

Development and manufacture of polymer based microfluidic devices by micromilling and thermal bonding

Kamil Żukowski

Micromilling constitutes the development of a technique often used in industry on a macro scale whereas micromilling machines have a virtually identical structure as their larger counterparts and differ mainly in precision (2.5 μm / step) and repeatability (less than 5 μm) of applied stepper motors. Micromilling involves the removal of a part of the milled material by the micro-endmill spinning at a high speed. The smallest available micro-endmills have a diameter of 5 μm , but the most frequently used ones have a diameter of 100 μm to 500 μm . Using this technique, you can create microstructures in the polymeric materials such as: PMMA, PC, COC, PEEK, etc., in metals (aluminum, copper) as well as in ceramics. Using micromilling, you can create even the most complex three-dimensional structures in a very easy and fast way.

DESIGN

Projects of microstructures are made mainly in CAD programs. They can be made in two variants:

1. 3D model
2. paths pattern on which the tool will be moving

It is also possible to perform the project as a graphic file.

Then, using CAM software, the performed project is converted into G-code which is executed by the micromill.

MICROMILLING PROCESS

The process of micromilling varies depending on the nature of the application of the executed microstructure. In the case of the microstructure creation in the polymer of the type such as PMMA, PC or COC, then during the process of micromilling the material is removed only where microchannels are located. In this case, the process of micromilling takes from several minutes to a few hours (depending on the complexity of the project). Microchannels created in such a way require sealing. This is achieved by thermal bonding. As a result of high temperature and applied pressure a permanent joint of two polymer plates takes place.

Thanks to the process of micromilling you can also perform molds used to cast microstructures made of PDMS. In this case, the process of micromilling takes a few hours.

This process generates molds comparable to molds produced in SU8. Additionally, you can create molds in full 3D in a very easy way.

APPLICATIONS

- Micromixers,
- Flow cells with integrated optical fibers,
- Multichannel micro-valves,

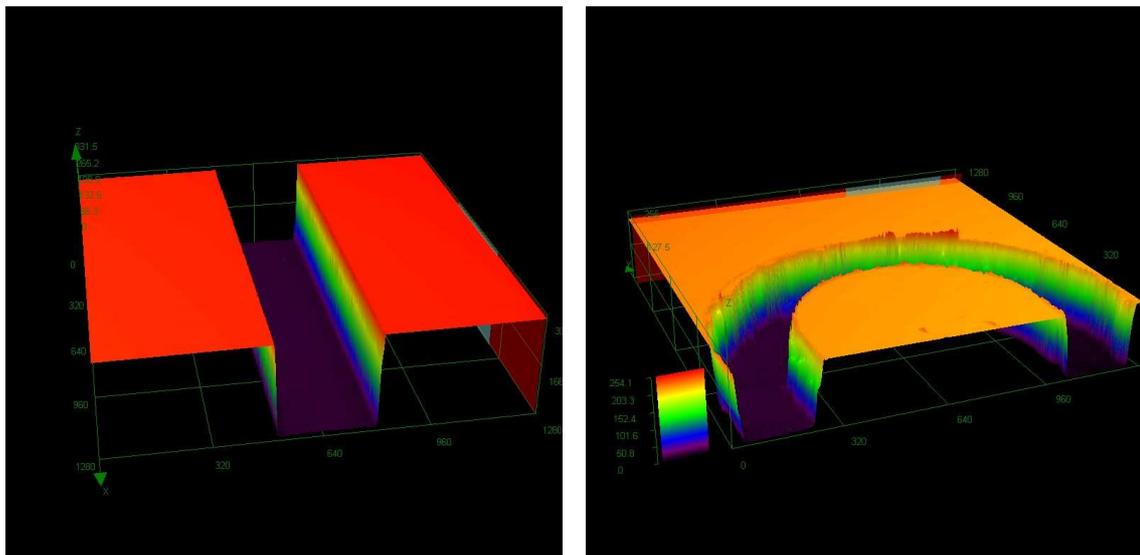


Fig. 1. 3D measurements of the milled microchannels

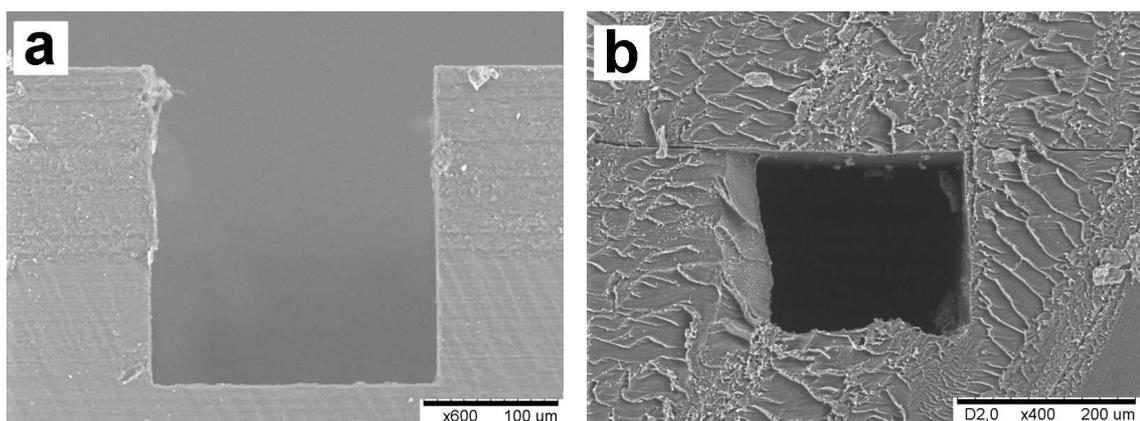


Fig. 2. Cross sections of the milled microchannels: a) before bonding process, b) after bonding process,

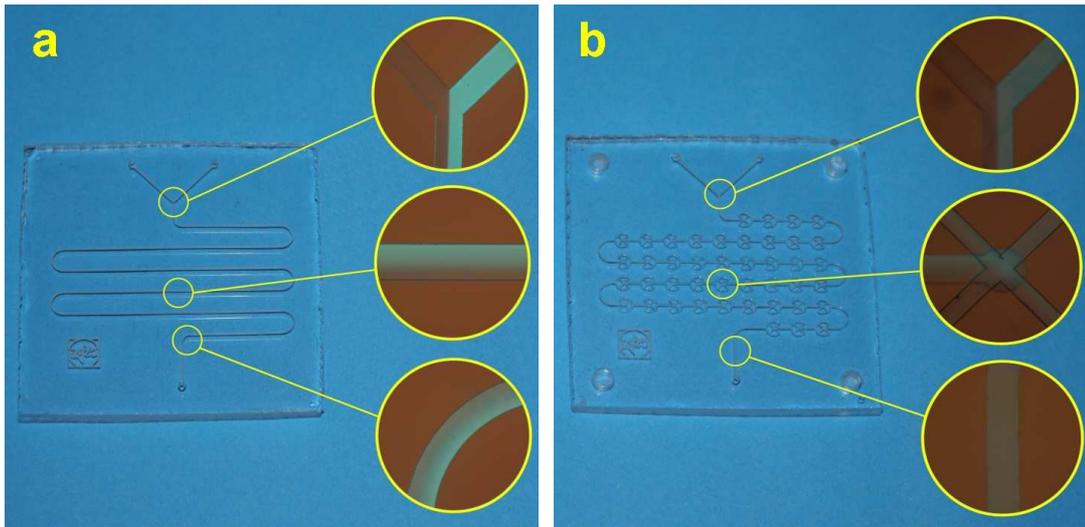


Fig. 3. Mixing process in: a) simple 2D micromixer, b) 3D micromixer

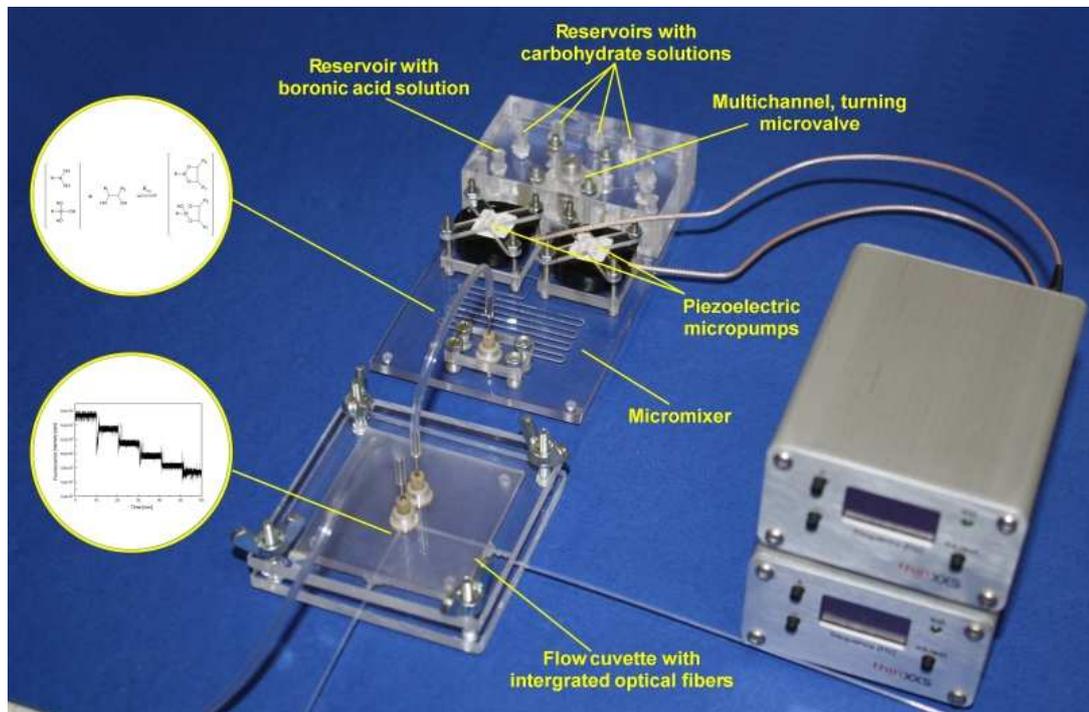


Fig.4. Integrated microsystem for fluorescence, nonenzymatic determination of carbohydrates