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Chemical and Biomolecular Detection at a Polarizable Electrical Interface

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Abstract : Development of low-cost, rapid, sensitive and portable biosensing systems are important for the detection and prevention of disease in developing countries, biowarfare/antiterrorism applications, environmental monitoring, point-of-care diagnostic testing and for basic biological research. Currently, the most established commercially available and widespread assays for portable point of care detection and disease testing are paper-based dipstick and lateral flow test strips. These paper-based devices are often small, cheap and simple to operate. The last three decades in particular have seen an emergence in these assays in diagnostic settings for detection of pregnancy, HIV/AIDS, blood glucose, Influenza, urinary protein, cardiovascular disease, respiratory infections and blood chemistries. Such assays are widely available largely because they are inexpensive, lightweight, and portable, are simple to operate, and a few platforms are capable of multiplexed detection for a small number of sample targets. However, there is a critical need for sensitive, quantitative and multiplexed detection capabilities for point-of-care diagnostics and for the detection and prevention of disease in the developing world that cannot be satisfied by current state-of-the-art paper-based assays. For example, applications including the detection of cardiac and cancer biomarkers and biothreat applications require sensitive multiplexed detection of analytes in the nM and pM range, and cannot currently be satisfied with current inexpensive portable platforms due to their lack of sensitivity, quantitative capabilities and often unreliable performance. In this talk, inexpensive label-free biomolecular detection at liquid interfaces using a newly discovered electrokinetic phenomenon known as fluidic dielectrophoresis (fDEP) is demonstrated. The electrokinetic approach involves exploiting the electrical mismatches between two aqueous liquid streams forced to flow side-by-side in a microfluidic T-channel. In this system, one fluid stream is engineered to have a higher conductivity relative to its neighbor which has a higher permittivity. When a “low” frequency (< 1 MHz) alternating current (AC) electrical field is applied normal to this fluidic electrical interface the fluid stream with high conductivity displaces into the low conductive stream. Conversely, when a “high” frequency (20MHz) AC electric field is applied, the high permittivity stream deflects across the microfluidic channel. There is, however, a critical frequency sensitive to the electrical differences between each fluid phase – the fDEP crossover frequency – between these two events where no fluid deflection is observed, and the interface remains fixed when exposed to an external field. To perform biomolecular detection, two streams flow side-by-side in a microfluidic T-channel: one fluid stream with an analyte of choice and an adjacent stream with a specific receptor to the chosen target. The two fluid streams merge and the fDEP crossover frequency is measured at different axial positions down the resulting liquid

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