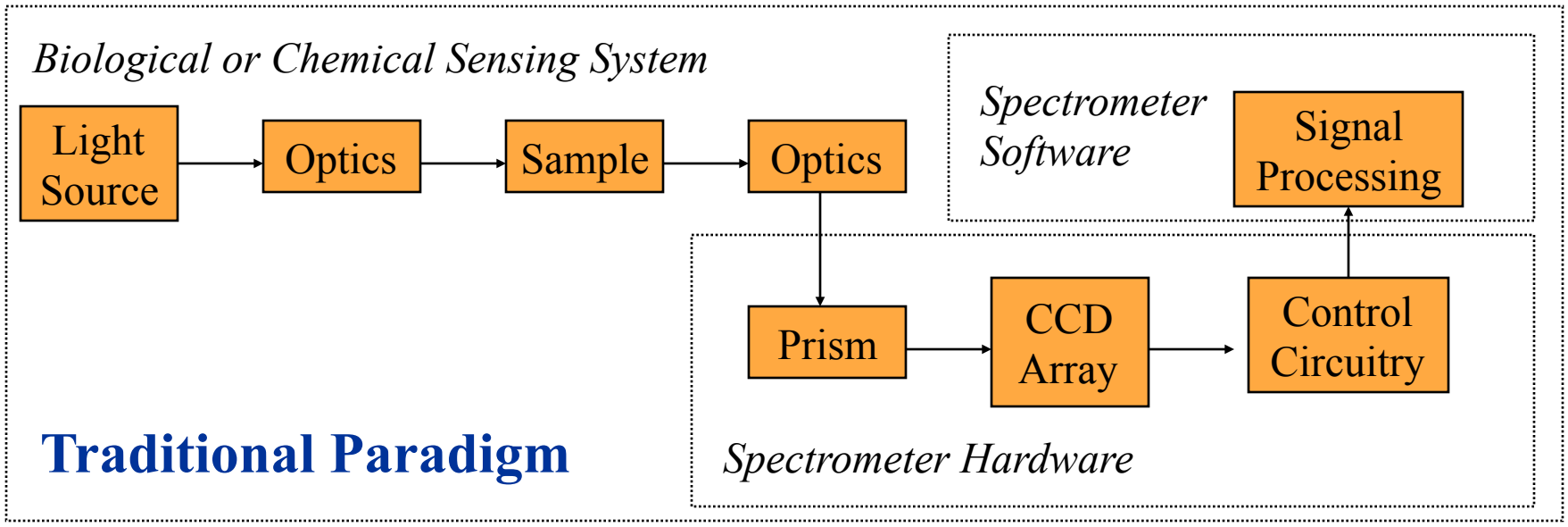
What's the problem?

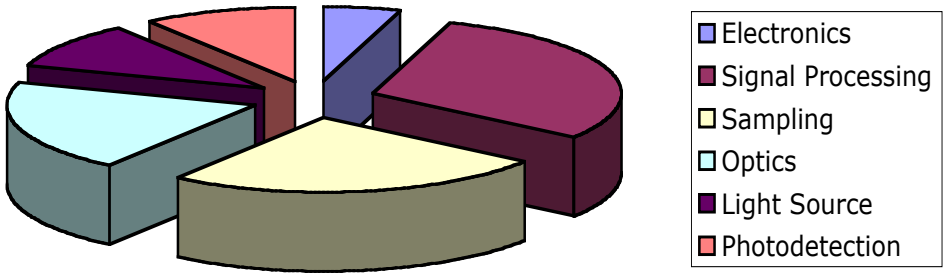
Reducing the cost/size/power envelope of
Traditional Spectrometer Design
is impossible
Within reasonable expectations of performance.

Ocean Optics sells
the current market standard
in portable spectrometers at
$4000-$10,000 (configured)



What are the barriers to solving the problem?

Footprint reduction
(in the spectrometer's present form)
will reduce performance.

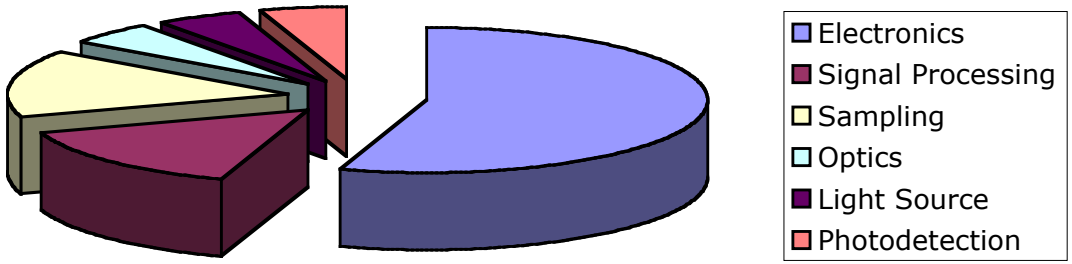


Approach	Size/Power	Accuracy
Benchtop	Large/High	High
Semi-Portable	Moderate/Low	Moderate
Portable	Small/ Low	Low

Spectral Dispersion Optics require high resolution photodetection and complex signal processing for achieving target performance

What does the new design do?

The new design paradigm enables scalable systems without compromising performance.



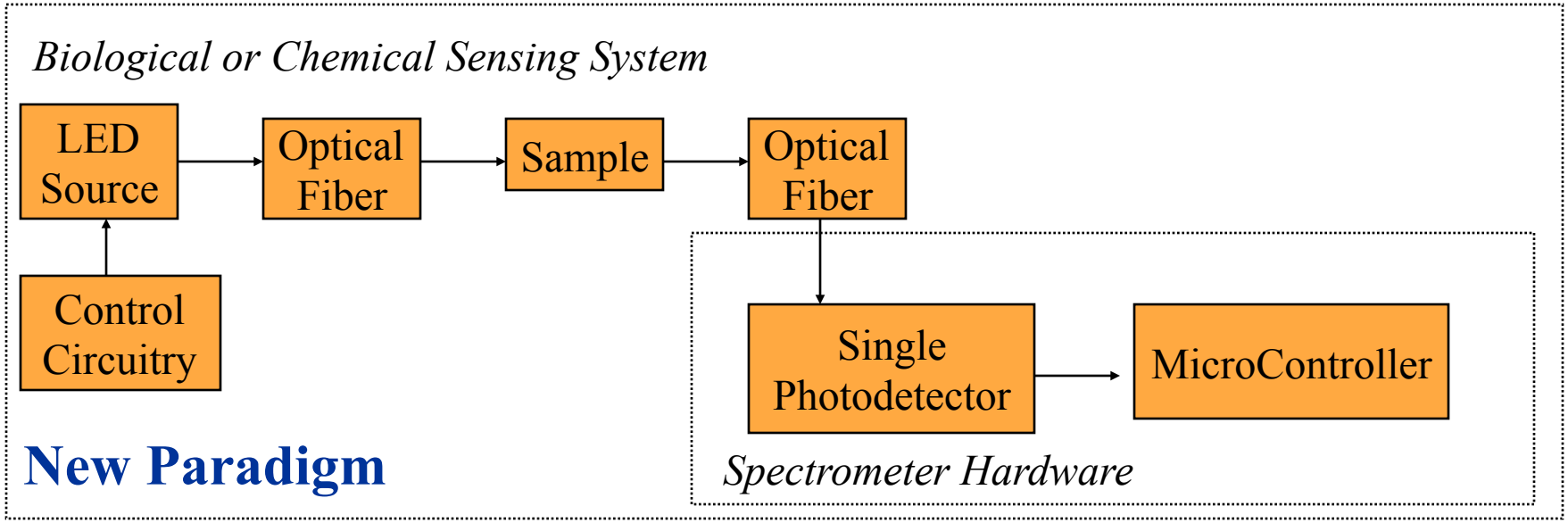
Approach	Size/Power/Size	Accuracy
MMS (Semi-Portable)	Small Low	Moderate*
MMS (Portable)	Very Small Very Low	Moderate*

The burden of spectral dispersion is moved to the light source and its control electronics, which are (far) more readily miniaturized.

**Relative to benchtop systems at $50,000+ unit cost*

The Alternative Spectrometer Design

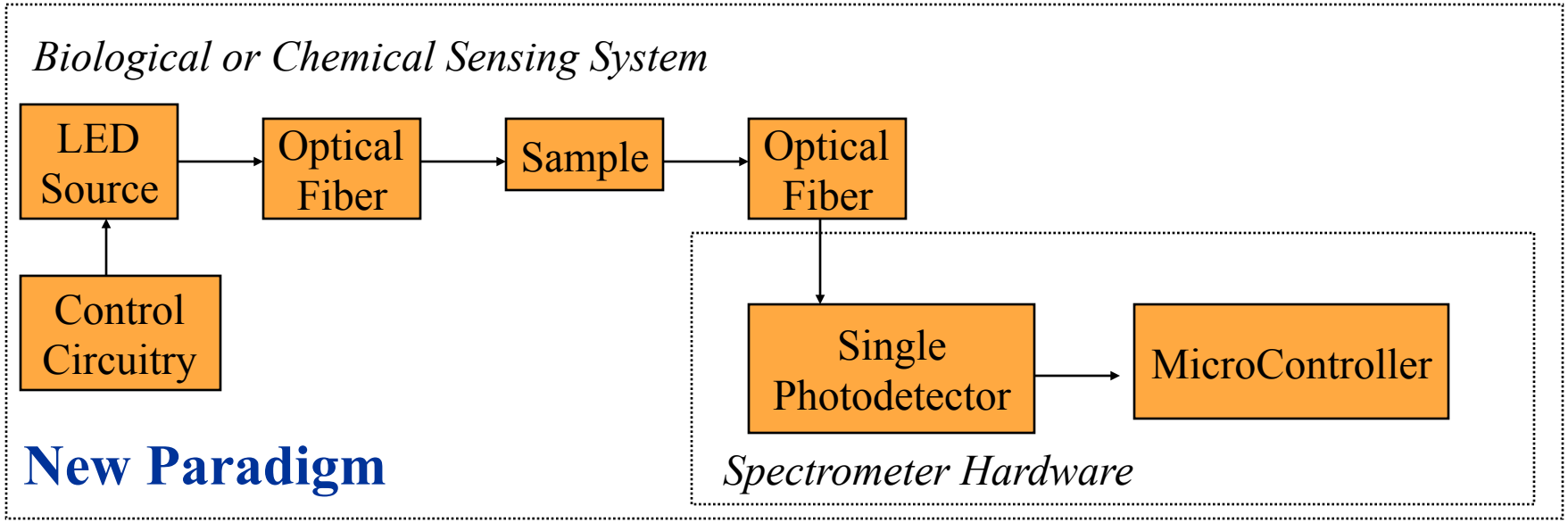
Spectral Dispersion is accomplished with:
Precise, high resolution manipulation of LED spectral emission
Rather than
Via Optical Means
Resulting in one light source/one photodetector systems with minimal optics



Alternative Spectrometer Design
Making it Competitive

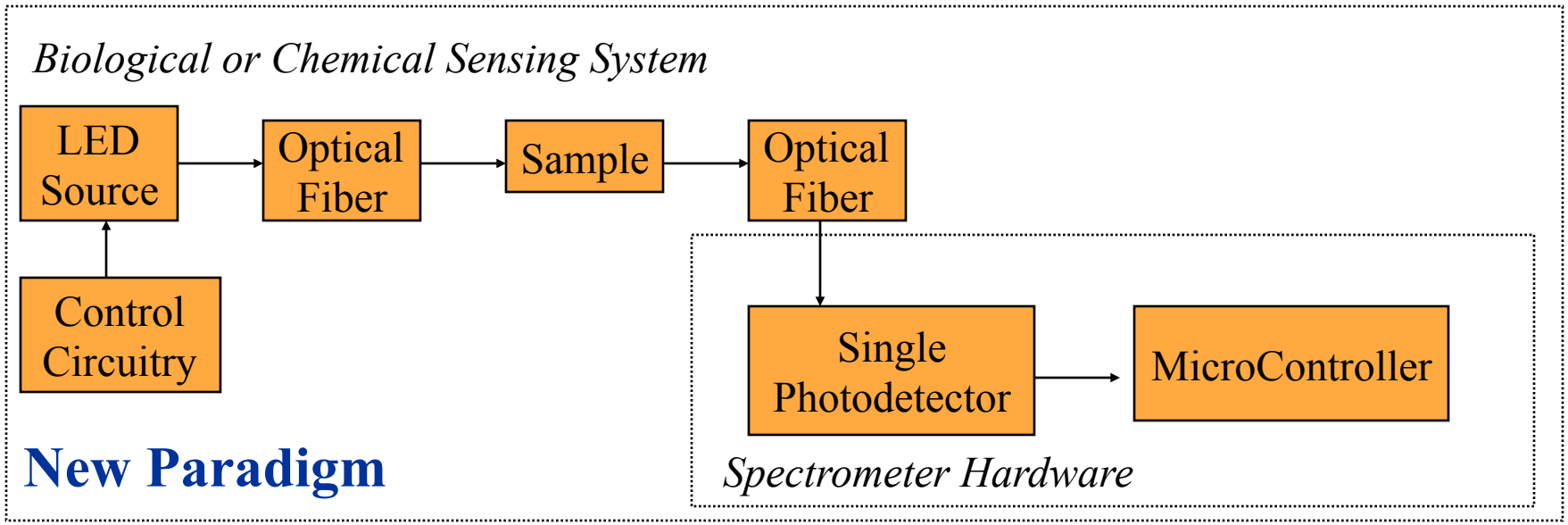
Relevant Questions:

1. **Does LED-based Spectral Manipulation really work?**
2. **Does this design work well in a practical context?**
   - **Application #1: Fluorescence Analysis**
   - **Application #2: Surface Plasmon Resonance**
3. **Business Strategy**



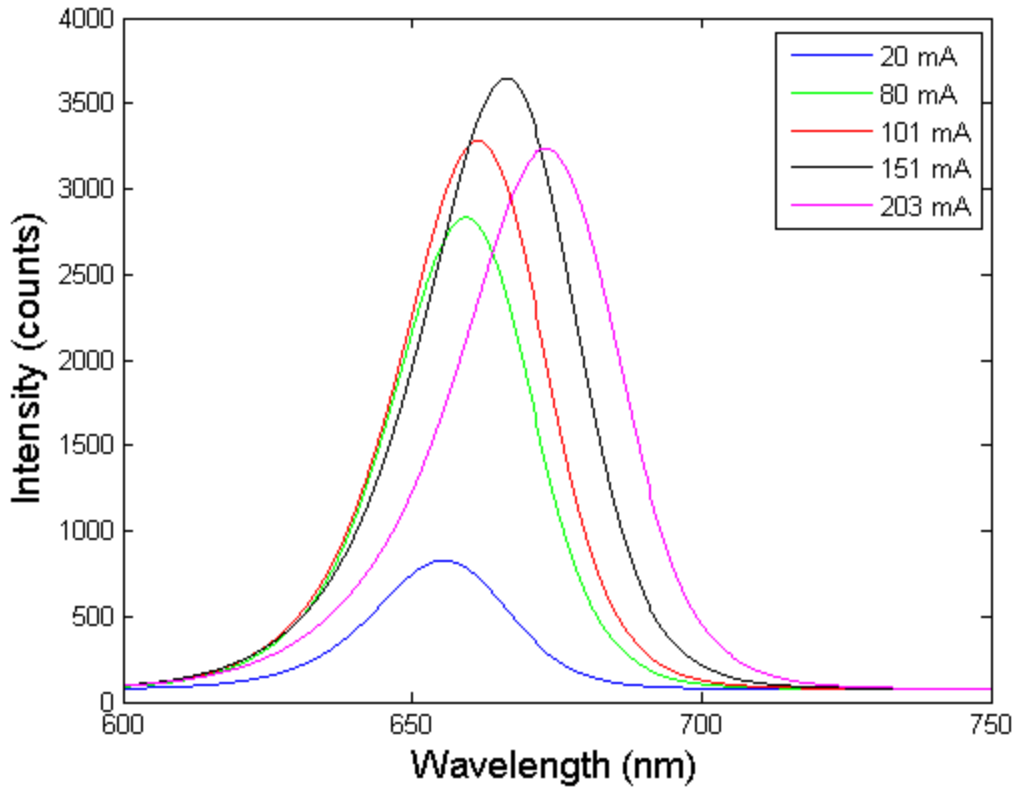
Alternative Spectrometer Design Making it Competitive

1. Does LED-based Spectral Manipulation really work?



Does LED Spectral Manipulation Work?

Controlled Spectral Shifts up to 40nm are possible.



Drive current (and "on" period) produce fine shifts in the output spectrum of a red LED

$$m_{peak} + \frac{1.24}{[E_g + (E_{FN} - E_C)]}$$

Thermal Effects

Electron Injection

Does the MMS Design Work in Context? Application #1: Fluorescence Analysis

Fluorescence Analysis is **one of the most common uses of the spectrometer**, AND

Portable fluorescence analysis is essential to:

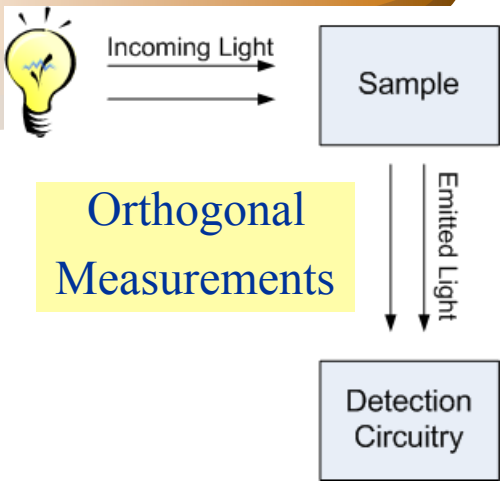
- **In-Situ,**
- **Point of Care,**
- **Continuous,**
- **Distributed,**

Monitoring of Biological and Chemical Systems

Biological Units:	*Biological Events:*	*Chemical Units:*
Proteins	Metabolism	Oxygen
Plankton	Respiration	pH
Bacteria	Efficacy	Ions
DNA/RNA	Reproduction	Carbon Dioxide

Does the MMS Design Work in Context? Application #1: Fluorescence Analysis

- Of the two most common means of fluorescence analysis:
  - Steady-State
  - Lifetime Analysis
- This system demonstration focuses on Steady-State

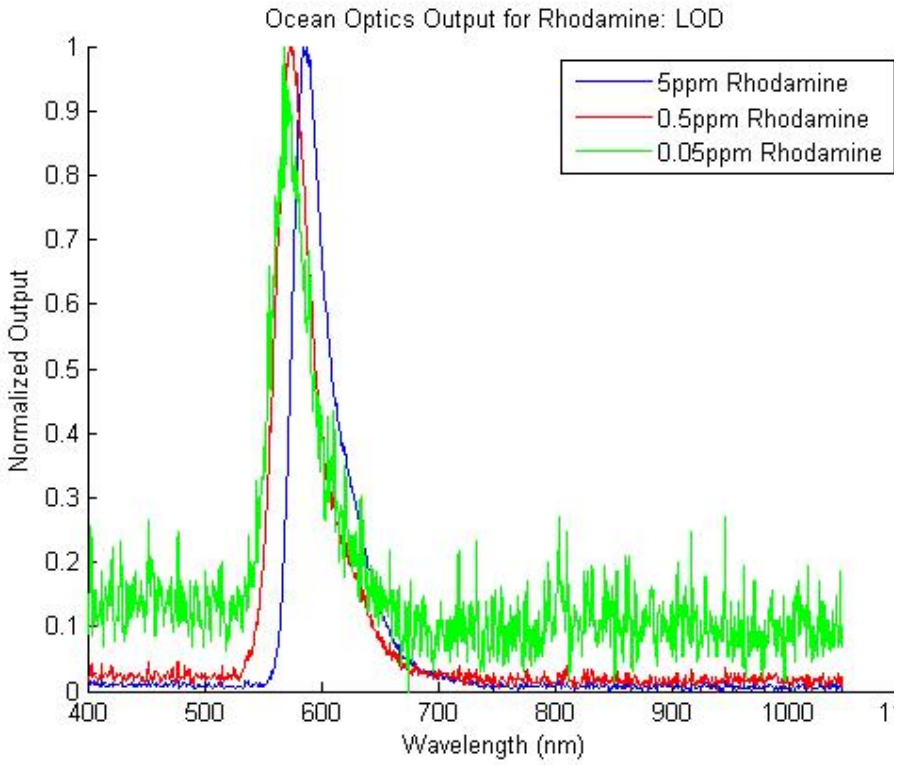


Key Elements of Demonstrating Competitiveness

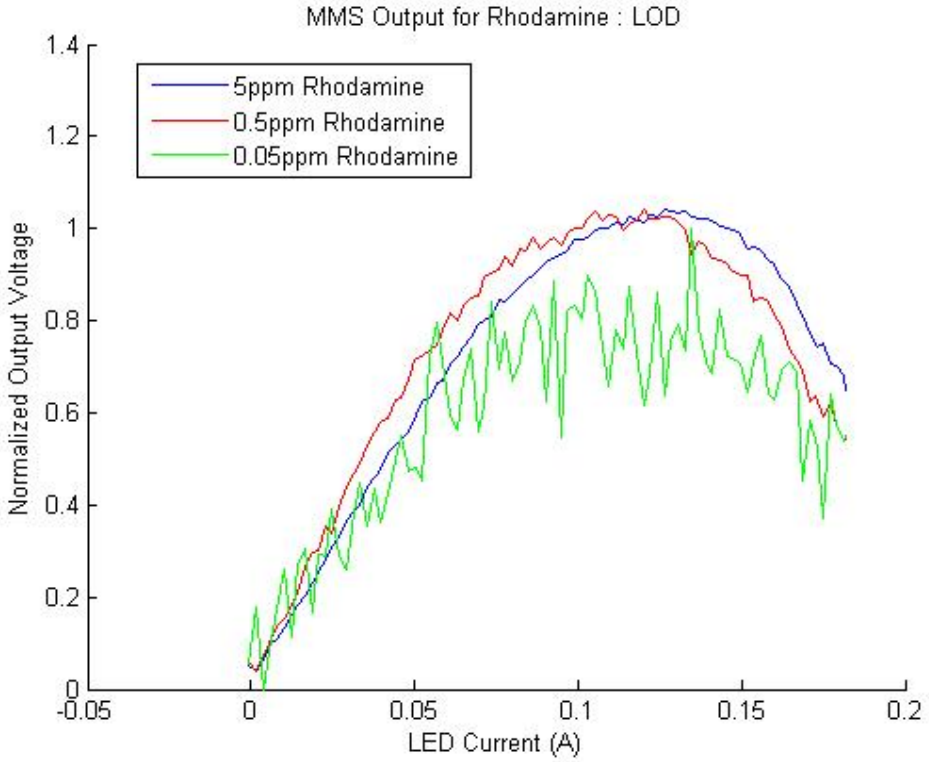
Performance Metric: Limit of Detection (how little can I see?)	*Footprint:* Power Cost Size	*Performance Metric:* Stability (drift over 1 experiment)
Performance Metric: Selectivity (do two look different?)		*Performance Metric:* Repeatability (drift over >1 experiments)

Does the MMS Design Work in Context? Application #1: Fluorescence Analysis

Limits of Detection (Rhodamine)



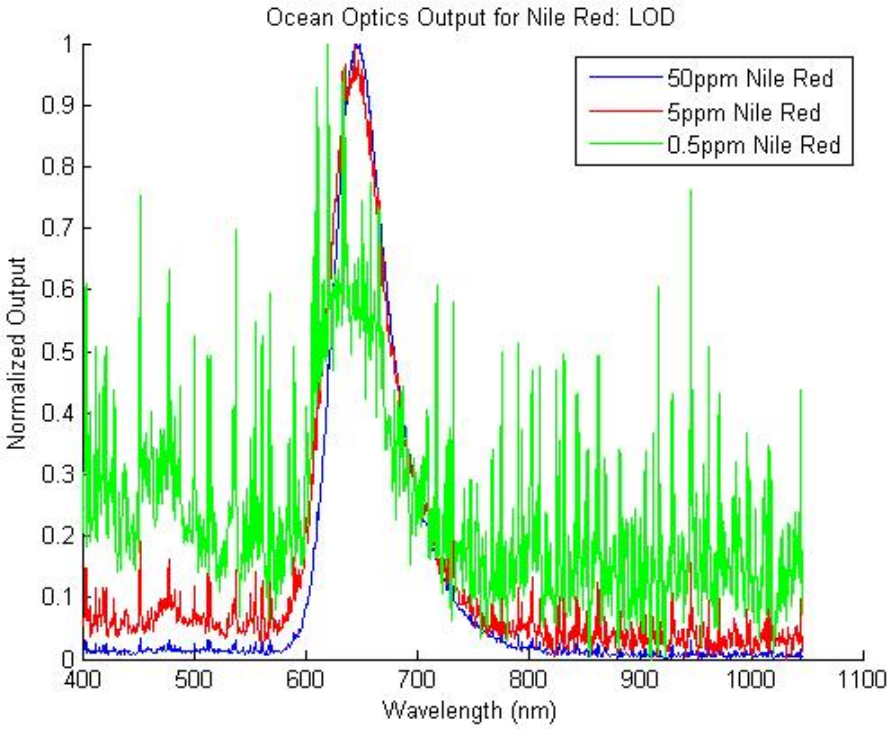
Ocean Optics USB2000 (Benchmark)

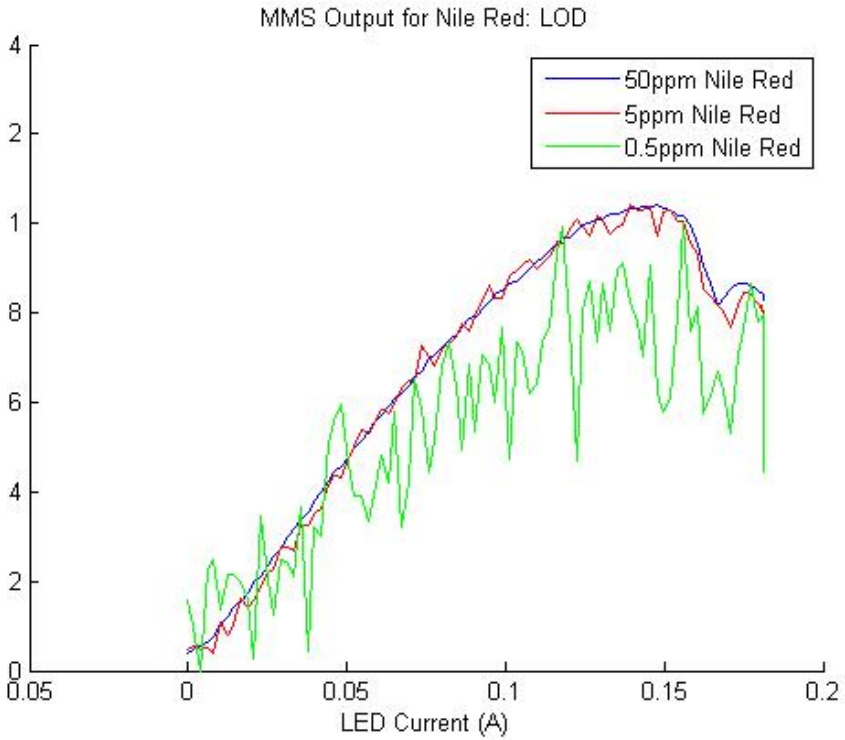


Micro-Miniature Spectrometer

Does the MMS Design Work in Context? Application #1: Fluorescence Analysis

Limits of Detection (Nile Red)



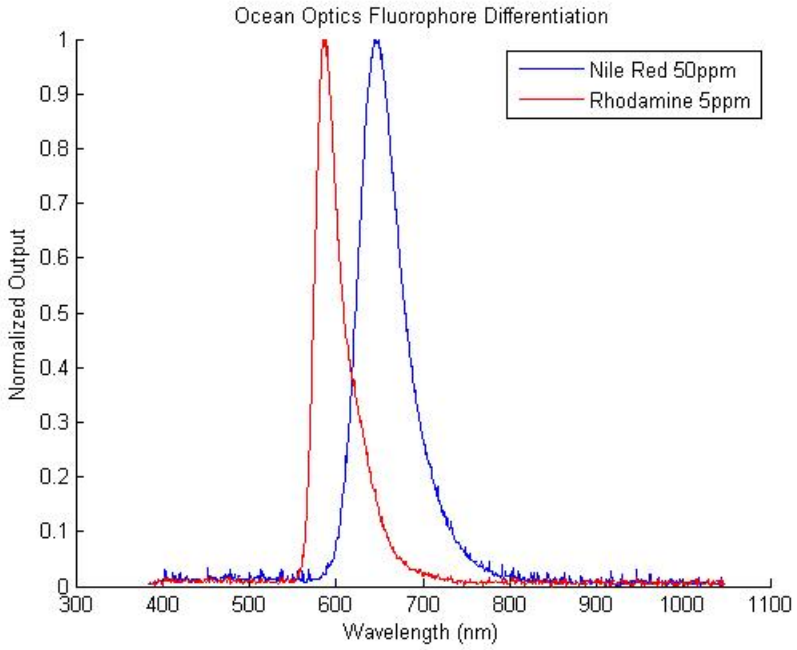


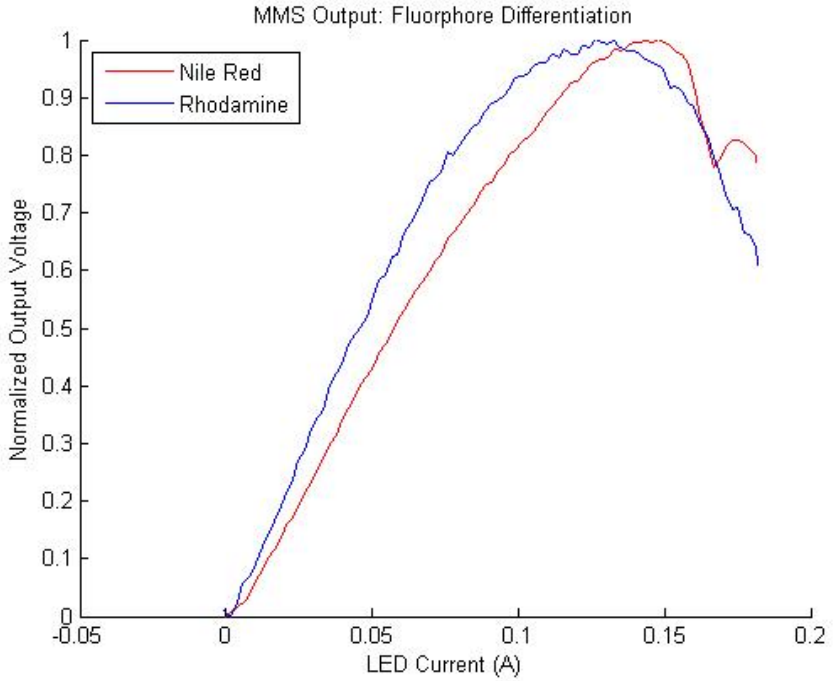
Ocean Optics USB2000 (Benchmark)

Micro-Miniature Spectrometer

Does the MMS Design Work in Context? Application #1: Fluorescence Analysis

Selectivity (Rhodamine B & Nile Red)



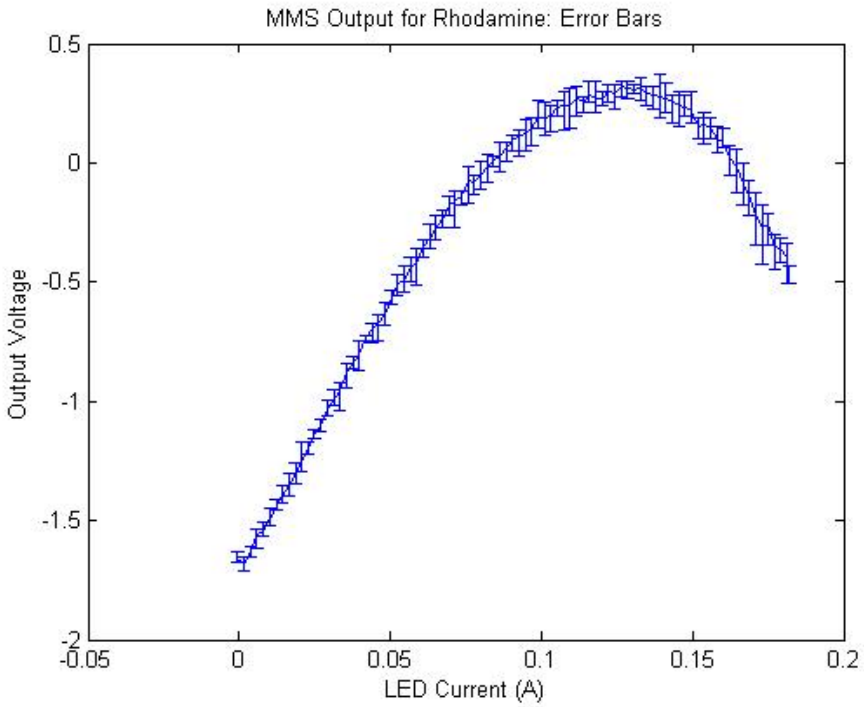


Ocean Optics USB2000 (Benchmark)

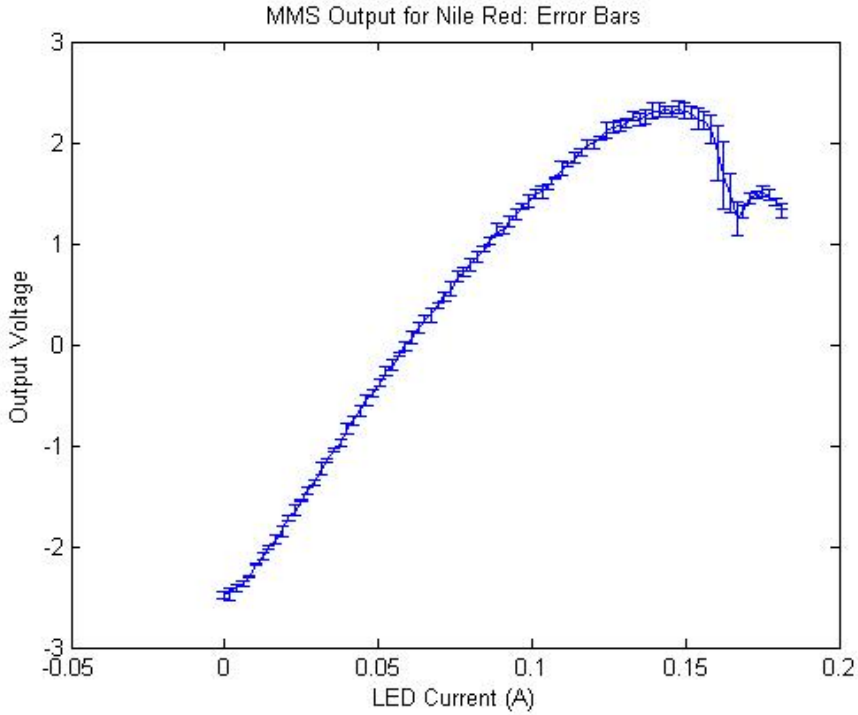
Micro-Miniature Spectrometer

Does the MMS Design Work in Context? Application #1: Fluorescence Analysis

Repeatability (Rhodamine B & Nile Red)



Rhodamine



Nile Red

Does the MMS Design Work in Context? Application #1: Fluorescence Analysis

YES

Performance Summary

System	Limit of Detection	Selectivity	Stability	Repeatability
Ocean Optics USB2000	0.5 ppm (Nile Red) 0.05 ppm (Rhodamine)	Yes	2.02%/ 5 min*	5.06%/ 5 Days
MMS	0.5 ppm (Nile Red) 0.05 ppm (Rhodamine)	Yes	3.22%/ 5 min*	6.63%/ 5 Days

*Combination of drift, EMI, and fluctuations in sensing medium