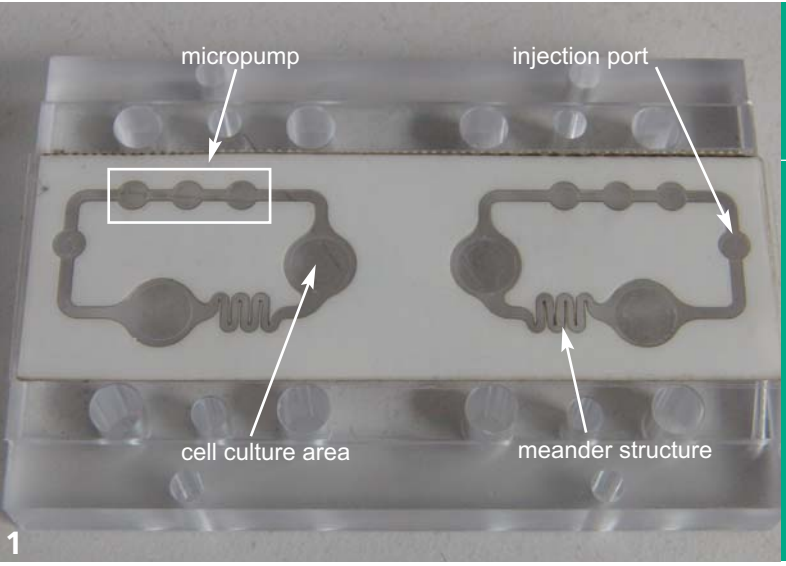
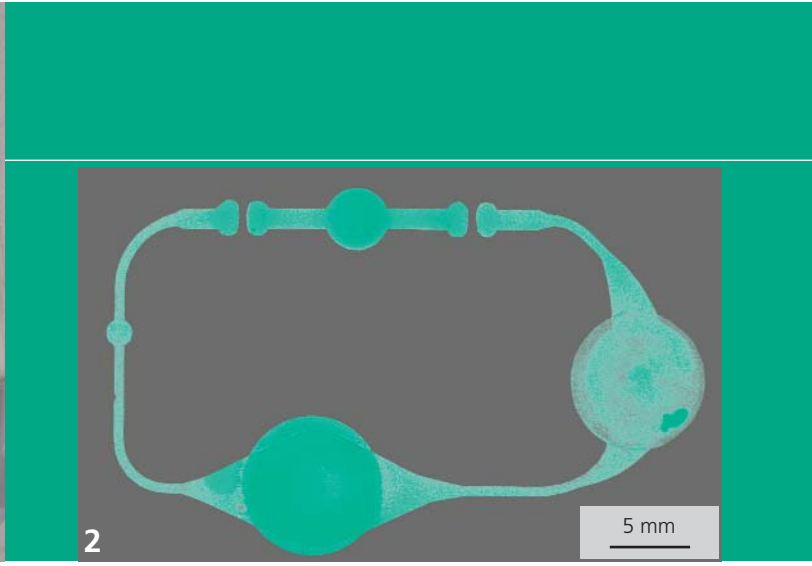




INEXPENSIVE LAB-ON-A-CHIP SYSTEMS WITH MULTILAYER DESIGN FROM LASER MICROSTRUCTURED FOILS

THE TASK

Miniaturization, fast prototyping and automation are increasingly important in the field of lab-on-a-chip technologies. These systems are used in medical diagnostics and to replace animal testing in pharmaceutical and cosmetic industries. Multi organ chips (MOC) are well suited to mimic processes in living organisms.

Testing substances on a chip require the implementation of closed circulatory systems. These consist of several cell culture segments, storage chambers and a micropump. So far the fabrication was accomplished by casting a silicone flow cell to a connector plate. This process is complicated, expensive and difficult to automate. It also limits the microfluidic system to be designed in a single layer.

OUR SOLUTION

Fraunhofer IWS engineers are developing a closed process chain to cost effectively (automated) manufacture inexpensive chips. The new system is a multilayer design made from laser microstructure foils.

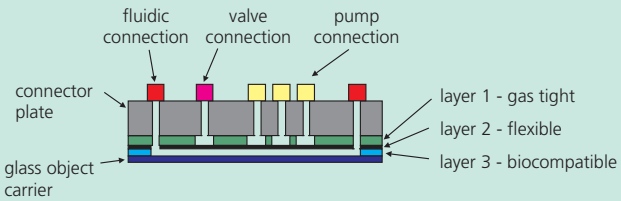
The first step is to slice the microfluidic system design into individual layers so that later each layer can be fabricated on a separate foil. The next step is to select the desired properties (e.g. hydrophilic, hydrophobic, transparent, …) for each foil, which depends on the functional requirements. In the third step these foils are laser processed on both sides, i.e. they are microstructured and functionalized. The final fourth step is laminating these individual foils into a multilayered system via adhesive or plasma bonding.

The multilayer technology is also applied to fabricate pneumatically powered pumps and valves. The associated peristaltic pump is a reciprocating and rotary pump, which operates as a membrane pump. The pump chambers are connected in series and (with suitable control) accomplish a directed transport of the liquid. Under excess pressure a thin polymer membrane bulges and displaces liquid in the underlying chamber.

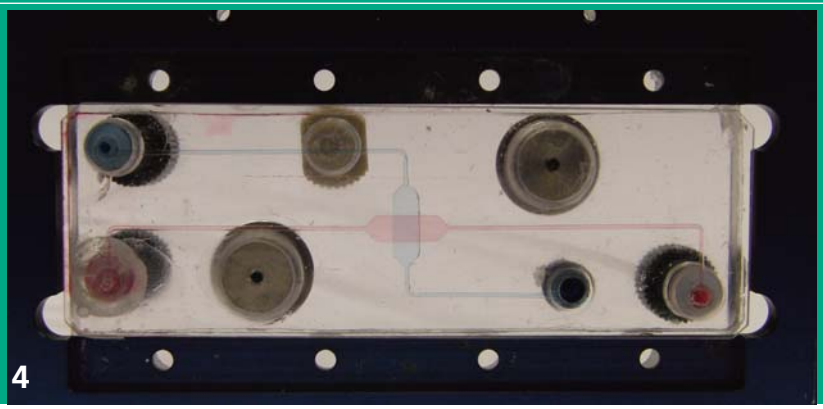
Under lowered pressure however the membrane withdraws and increases the chamber volume. To make valves the membranes are equipped with addition seal lips.

Fig. 3 shows a representation of the established microfluidic platform. It consists of a connector plate with fluidic and pneumatic connections, the multilayer flow cell with integrated micropump and a glass cover plate. This plate

Schematic design of a multilayer lab-on-a-chip system with integrated micropumps and valves



3



provides the seal on the bottom of the chip and serves as the optical access port.

RESULTS

A closed technology chain was established at the IWS Dresden to automatically manufacture inexpensive lab-on-a-chip systems based on multilayer designs made from laser microstructured foils. Different industrial lab-on-chip-systems can be built.

A particular system was made from polycarbonate foils and Teflon. The foils were structured and functionalized with a ps laser system at wavelengths of 532 nm and 355 nm. Finally they were laminated in a special holder. Fig. 1 shows the prototype of a fluidic system with two closed circuits, two cell culture areas, one injection port and a 3-point peristaltic pump as well as meander structure as a damper. Fig. 4 shows a prototype with intersecting channels, which run at different levels. The chip was filled with two different dyes to make the fluidic separation of the two channels visible.

Microfluidic structures can be placed at different levels in the multilayer design, which results in greater functionality per chip area. Wettability can be tailored by using foils with different properties (hydrophilic, hydrophobic, functionalized). This enables the implementation of new functions such as capillary stop valves and the tailored occupation of areas with cells. Foils can also be used to integrate thin film electrodes.

1 Prototype with two circuits
2 Dye filled circuit
4 Prototype with intersecting channels

CONTACT

Dr. Frank Sonntag
phone +49 351 83391-3259
frank.sonntag@iws.fraunhofer.de