AutoCUT: Repeatable results in PDMS-Production

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Microfluidics chips are produced for research purposes by silicone casting. To use these chips for small scale applications in the future the production needs to be more reproducible to generate chips with identical size and shape. Therefore, automation of the currently manual manufacturing processes is required.

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Introduction and Objectives

The microfluidic chips are fabricated in the BFH clean-room laboratory by using photolithography to image a mask on a 4-inch silicon wafer. This silicon wafer can then be used as a negative mould to cast a 4-inch disk of polydimethylsiloxane (PDMS). A PDMS wafer can contain of up to 16 microfluidic chips, which are then cut out by hand with a blade. A drop of fluidics can then be placed on the chip's entrance that draws it in by capillary forc-es such that the liquid can be investigated in the field of view by a microscope. This field of view of 200 x 300μm² must coin-cide with a microfluidic channel on the chip that has a length of 2mm and a width of 200μm. Thus, precise placement under the microscope for proper aligned imaging is crucial for applications.
The thesis aims to optimize the process of manufacturing the microfluid chips so that they are reproducible.

Research Method and Implementation

The thesis developed a functional prototype. A fixture, consisting of three components, was designed that allows the chip to be picked up and specifically guided so that the field of view is directly below the lens of the microscope at a distance of 0.5mm. To reproducibly fabricate the microfluid chips and thus be able to use the fixture with the intended alignment, a cutting system consisting of mechanics, electronics, and software was designed, developed, and built from scratch to cut the chips of the PDMS slice fully autonomously. Further, a new casting mold was designed for the PDMS discs, allowing them to be cast in such a way that they can be processed by the cutting system.

Results

The cutting system has five stepper motors controlled by a Python program on a Raspberry Pi, allowing movement in four degrees of freedom. A springloaded round blade used for cutting the PDMS can thus be moved in the X and Y directions while the PDMS slice can be rotated for proper alignment and moved in Z direction to guide it to the blade. For the cuts to be made autonomously, proper detection of the slice was implemented using a camera. Image processing is used to detect the position and orientation of the slice. The generated data can then be used to calculate the cutting pattern.
Tests with paper PDMS wafers show that the cutting system can cut the microfluidic chips fully automatically with a maximum tolerance of 1 mm. This more precise production now enables a fixture to be used to place the microfluidic chip under the lens of the microscope with the highest accuracy, allowing direct viewing of the field of view without alignment. This enables future automated fluid image analysis.

Implications and Recommendations

The thesis demonstrates that it is feasible to develop a customized cutting system that both serves as a prototype and can also be used in a productive way. To make the system easier to use for different microfluid chips, a plugin could be implemented to allow new data to be entered directly into the graphical user interface. To improve the accuracy of the system, the quality of several components would need to be increased.

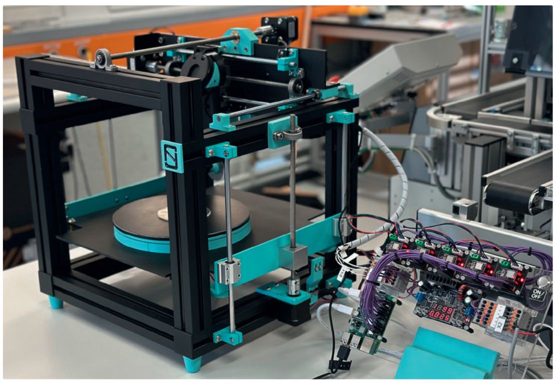

Figure 1: Cutting system with control unit for automated cutting of microfluid chips.