Polymeric and three-dimensional biochips for biological investigations through microfluidics

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Labs-on-a-chip (LoCs), defined as devices in which multiple laboratory techniques are integrated within a chip of a few square centimeters, have tremendous potential for application in various fields of chemistry and life sciences[1, 2]. Rapid prototyping methods in design and fabrication of polymeric lab on chips are on the rise as they allow high degrees of precision and flexibility. A microfluidic platform may require an optimization phase in which it could be necessary to continuously modify the architecture and geometry and this can be only possible if easy controllable methods of fabrication and low-cost materials are available. In our research activity, we optimize the realization of microfluidic tools, from the FEM simulation, to CAD design to the biological applications. In particular, we explored the possibility to obtain monolithic 3D structures with buried running channels, starting from separately microfabricated polymethyl methacrylate (PMMA) layers and to obtain multi-compartment biochips for transwell assay with customized features. The entire platform has been realized in PMMA combining femtosecond laser and micromilling fabrication technologies. The multilayer structure has been assembled through a facile and low-cost solvent-assisted method. The obtained devices show increasing complexity and have been used in a range of biological applications: as capture device for circulating tumor cells[3], as mixing tools for particles and cells, to obtain on-chip dilution of formulations[4].The advantage of such a system is its robustness: a “plug-and-play” operating system was realized and no additional glue, luer fittings, or gaskets were necessary for a watertight seal, thus ensuring a degree of reproducibility which is crucial for biological assays.The low-costs of materials used, the customizable methods, together with the proof-of-concept biological application make the realized platform suitable for industrial exploitation.

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