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MULTILAYER BASED LAB-ON-A-CHIP-SYSTEMS FOR SUBSTANCE TESTING

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INTRODUCTION

Realization of complex 3D tissue cultures on a chip requires the implementation of closed circulation systems. These consist of several cell culture segments, storage chambers and micro-pumps. 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 [1, 2 and 3].

SETUP

We are developing a closed process chain to manufacture automatically cost effectively inexpensive chips. The novel system is a multilayer design based on laser micro structured foils. The first step is to slice the microfluidic system design into individual layers so that each layer can be fabricated on a separate foil. The next step is to select the desired properties (e.g. hydrophilic, 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 micro structured 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. For this purpose the design of these elements has to be adapted.

RESULTS

Microfluidic structures can be placed at different levels in the multilayer design, which results in greater functionality per chip area. Surface properties can be tailored by using foils with different properties (hydrophilic, hydrophobic) in combination with laser structuring and laser functionalization. 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] K. Schimek and M. Busek et al: "Integrating biological vasculature into a multi-organ-chip microsystem", Lab Chip, 13, 3588-3598, 2013.
[2] I. Wagner et al: "A dynamic multi-organ-chip for long-term cultivation and substance testing proven by 3D human liver and skin tissue co-culture", Lab Chip, 13, 3538-3547, 2013
[3] B. Atac et al: "Skin and hair on-a-chip: in vitro skin models versus ex vivo tissue maintenance with dynamic perfusion", Lab Chip, 13, 3555-3561, 2013.

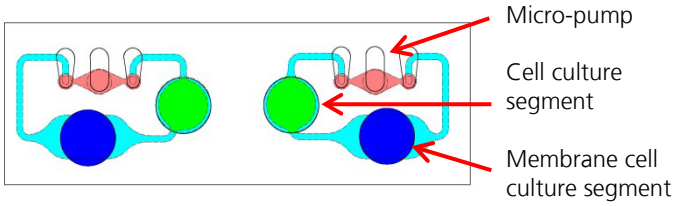

FIG. 1:
Schematic design and prototype of a lab-on-a-chip-system with two circulation-systems

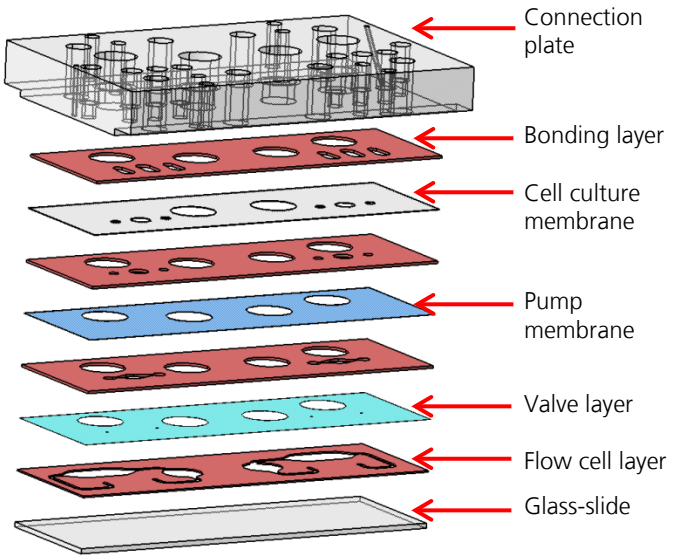

FIG. 2:
Exploded view of multilayer based lab-on-chip-system

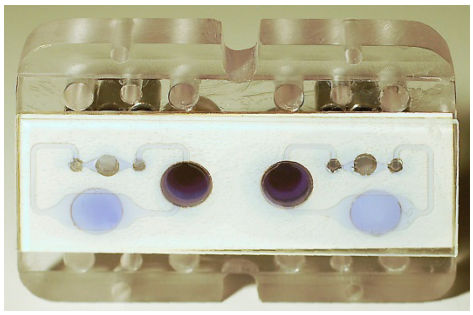

FIG. 3:
Prototype of multilayer based lab-on-chip-system with integrated membranes, pumps and valves