FAST DEVELOPMENT STRATEGY: ONE-WEEK-TO-CHIP

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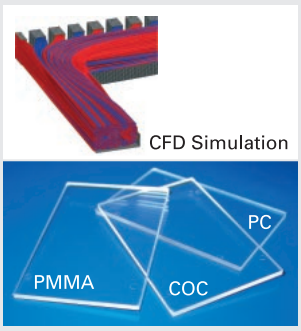
Abstract

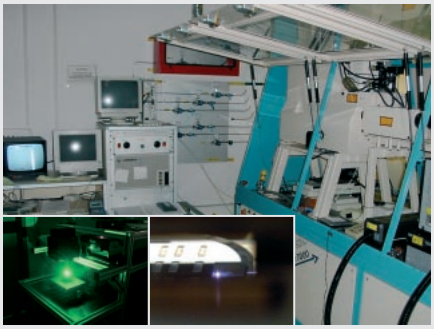
Looking at recent reviews a wide range of micro technological solutions for manufacturing lab-on-a-chip systems is available. Mass manufacturing techniques like injection moulding and lamination processes are established that allow the production of final disposable products at reasonable costs. What is missing is the transfer of academic results to a robust design that meets manufacturing demands and customer's needs. A process is needed that allows fast tests on concepts and for the validation of the final chip design. Such tests pick up more and more speed the more you can rely on already established elements.
A process that meets these demands is the one-week-to-chip. This means: Having the idea on Monday, putting it into a CAD design until Tuesday, realising it with prototyping techniques, assembling it on Thursday and putting it to the test in the lab on Friday. If a thorough theoretical understanding is needed also simulations using the generated CAD design can be implicated before manufacturing. This provides also a sound theoretical basis for the interpretation of the experimental findings.
The basis therefore is twofold: 1) advanced prototyping technologies and 2) standardization. For the realization process this means that there are blank standard chips already available on the shelf. Using these blanks processes to generate channel systems and to do the assembly are standardised and only have to be adapted to the special needs.

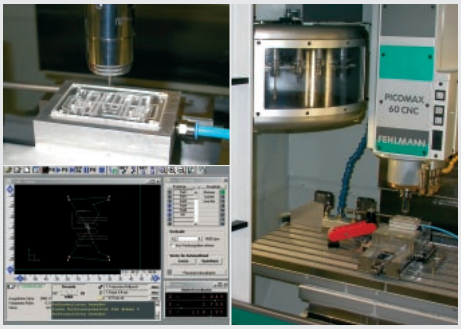
Procedure and Realization

Monday to Tuesday

A customer has a new idea on Monday morning. A sketch is made and handed over to a design engineer. The CAD drawing is realized with tools like ProEngineer, AutoCAD or SolidEdge. Complex questions could be answered by additional CFD simulations which helps to avoid design failures efficiently. The chip blanks (typical dimension: 64 x 43 mm) are manufactured by injecting molding and available in, e.g., Polymethyl methacrylate (PMMA) and Cycloolefin copolymer (COC).





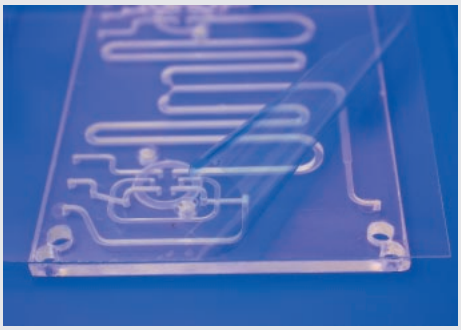


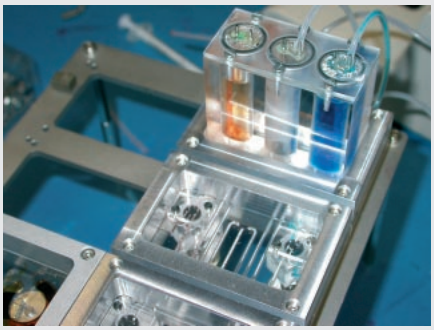
Wednesday to Thursday

After design freeze the manufacturing process begins. Down to 200 µm the channel structures are realized by CNC milling (Fehlmann Picomax 60 CNC). The CAD data is easily transferred to machine-code supported by software. Below 200 µm of structure size laser treatment (excimer laser Exitech 700, 193 nm, 200 mW) could be applied, not only as one manufacturing possibility but also as a subsequent process step after micro milling. Although micro milling forms rough surfaces compared to injection molding and hot embossing it is less time consuming for prototyping and design failures could be detected faster and corrected less expensive.

Thursday to Friday

After the manufacturing of the microchannels the chip has to be sealed. For fast and easy tests adhesive tape would be a good choice. For longer durability or chemical resistivity the chips are sealed by solvent bonding specialized for different kinds of polymers. A modular chip platform serves as housing for final tests. Each module consists of a lower and an upper frame. Between these frames the actual chip comprising specific microfluidic components is clamped. Once a module is equipped with an individual polymeric chip it can be placed at a specific position on a base plate and combined with at least twelve different modules.





Conclusions

With the presented process of one-week-to-chip a concept is established that enables rapid and efficient development of microfluidic solutions, thereby supporting the increasing demand for sensitive clinical and industrial analytics and accelerating the development process for lab-on-a-chip systems. Individual microfluidic chips made from different kinds of polymers or other materials can be combined in an arbitrary arrangement and interconnected with each other in a two-dimensional array for testing. The channel structures of each module are designed in CAD and translated into polymer blanks by CNC machines or excimer lasers utilizing CAM technology. Finally, the chips are covered with a foil by e.g. solvent bonding or other techniques. Thus, it is possible to develop test chip designs quickly and use them immediately within the presented modular platform. In urgent cases or cases of redesign the manufacturing process could be accelerated up to one or two days to chip. This strategy provides a new level of quality and efficiency with respect to the manufacture of microfluidic prototypes. Time to market is reduced and also the development risk in microfluidics and new lab-on-a-chip systems is kept within a limit. This approach offers the possibility to concentrate more on bioanalytical and microfluidic tasks than on peripheral devices.