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iTIRF- Cell phone based biosensor for molecular diagnostics

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Smart phones have become indispensable part of everyday life. In 2013, there were more than 7 billion cell phones worldwide, including more than 4 billion users from the developing countries. Massive manufacturing of smartphones stimulated gigantic reduction of their cost and rapid progress of their hardware and software. Advanced state of the art of cell phones has changed the landscape of many technological areas, including biodetection. Excellent optical sensors-low light high resolution CCD cameras are now available in billions of smartphones. This progress promises numerous opportunities for optical sensors in the area of molecular diagnostics. In this paper we will introduce novel molecular diagnostics technology, referred to as "iTIRF™". iTIRF sensor is based on iPhone and employs Total Internal Reflection Fluorescence (TIRF). The sensor consists of a cradle, a smart phone, and a cartridge. HTC One and other smartphone can be used with iTIRF as well. iTIRF cartridge carries enhanced TIRF microarrays that simultaneously detect protein, nucleic acid, and metabolite biomarkers. The sensor requires no or minimal sample preparation and is capable of detecting from a single to several thousands of molecular markers in a 50-microliter sample of biological fluids, including whole blood. Limit of Detection (LOD) for miRNA is 10-18M. For proteins and metabolites LOD depends on the assay; for certain antibody-based assays LOD is at the level ~10-15 M. Broad dynamic range - 10-8-10-18 M covers the entire spectrum of clinically significant concentrations for most of biomarkers. Classical TIRF microarrays operate with small, sub-monolayer amounts of antibodies (and probe DNA) immobilized on the surface. TIRF signal from the sub-monolayer is inherently small. Low light photodetector, e.g. EMCCD camera is necessary for sensitive detection. Unlike classical TIRF, iTIRF uses larger amounts of molecular beacons and antibodies per unit area of bioassay spots. iTIRF signal is thousand-fold greater than that in classical TIRF. Therefore, CCD cameras of smartphones are sensitive enough for detecting iTIRF signal. For the enhancement, iTIRF employs a novel patent-pending technology, which uses unique properties of silk fibroin, an amazing natural material. Firstly, silk hydrogel captures the excitation light allowing silk to become an integral part of TIRF lightguide. The amount of silk-immobilized bioassay molecules increases thousand-fold. Secondly, silk fibroin scaffold provides biologically friendly environment to bioassays, increasing their sensitivity and selectivity. Finally, silk fibroin stabilizes antibodies and prolongs their shelf life to several months. Because of several unique advantages iTIRF biosensors will become popular devices for hundreds of applications, including biodetection and molecular diagnostics. TIRF Labs pursues the goal to make iTIRF sensors available and affordable to broad public. At the initial stage, we plan to make cartridge blanks and iTIRF sensors cradles available to broad biodetection community, including academic, industrial, and government research groups.

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