PROJECTS

HiPerCycle

Project information

Project title: *High-performance polymer materials for recyclable analytical chips*

Duration: *36 months, from May 2022 to April 2025*

Project No.: *FTI-Initiative Produktion der Zukunft / FFG #891182*

FTI-Initiative Produktion der Zukunft

FFG Forschung wirkt.

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Project Objective

The primary objective of the project is to investigate, for the first time worldwide, the new material class of vitrimers for UV bonding and subsequent lamination of microfluidic structures for analytical chips. Roll-to-roll bonding and lamination processes are to be implemented for the first time for processing the material. The potential of the technologies will be demonstrated by the novel implementation of multilayer analysis chips. For this purpose, microfluidic bonding tools with multilevel lithography will be explored for the first time with the relevant size of up to 14 inches and with shape adaptation to the needs of roll-to-roll bonding. Vitrimer-based materials enable the recycling of functional composite workpieces for the first time – so corresponding investigations of recycling processes together with a life cycle assessment are also the aim of the project.

Abstract

Analytical chips have a wide range of applications, e.g. in chemical, medical, and environmental analysis, and enable miniaturization and simplification of measurement procedures. They are being intensively studied in the research field of microfluidics – not least because of the current demand for rapid tests in the wake of the Covid 19 crisis. HiPerCycle primarily addresses the need for new sustainable high-performance materials, focusing on functional UV-curable materials and their processing on foil substrates.
The basic idea of HiPerCycle is to research a new class of UV-curable polymer materials and their advancement into functional materials for highly efficient roll-to-roll processing. The materials of choice are so-called vitrimers, which undergo thermo-activated bond exchange reactions.

This feature gives vitrimers unique properties:

- they can be patterned, e.g., by UV embossing, and enable higher chemical stability than thermoplastics,
- they are compatible with thermal post-processing steps, e.g., for self-healing and material joining (in contrast to conventional cross-linked polymers), and
- they enable low-loss disassembly of composites and thus recovery of the base materials – the basis for efficient recycling of multi-material products.

To improve the efficiency of the processing and to meet the requirements of roll-to-roll patterning, lithographic multilayer mastering of microfluidic structures is scaled up to sizes of 14 inches. On the materials side, research activities are focused on achieving high-quality UV-NIL replication, thermal lamination, and compatibility with chip-based analytical applications, as well as decomposition after use. The performance of the approach is demonstrated using foil-based microfluidic chips a case study of high relevance – since analytical chips often consist of different materials (here carrier foil, UV-curable vitrimers, silver electrodes) and, as consumable materials, are usually discarded after a few measurements. Simple vitrimer-based decomposition processes will promote recycling and recovery of base materials for a circular economy. The benefits of vitrimers and manufacturing methods will be evaluated using a life cycle assessment focused on greenhouse gas emissions compared to established materials and methods.

The expected outcomes of the collaborative project are:

- novel high-performance vitrimer-based materials,
- corresponding efficient and scalable patterning,
- lamination methods,
- a detailed life cycle assessment focusing on the environmental impact of the new materials and manufacturing technologies and
- demonstration of the applicability of the materials and methods for the production of fluidic chips on flexible foils.

Thus, the project addresses the efficient use of resources and efficient production technologies and has the potential to significantly reduce the use of resources and raw materials as well as the emission of CO2 in the production of material goods in the future.

Our role in the project

- PESSL will contribute to the new chip layout & design definition in WP3.
- PESSL will perform tests with the resulting chips for the comparison of different bonding approaches in WP4.
- PESSL will also perform tests with the resulting chips for the bonding performance and lamination results evaluation in WP4.
- The main contribution from PESSL can be seen on the WP6 Read-out device and functionality tests of analytical chips.
- Milestone 6.1 The device will be adapted to new requirements of novel materials and new

chip design.
- Milestone 6.2 Single-layer chips from vitrimer material approval after testing cycles and evaluation process.
- Milestone 6.3 Multilayer chips approval after testing cycles and evaluation process.
- Deliverable 6.1 Calibration series with adapted chip read-out device MobiLab.
- Deliverable 6.2. Measurement series of ion solutions measured with the vitrimer-based chips.

Consortium

Coordinator: Joanneum Research Forschungsgesellschaft mbH (JR)

Partners:
- Polymer Competence Center Leoben (PCCL)
- Pessl Instruments GmbH (PESSL)
- Temicon GmbH (TEM)