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Manufacturing pipeline for high-pressure resistant microfluidics

E. Uhlmann[1,2], C. Hein[1], C. H. Weber[1], G. Duerre[1]

[1] Fraunhofer Institute for Production Systems and Design Technology IPK, Germany

[2]Institute for Machine Tools and Factory Management IWF, Technische Universität Berlin, Germany

gregor.duerre@ipk.fraunhofer.de

Abstract

Microfluidics has developed into one of the most important fields of research in biosensing, lab-on-a-chip systems, and also vaccine production. The possibility of a highly controlled, small-scale reaction environment has led to widespread use in biological and pharmaceutical applications. Due to the lack of a fully understood manufacturing process chains, the manufacturing process is time consuming and involves a large number of error-prone intermediate steps.

The objective of the presented research is to develop a lean manufacturing process chain for the fabrication of high pressure resistant microfluidic systems, which can be used for a wide range of different fluidic structures and can lead to a significant reduction in development time.

A 5-axis high-precision machine tool creates the defined channel structures in the substrate material, which consists of either COC or PC. These materials have optimal properties in terms of subtractive manufacturing, biocompatibility and adhesion conditions. Following the milling process, the substrates are cleaned with isopropanol and nitrogen, and the contact surfaces are subjected to corona treatment. The hydrophilic material properties thus produced form the basis for a stable adhesive bond and the required wetting properties. Bonding parameters such as pressure, temperature or process duration have been defined for COC and PC and can easily be adapted to different materials or scales. The permanent connection between the microfluidic system and the adapters of the connection tubing, which is free of air entrapment and leakage, is realized with a UV-curing adhesive.

With this process chain, it is now possible to manufacture high-pressure resistant microfluidics for Reynolds numbers up to Re = 3000 and pressures of p = 30 bar within one hour from design concept to finished product. The microfluidics produced have a dimensional accuracy of G ≤ 3 µm with minimal lateral deformation of the channel height.