A Portable Fluorescent Sensing System Using Multiple LEDs

Young-Ho Shin[1], Jonathan Z. Barnett[2], Maria T. Gutierrez-Wing[2], Kelly A. Rusch[3], and Jin-Woo Choi[1]

[1]School of Electrical Engineering and Computer Science, [2]Department of Civil and Environmental Engineering
Louisiana State University, Baton Rouge, LA 70803, USA

[3]Office of Research and Creative Activity
North Dakota State University, Fargo, ND 58102, USA

Abstract

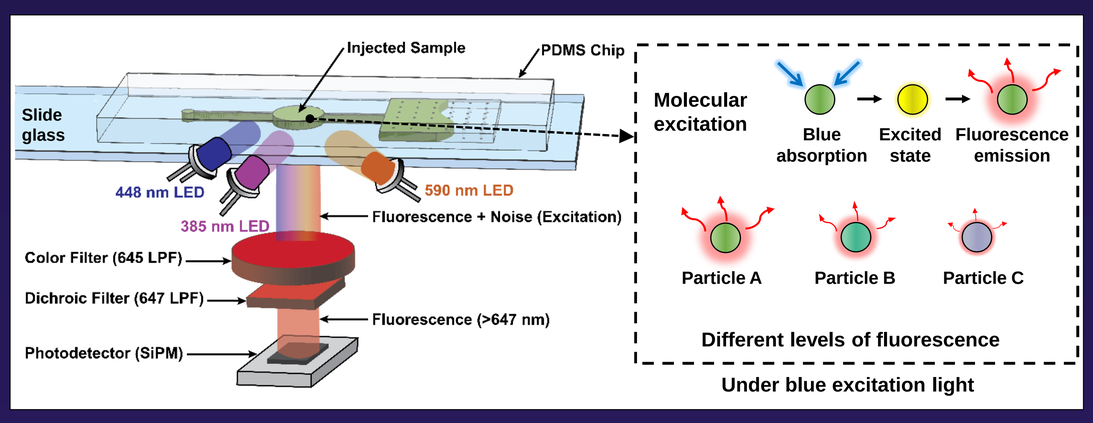
This work reports the development of a portable multi-excitation LED based fluorescent sensing platform to detect and distinguish multiple analytes. The sensor system has three different wavelengths (385 nm, 448 nm, 590 nm) of excitation light emitting diodes (LEDs) for selectively stimulating the target analytes, and a highly sensitive silicon photomultiplier(SiPM) was used to detect the corresponding fluorescent signal. Based on the unique pattern of fluorescence collected from each sample, simultaneously differentiate the one analyte from the other in a mixed solution. As a demonstration, the microalgae and cyanobacteria samples are used. The microalgae biomass is determined by measuring the chlorophyll a fluorescence and cyanobacteria biomass is determined by measuring the phycocyanin fluorescence. A custom-built electronic system processes the measured data and simultaneously displays the result with an integrated LCD screen.

Introduction

- A remote sensing system for multi analyte detection has a great potential in environmental, clinical, and industrial applications and
- Fluorescence-based sensor provide high specificity, sensitivity, and speed.
- This presentation reports a portable fluorescent sensing platform containing multiple excitation LEDs for multi analyte detection.

Detection principle

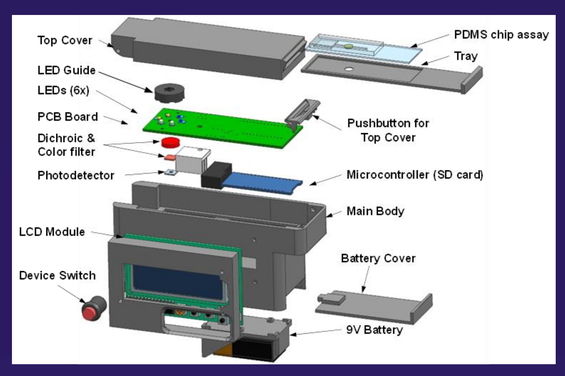
- Each photo-pigment molecule has different responsivity to the different wavelength of the light excitation
- Three LEDs are sequentially switched on/off to measure the unique fluorescence pattern of the target of interest.

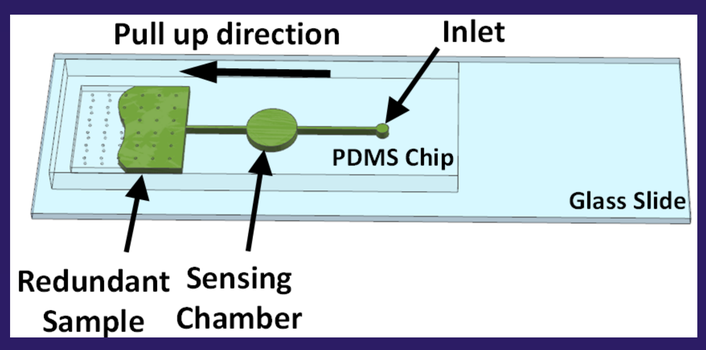


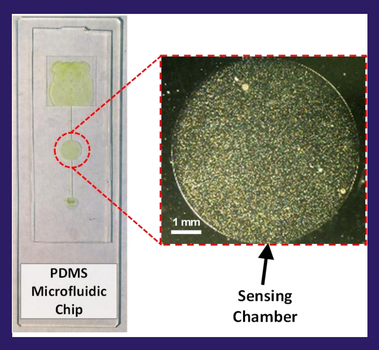
System Overview

System Design

- Exploded view of a fluorescent sensor platform
- 3D printed sensor system with a disposable microfluidic chip for a remote sensing application







Experimental Results

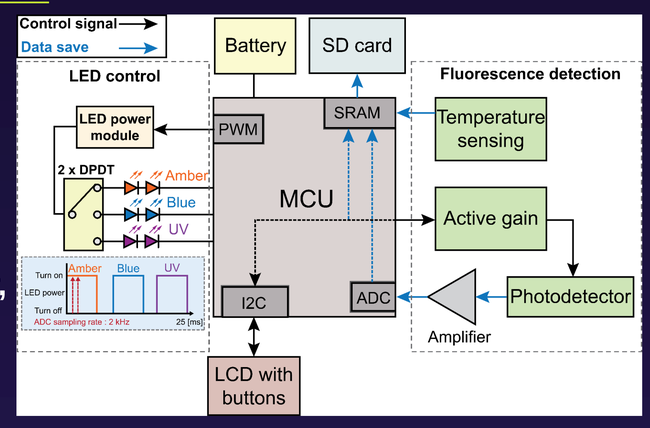
Fluorescence-based microalgae and cyanobacteria detection

- Microalgae (*Chlorella vulgaris*) and cyanobacteria (*Spirulina*) have different photo-pigments: chlorophyll *a* and phycycocyanin
- Different wavelengths of excitation peak for each pigment provides the multi-analyte capability

	Microalgae	Cyanobacteria
Sensing pigment	Chlorophyll *a*	Phycocyanin
Absorption λ	440 nm	620 nm
Emission λ	680 nm	645 nm
LED excitation λ	448 nm	590 nm

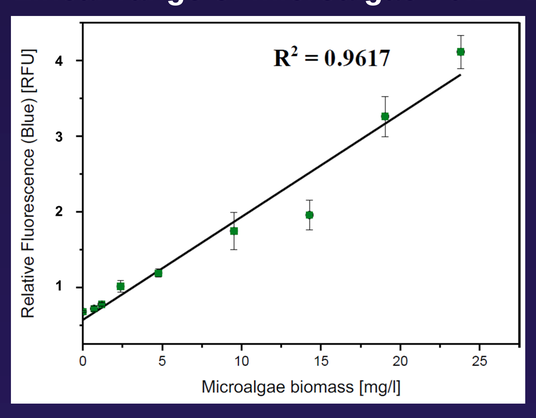
Electronic design configuration

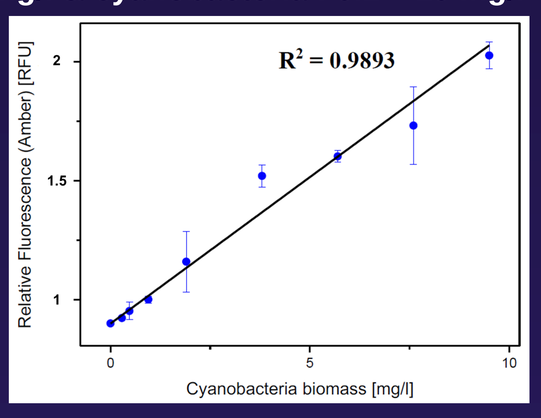
- The sensor system consists of LED control, fluorescent detection, and peripheral circuit modules.
- Adjustable switching current was generated for LED control, and the photodetector, SiPM, was reverse biased with an active gain control for a temperature compensation.



Measurement of a single analyte

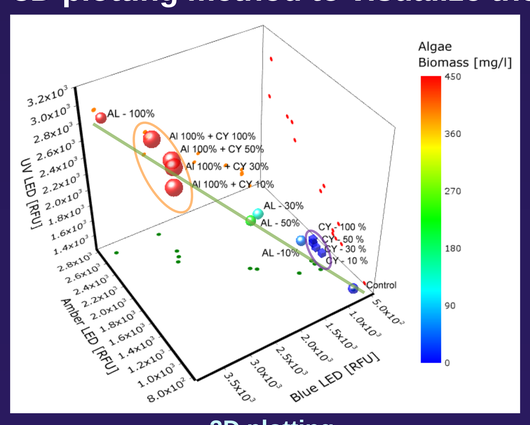
- Linear range of microalgae : 0.1 – 25 mg/l & cyanobacteria : 0.1 – 10 mg/l



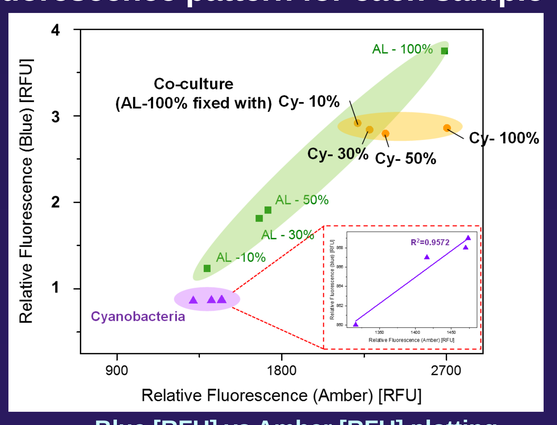


Classification of multi-analyte

- 3D plotting method to visualize the fluorescence pattern for each sample



3D plotting



Blue [RFU] vs Amber [RFU] plotting

Discussion and Conclusions

- A portable fluorescent sensing system with multicolor LEDs was developed to simultaneously detect the microalgae and cyanobacteria.
- It can be used as generic fluorescent sensor platform for on-site detection of other biochemical molecules.

Future Improvements:

- Future improvements will include integrating additional excitation LEDs and developing an advanced multivariate algorithm for three or more analytes.

Acknowledgements

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