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Attension [Application Note] 15

Contact angle measurements for research, product development and quality control of microfluidic chips

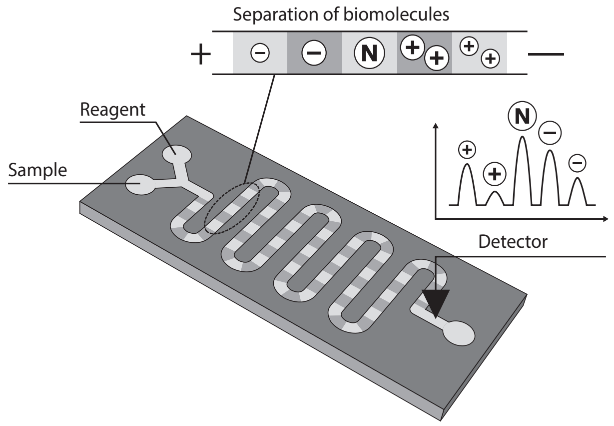
This application note describes how optical tensiometers are utilized in microfluidic research.

Introduction

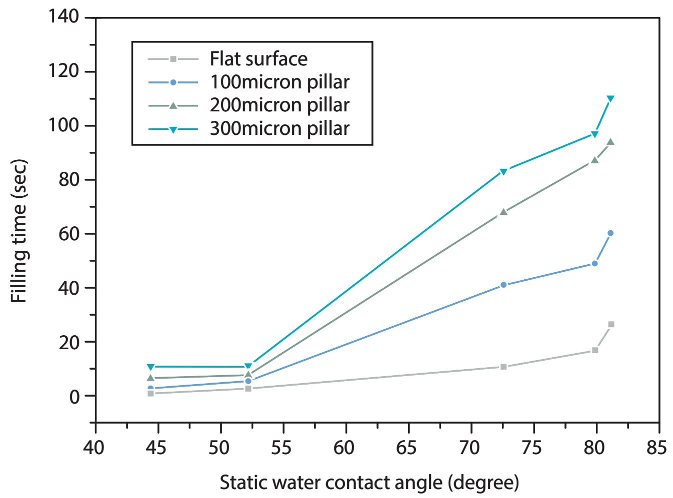
Microfluidics is a field of science that studies the behavior of fluids (liquid and gases) in micrometer scale structures. The behavior of fluids differs significantly when moving from macro sized systems in the micro sized devices due to increased surface to volume ratio. Factors such as surface tension and fluidic resistance start to dominate the system. Main application area for microfluidics is in pharmaceutical and biological research as well as in diagnostics although applications can also be found in energy and electronic sectors as well [1]. Microfluidics is a fast growing field that is in the stage of moving from the research laboratories into commercial products. Small spin of companies have emerged especially in central Europe and larger medical companies have departments devoted to microfluidic research mainly in USA. Japan has also been an active player in this field.

The first microfluidic components were introduced more than 30 years ago. These components were inkjet printing nozzle arrays that were etched on silicon and gas chromatograph (GC) fabricated on the silicon wafer. The gas chromatography was the first step towards lab-on-a-chip which goal is to shrink the standard laboratory instrument into microchip. Compared to standard size gas chromatography, these chips are smaller in size and require lower fluid volumes, resulting in less waste, lower reagent costs and fewer sample required for diagnostics. Faster analysis and response times are also achieved due to short diffusion distances and fast heating and cooling, which are required e.g. for efficient duplication of DNA. Several different functionalities, such as sample pre-treatment, separation and detection can be integrated on the same chip. Since chips are fabricated by using microfabrication techniques adopted from the semiconductor industry, the fabrication costs can be kept low, making disposable chips cost-effective. Disposable chips are especially useful in diagnostic applications, since they reduce the risk of cross-contamination between different patient samples.

Schematics of a typical microfluidic chip is presented in Figure 1. The biomolecules in the sample eg. blood, are separated from each other by size and electric charge. Molecules with the positive charge travel faster toward the cathode than ones with the negative charge. The molecules are detected at the end of the micro channel by using eg. fluorescence light. The amount of each molecule in the sample can be seen from the spectrum.



[Figure 1]: Schematic of the microfluidic chip.



[Figure 2]: Effect of static contact angle and micro pillar diameter to the filling time of the microfluidic channel.

Due to high surface to volume ratio, surfaces play a key role in microfluidic research. In microfluidic chips, the liquid is often driven through the microchannels just by using capillary forces. When capillary forces are utilized, the contact angle of the microchannel surface has to be low (well below 90 °) for sufficient filling times. Microfluidic chips are often fabricated on polymer substrates which are hydrophobic in nature. Contact angle measurements are utilized to study effectiveness and stability of these treatments [2]. Contact angle measurements are also used as a quality control tool e.g. to evaluate the quality of the functional coating on microfluidic chip.

Case study: Effect of surface wetting to the filling time of microfluidic chip

Mukhopadhyay et al. studied the effect of the static contact angle (CAM 200, Biolin Scientific, Finland) and micropillar diameter on the filling time of the microchannel [3]. Flat channel surface as well as three different pillar diameters, 100µm, 200µm and 300µm, were tested. Different static contact angles were achieved by plasma treatments and surface coatings. Results are presented in Figure 2. It can be concluded that pillars have significant effect on the filling time with higher contact angle values. However when static contact angles are low, the effect was less significant.

Conclusion

Microfluidics is a growing field that finds applications in many industrial areas. Contact angle measurements are important in microfluidic research and quality control since surfaces with different wettabilities are often utilized in microfluidic chips. Also different type of surface treatments are often implemented to modify the contact angle of the surface to be suitable for the certain application.

References:

[1] G.M. Whitesides, "The origins and future of microfluidics", Nature 442 (2006) 368.

[2] V. Jokinen, P. Suvanto and S. Franssila, "Oxygen and nitrogen plasma hydrophilization and hydrophobic recovery of polymers", Microfluidics 6 (2012) 016501.

[3] S. Mukhopadhyay, S.S. Roy, R.A. D'Sa, A. Mathur, R.J. Holmes and J.A. McLaughlin, "Nanoscale surface modification to control capillary flow characteristics in PMMA microfluidic devices", Nanoscale Reasearch Letters 6 (2011) 411.

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