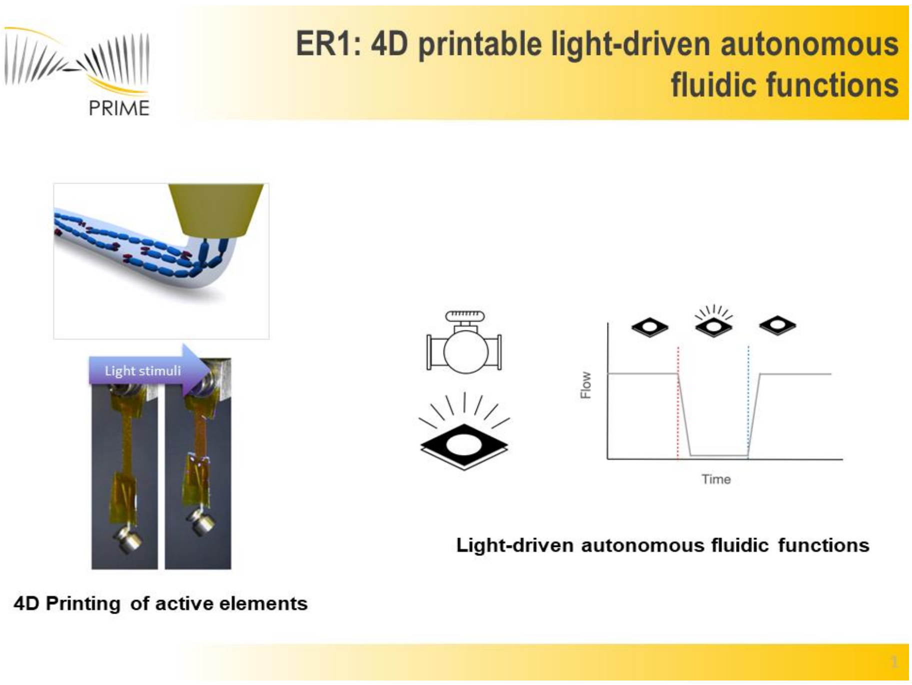
SCIENTIFIC ABSTRACTS

1. 4D printable light driven autonomous fluidic functions

Microfluidic devices can manipulate small amounts of liquid allowing cost-effective, accurate, fast and high-throughput analytical assays. Microfluidics is an expanding area; however, existing technologies suffer numerous limitations that heavily impede the global microfluidics market. These include complexity of the equipment, which limits their application to highly specialized laboratories and leads to high prices of the large-scale off-chip equipment. At PRIME we have developed fluidic valves activated by light. By integrating these valves into microfluidic chips we aim to create a new generation of active, tubeless and contactless microfluidic chips effectively changing the currently established paradigm. PRIME aims to lay the foundation of a new technology that could not only make industrialization possible, but also bring smart material properties to the table, enabling the monolithic integration of new functional capabilities. The final device will be remotely activated using simple photonic elements that can be integrated in compact, portable and cheap operation & read devices.

In PRIME, to implement active microfluidic valves, we have brought into this scenario the 4D printing of responsive materials. For integrated active chip elements, it is important to achieve a large and fast shape morphing. PRIME has developed robust and reproducible synthetic procedures to yield high-quality inks and printed actuators with enhanced response. Advances in the materials and processing are connected with modelling approaches to narrow the gap between the developed materials and the active fluidic elements. We have developed different geometries and integration strategies leading to microfluidic devices incorporating the concept of the PRIME valve based on smart materials. We have demonstrated, at this stage, the valve concept able to stop a flow at a constant pressure configuration. The functional prototype of the PRIME valve at this stage is working at pressures of tens of mbar and at flow rates in range of tens or hundreds of µL/min, with response times in the range of tens of seconds (complete valve closure). Improvements of these figures are in progress within the framework of the project.

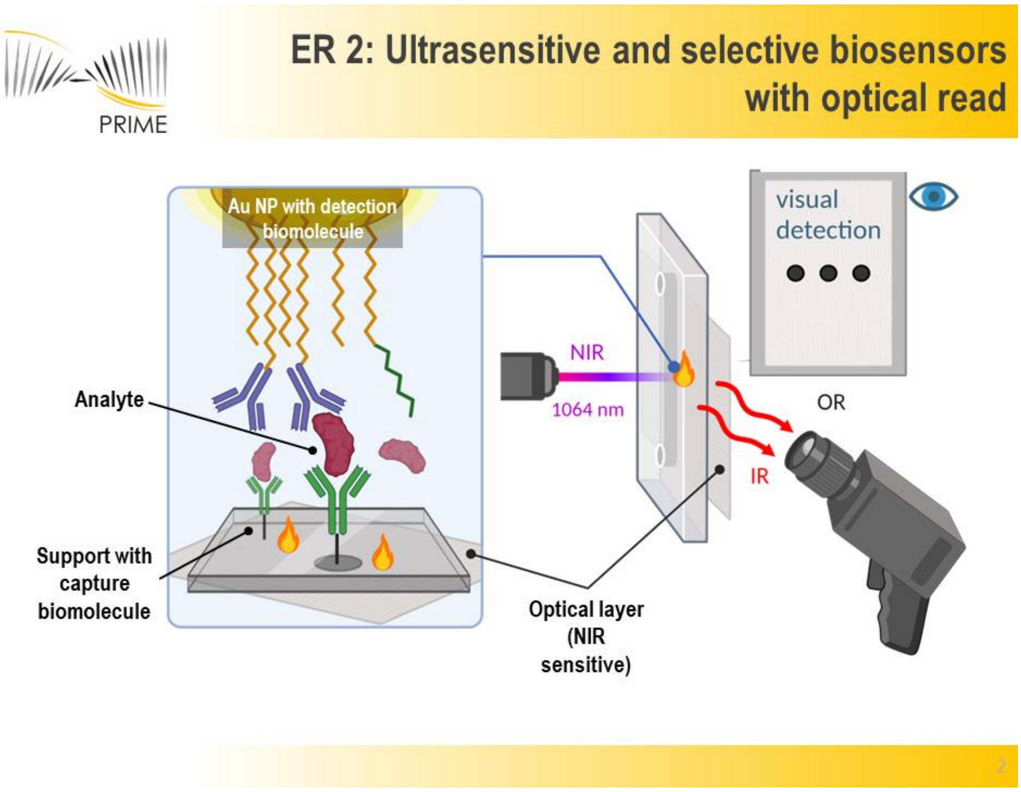


2. Ultrasensitive and selective biosensors with colorimetric thermal transducer

PRIME aims to integrate new ultra-sensitive and selective sensors in the chip, readable with light. The final device will be remotely activated and read using simple photonic elements that can be integrated in compact, portable, and low-cost operation-and-read devices.

The sensing elements consist of a capture antibody crosslinked to the base floor of the microfluidic channel, and a detection antibody bioconjugated to the surface of an NIR-absorbing nanoparticle. When the sample is loaded, the analyte, if present, interacts with the capture antibody and is retained in the channel. Nanoparticles are retained by the detection antibody in the presence of the analyte. In a later step, the nanoparticles retained this way are irradiated with an NIR laser (1064 nm), and transduce this incoming light into heat thanks to their plasmonic properties. This heat generated can change a colorimetric thermal transducer (CTT), which is the optical detection element.

At this stage we have demonstrated the sensing concept for the detection of Carcinoembryonic Antigen (CEA), using a functional prototype of the sensing chips with a CTT. Within the framework of the project, we are striving to increase the sensitivity of detection in these systems.



3. Thermoplastic liquid crystal elastomer (LCE) actuators

Stimuli-responsive liquid crystal elastomers (LCEs) are capable of performing fast, reversible actuation and have readily been applied as soft actuators in applications such as soft robotics, smart textiles, microfluidics, and artificial muscles. A macroscopic mechanical response arises from an ordered to less ordered state in the covalently cross-linked network thermosets. Hence, subjecting the responsive LCEs to an external stimulus such as heat results in a contraction along the orientated mesogens-based network's director field and expansion perpendicular to it, inducing macroscopic shape changes. After removing the stimulus, the initial molecular order is recovered, and the shape is restored due to the crosslinked network. A proven method to prepare aligned LCEs is by first mechanically stretching a partially crosslinked material to induce alignment, followed by fully photocrosslinking the polymer, locking in the desired molecular orientation of the mesogens. Although the currently available materials exhibit large deformations, have good mechanical properties, and are sufficiently stable, they cannot be reprocessed and recycled. An alternative strategy to circumvent permanently crosslinked networks is by introducing supramolecular interactions as dynamic physical crosslinks. To date, however, supramolecular crosslinked LCE actuators have been prepared by multistep synthesis, while simultaneous integrated stimuli-responsive, reprogrammable, and reprocessable properties have not been reported. In addition, the application of reprocessable and reprogrammable soft actuators is limited by the synthetic strategies, 3D-shaping capabilities, and small deformations.

We have prepared melt-processable supramolecular soft actuators based on segmented copolymers containing thiourethane and liquid crystal segments via sequential thiol addition reactions in a one-pot approach using commercially available building blocks. The actuators demonstrated immediate, reversible response and weightlifting capabilities with large deformations of up to 32%. Through exploiting the supramolecular crosslinks, the material could be recycled and reprogrammed into 3D actuators and welded into an actuator assembly with different deformation modes.

Our invention relates to a method for the preparation of thermoplastic liquid crystalline polymers. The invention relates to segmented copolymers containing thiourethane, amide, or linear bismaleimide hard segments and liquid crystal soft blocks.