Membrane-based microfluidic devices for real-time sensing and autonomous pumping

Ilenia Viola, CNR NANOTEC

Functional, flexible, and integrated lab-on-chips, based on elastic membranes, are capable of fine response to external stimuli, so to pave the way for many applications as sensors for a wide range of chemical, physical and biomedical processes as well as mechanical actuators for pumping purposes in microchannels [1,2]. Here, we first report on the use of elastic thin membranes (TMs), integrated with a reaction chamber, to fabricate a membrane-based pressure sensor (MePS) for reaction monitoring [1]. In particular, the TM becomes the key-element in the design of a highly sensitive MePS capable to monitor gaseous species production in dynamic and temporally fast processes with high resolution and reproducibility. Indeed, we demonstrate the use of a functional MePS integrating polymeric TM by monitoring the dioxygen evolution resulting from catalytic hydrogen peroxide dismutation. The MePS, tested in a range between 2 and 50 Pa, allows detecting a dioxygen variation of the µmol L^{-1} s^{-1} order. Then, the pressure gradient produced by the oxygen evolution was studied in capillary conditions [3-5] and demonstrated to generate autonomous pumping within a microfluidic device [2] .

[1] A. Zizzari et al., Highly Sensitive Membrane-Based Pressure Sensors (MePS) for Real Time Monitoring of Catalytic Reactions, Anal. Chem. 2018, 90, 7659−7665.

[2] A. Zizzari et al., Self-powered catalytic microfluidic platforms for fluid delivery, Coll. Surf. A 532 (2017) 257–262.

[3] A. Zizzari et al., Catalytic oxygen production mediated by smart capsules to modulate elastic turbulence under a laminar flow regime, Lab. Chip. 2014, 14(22), 4391-4397.

[4] LL. Del Mercato et al., Catalytic self-propulsion of supramolecular capsules powered by polyoxometalate cargos, Chemistry – Eur. J. 20(35), 10910-10914.

[5] I. Viola et al., Microfluidic motion for a direct investigation of the structural dynamics of glass-forming liquids, Anal. Chem. 2005, 77, 591-595.