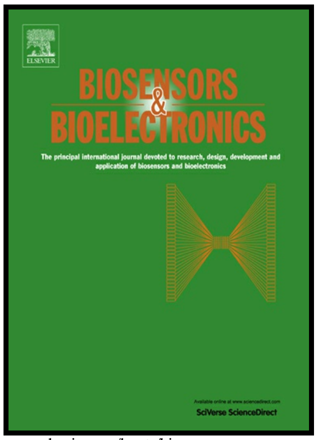

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A Compact, Low-cost, Quantitative and Multiplexed Fluorescence Detection Platform for Point-of-Care Applications

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Abstract

An effective method of combating infectious diseases is the deployment of hand-held devices at the point-of-care (POC) for screening or self-monitoring applications. There is a need for very sensitive, low-cost and quantitative diagnostic devices. In this study, we present a low-cost, multiplexed fluorescence detection platform that has a high sensitivity and wide dynamic range. Our system features inexpensive 3x3 mm interference filters with a high stopband rejection, sharp transition edges, and greater than 90% transmission in the passband. In addition to the filters, we improve signal-to-noise ratio by leveraging time for accuracy using a charge-integration-based readout. The fluorescence sensing platform provides a sensitivity to photon flux of ~1x10^4 photons/mm^{2}sec and has the potential for 2 to 3 orders of magnitude improvement in sensitivity over standard colorimetric detection that uses colored latex microspheres. We also detail the design, development, and characterization of our low-cost fluorescence detection platform and demonstrate 100% and 97.96% reduction in crosstalk probability and filter cost, respectively. This is achieved by reducing filter dimensions and ensuring appropriate channel isolation in a 2x2 array configuration. Practical considerations with low-cost interference filter system design, analysis, and system performance are also discussed. The performance of our platform is compared to that of a standard laboratory array scanner. We also demonstrate the detection of antibodies to human papillomavirus (HPV16) E7 protein, as a potential biomarker for early cervical cancer detection in human plasma.

Keywords: Point-of-care, diagnostics, multiplexed, fluorescence, colorimetry, limit of detection

1. Introduction

The relatively lower performance of lateral flow assays (LFAs) compared to central laboratory assay techniques is a major factor limiting the widespread implementation of fluorescent LFAs in hand-held diagnostic devices (Tang et al., 2016). Other issues include the cost and bulkiness of optical and electronic components. The development of low-cost, compact, and disposable devices, most notably those intended for use in point-of-care (POC) settings have received a lot of attention in the last 2 decades (Hu et al., 2014; Kumar et al., 2015; Lee et al., 2013). Several groups have attempted to develop portable and sensitive platforms aimed at improving the sensitivity and limit of detection (LOD) for POC diagnostic devices. However, many high performance fluorescence systems rely on bulky optical components and expensive detectors including cooled charged coupled devices (CCD), complementary metal-oxide semiconductor (CMOS) cameras, or photomultiplier tubes (PMTs). Many systems intended for POC application still use bulky laser light sources,

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