Microfluidic Imaging:
Pixelation and Pre-concentration for
Biological and Chemical Sample Analyses

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Abstract

The novel concept “microfluidic imaging'” that spatially resolves the composition of complex biological and chemical samples by pixelation within a microfluidic platform was explored. The approach integrates two different microfluidic techniques: sample pre-concentration and droplet-based pressure driven flow system.

An electrokinetic pre-concentration method for amino acid enrichment was explored. This technique can be integrated to manipulate pixelated sample that have low-abundant analytes in very small volumes. Agarose gel excelled in fixing various samples on the surface and in the parallel uptake and pixelation step.

The presented device was designed and fabricated to image samples by discretising targeted areas into droplets suspended in a two-phase microflow. These droplets are transferred from parallel to serial mode for data readout similar to a CCD camera, thus referred as “microfluidic imaging”. Three major process steps conducted within the device were parallel sample pixelation and uptake, transfer from parallel to serial mode into a microchannel for individual analysis and image generation. This microfluidic pixelation method is capable of obtaining non-averaged data from heterogeneous specimen, with reduced arduous preparation steps while retaining the spatial information.

The ability to convert the compartmentalised information from a parallel to serial manner is an advantage this device has allowing to approach closer to automation and to implement preparation, separation and detection steps. In this respect, the concept has clear superiority over currently available techniques for capturing of cells from tissue, such as laser microdissection or capillary capture methods. With further pixel size reductions, controlled encapsulation of single cells in single droplets comparable in size to the cell diameter is accomplishable. This way the application of the concept in high throughput screening, clinical diagnosis, single cell bioreactors, and the investigation of stem cell differentiation can be appreciated, emphasising the importance of cellular heterogeneity within a population at single cell level.

Dortmund, 2008