

Active MOS Capacitive Sensor Array for Lab-On-a-Chip Applications

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Abstract. Lab-On a-Chip devices represents a synergistic combination of microelectronics technology and molecular biology, which holds the promise of improving, the way many important molecular analyses are performed.

In this work we introduce an active Metal-Oxide-Semiconductor (MOS) capacitive sensor for fast, massively parallel and highly selective nucleic acid analysis. Arrays of 50-100 Si-SiO₂-Au sensing areas were fabricated using standard Si fabrication techniques. Multiple probe sequences were immobilized on the Au electrodes using alkyl thiol linkages. The immobilization and hybridization events were monitored by measuring the Capacitance-Voltage (C-V) characteristics across the sensing elements. Due to the intrinsic negative charge on the DNA molecules, during the immobilization of the single stranded probe sequence on the Au metal gate, the C-V characteristics show a measurable shift in the direction of negative gate bias. The presence of an additional layer of negatively charged DNA molecules due to hybridization with complimentary targets enhances this effect.

Our experiments demonstrate that the rate and selectivity of hybridization reaction can be drastically improved by the application of an external electric field. Since oligomers in solution carry a net negative charge they can be transported towards the probe molecules immobilized on the sensor surface (Au) by application of a positive bias on the Au surface with respect to an electrode in solution. This electric field assisted transport of oligomers towards the immobilized probes will drastically enhance the rate of hybridization event. The movement of the target nucleotide molecules toward the immobilized probe sequences, facilitated by electric field can result in a concentrating

effect of the target molecules near the surface enabling the binding of probe and target sequences at a much higher rate.

The electric field induced transport of nucleotide molecules is also used for enhancing the selectivity of the sensing process. The sensor selectivity depends on the specificity of the binding between the target and probe sequences. The unhybridized target molecules which stay non-specifically bound on the sensor surface (Au electrode) will also contribute to the sensing signal. By applying an appropriate negative bias on the Gold (Au) surface these nonspecific target nucleotide molecules is released and repelled away from the sensing area, thereby eliminating their effect on the sensing signal.

By adjusting the electric field to the appropriate level, selective dehybridization of the target-probe pair is also demonstrated, which is promising for single nucleotide polymorphism (SNP) analysis. This result is confirmed by the use for fluorescently labeled target sequences.

