

Development of a Microfluidic Impedance Spectroscopy Module for Label-free Particle Sensing and Counting

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A microfluidic module suitable to automatically detect and count particles flowing in microfluidic channels was developed as a cytological tool, based on the micro Coulter particle counter principle using a diced borosilicate glass chip integrated in a multilayer microfluidic module. This tool is capable of easily combining various channel structures utilizing the modular chip-stack¹. The glass-chip contains Cr/Au microelectrodes designed for impedance spectroscopy. This method has the potential for “label-free” characterization and detection of particles and cells due to the fact that it does not require surface modification of particles such as tagging with fluorescence markers and is therefore less complicated and easier to miniaturize than automated optical detection methods.

Use of impedance spectroscopy in extension to the Coulter counter and sizing principle has shown that properties related to the cell membrane and cytoplasm can be measured electrically². A cell can be modeled as uniform sphere of a resistance (cytoplasm) and a non-conductive thin membrane as capacitance per unit area suitable for electrical detection. The particle size as well as the applied frequency directly affects the measured signal due to the large capacitance of the particle. The detection takes place between pairs of coplanar arranged Cr/Au microelectrodes within a microfluidic channel to sense an impedance change caused by particles carried by a liquid laminar flow passing the detection area. Interactions at the electrode-electrolyte interface, due to electrode design, material and bonding methods are crucial factors for measurement performances. E.g. the impedance of the interface creates an RC-filter at the input of the measurement amplifier which may limit the performance of the electrode measurement ability through filtering of the signal in an undesired way.

Integration and leak-free adhesion of the electrodes containing glass-chip into the PMMA module was achieved by passively aligning it in a molded recess area and a combination of UV-activation and thermal bonding yielding an alignment accuracy of better than 15 μ m. The electrodes are connected to an off-chip printed circuit board containing amplification electronics followed by an additional lock-in amplification stage to demodulate the out coming signal. Each particle’s impedance signal is recorded by a data-acquisition program.

¹ Datta, P., et al. *Microfluidic Platform for Education & Research*. in *Proc. COMS2008, Commercialization of Micro and Nano Systems*. 2008. Puerto Vallarta, Mexico.

² Gawad, S., et al., *Dielectric spectroscopy in a micromachined flow cytometer: theoretical and practical considerations*. *Lab on a Chip*, 2004. **4**(3): p. 241-251.