energy 121 (2024) 109248

[8] Asier Alvarez Rueda, et. al. Adv. Eng. Mater. 2024, 26, 2302140

[9] https://www.symphony-energy.eu/applications/