Real-time in-flow impedance sensing of microparticles using gold nanowires

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Detection of pathogens at low concentrations and sample volumes is one of the mainstreams in the current biomedical research due to the distinct demographic changes and wide spreading of the chronic and severe illnesses. Conventional pathogen detection approaches enzyme-linked immunosorbent assay (ELISA), flow cytometry or DNA amplification using polymerase chain reaction require high effort and time with regard to sample preparation, signal processing and data analysis. Furthermore, since these techniques rely on optical detection, high sample volumes, analyte labeling and bulky equipment is mandatory.

Consequently, there is a high demand for precise, cheap and portable sensor devices for application in the environment where the patient needs a proper treatment without available qualified personnel and hospitals, e.g. in developing countries. In this, the next generation of bio-sensors for the detection of biological species also require high sensitivity and selectivity at high throughput due to low concentration of analytes, *e.g.* pathogens[1], and in complex media like blood or saliva.

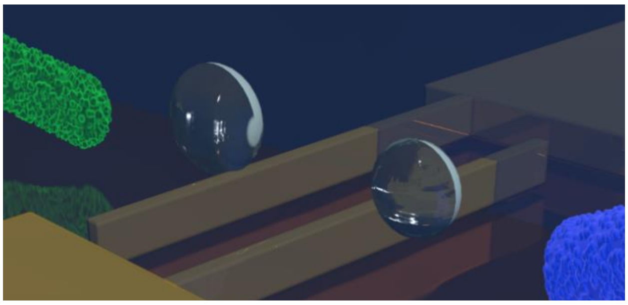

Figure 1: Schematic illustration of the nano capacitor sensing device. The analyte solution is guided between the gold nanowire electrode pair thereby altering the impedance of the sensing structure

We faced the challenge to establish a MEMS-sensor capable of single cell detection based on dynamic impedance analysis using gold nanowires to overcome the aforementioned limitations (see Figure 1). The detection of microparticles one by one is realized in flow, employing the cytometry principle. The transport system consists of a 3D focusing microfluidic structure, which converts the particle solution to interdigitating top-down fabricated gold nanowires, allowing higher sensitivity and selectivity due to electric field enhancement between the nanowires[2] (See Figure 2). We demonstrate the detection of single particles in real-time based on impedance changes in a proof-of-principle approach.

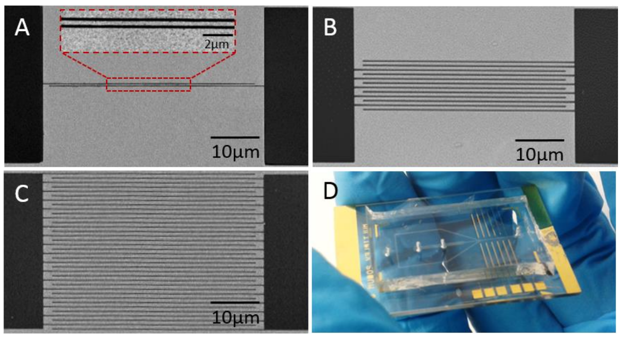

Figure 2: Geometries of the sensing structures with increasing sensing area: (A) Single nanowire pair (B) 12 nanowires pairs resulting in a sensing area of 500µm² (C) 36 nanowires pairs resulting in a sensing area of 2500µm²

References

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