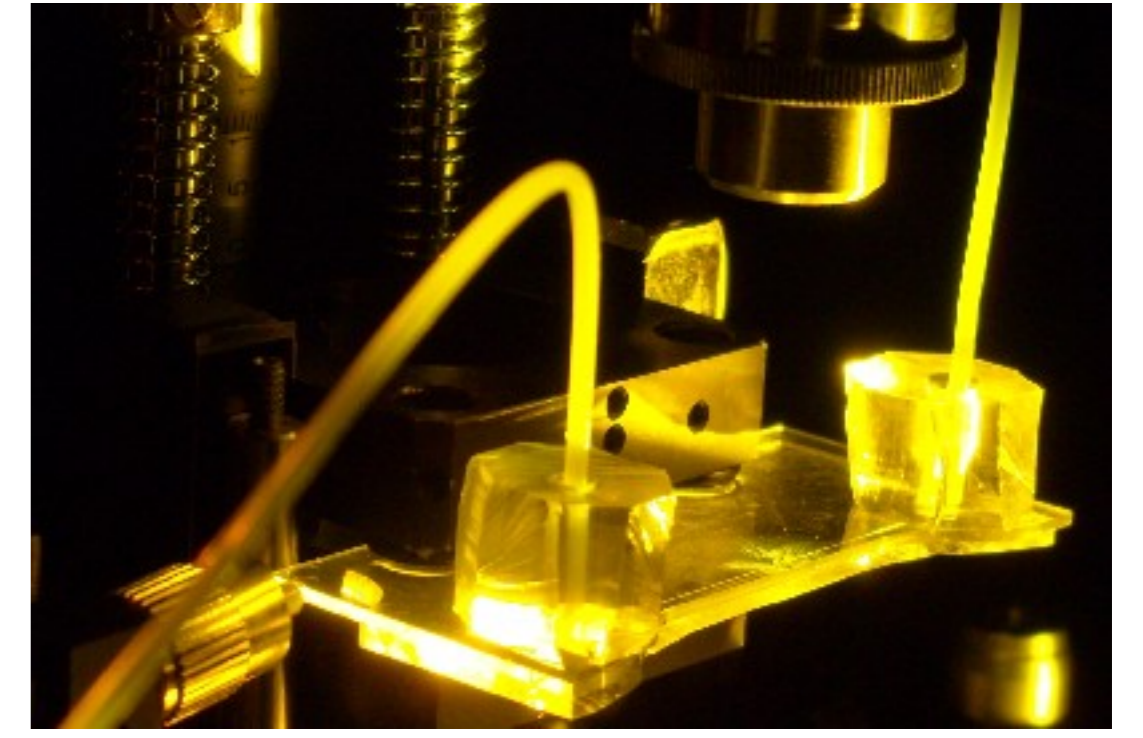


# Lab on a chip for monitoring algae populations

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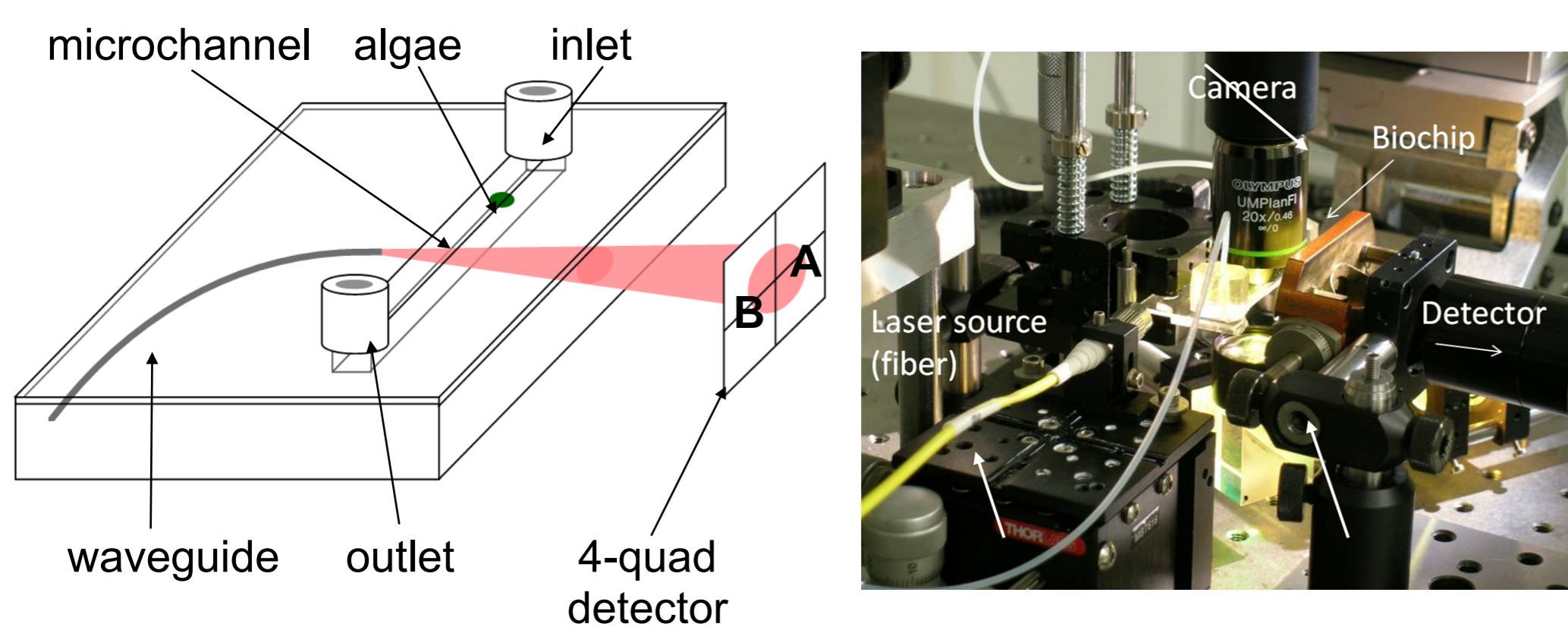


## Introduction & motivation

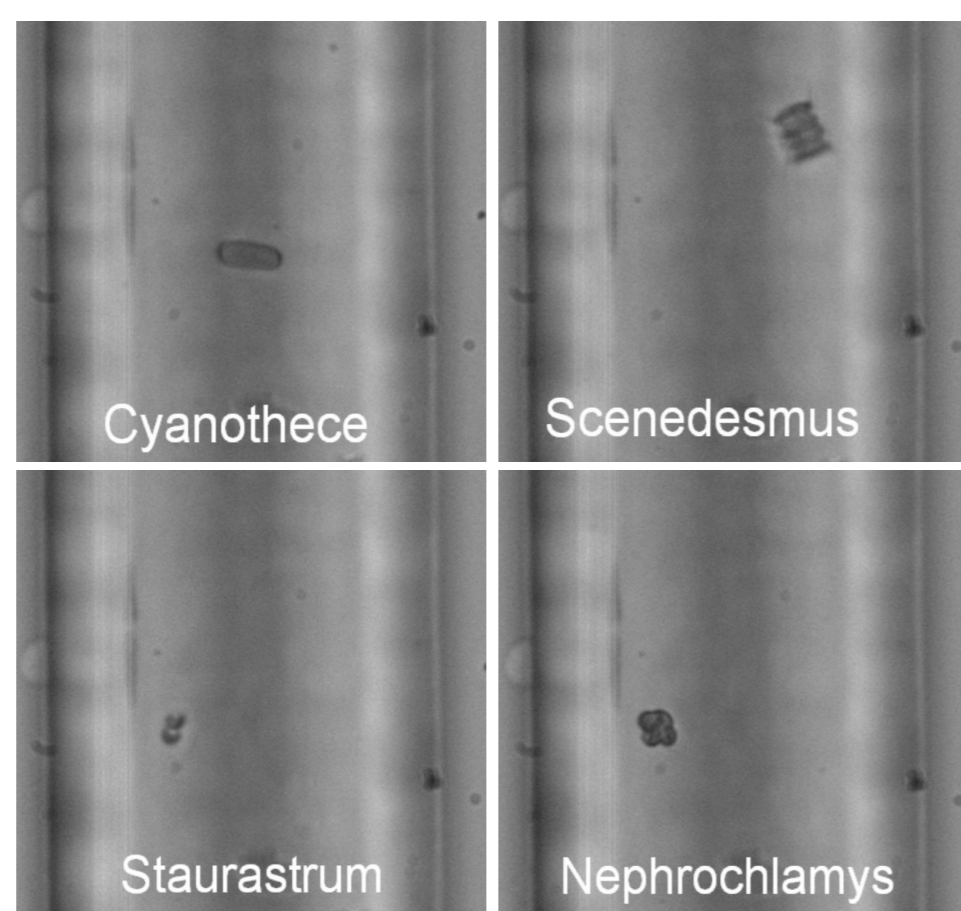
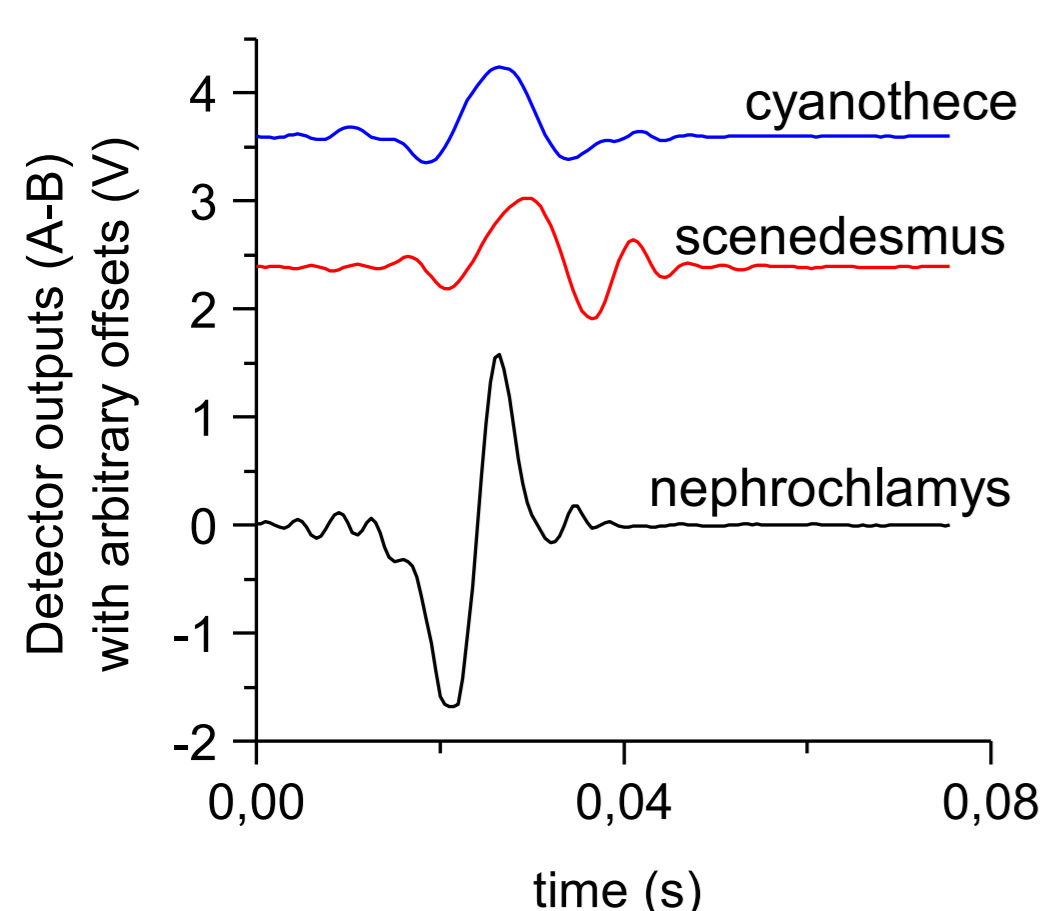
The identification of algae species in water is important for tracking water quality and environmental changes<sup>1,2</sup>. We present a chip-based approach to classifying and quantifying algae species in water in real-time, using microfluidics with integrated optics. We use a monolithic fabrication process, in which a femtosecond laser locally modifies the properties of a fused silica substrate, which enables the direct patterning of microchannels and optical waveguides<sup>3</sup>. The first results of the device are used to generate a library of algae signals and to demonstrate the device's ability to distinguish the toxin-producing algae *cyanothecae* from four other algae species.

## Fabrication & setup

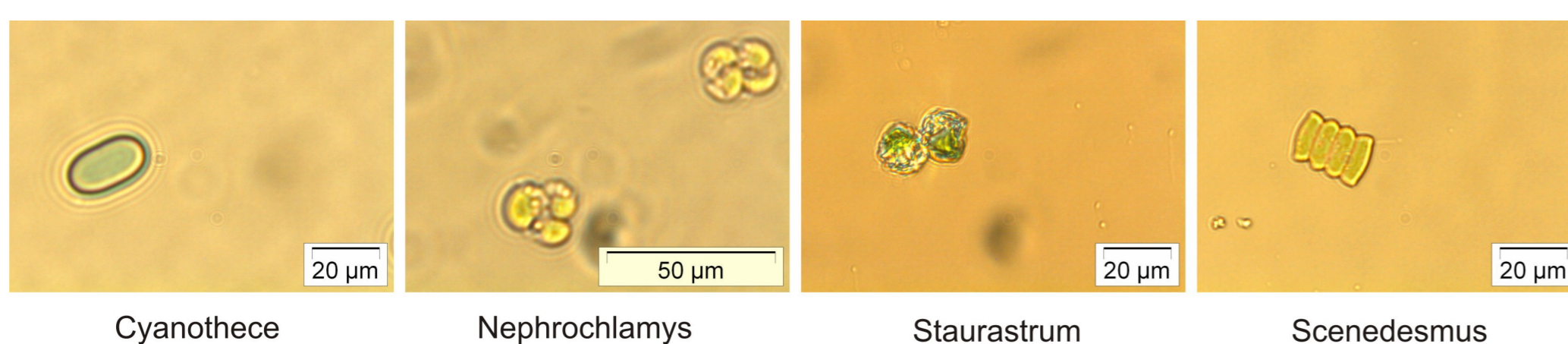
A square microchannel (100  $\mu\text{m}$  x 100  $\mu\text{m}$ ) and embedded waveguide (8  $\mu\text{m}$  x 8  $\mu\text{m}$ ) are patterned directly in fused silica with a femtosecond laser<sup>4</sup>. Polydimethylsiloxane (PDMS) is used to seal the top of the channel and make access ports.



A 1550 nm laser source illuminates a 4-quad photodetector across the channel, and the photodiode signal is recorded as algae travel through the channel. The difference between the upstream (A) and downstream (B) detectors was recorded. To match this signal to the algae type, a microscope-mounted camera took a photo of the algae in the channel, triggered by the signal amplitude.

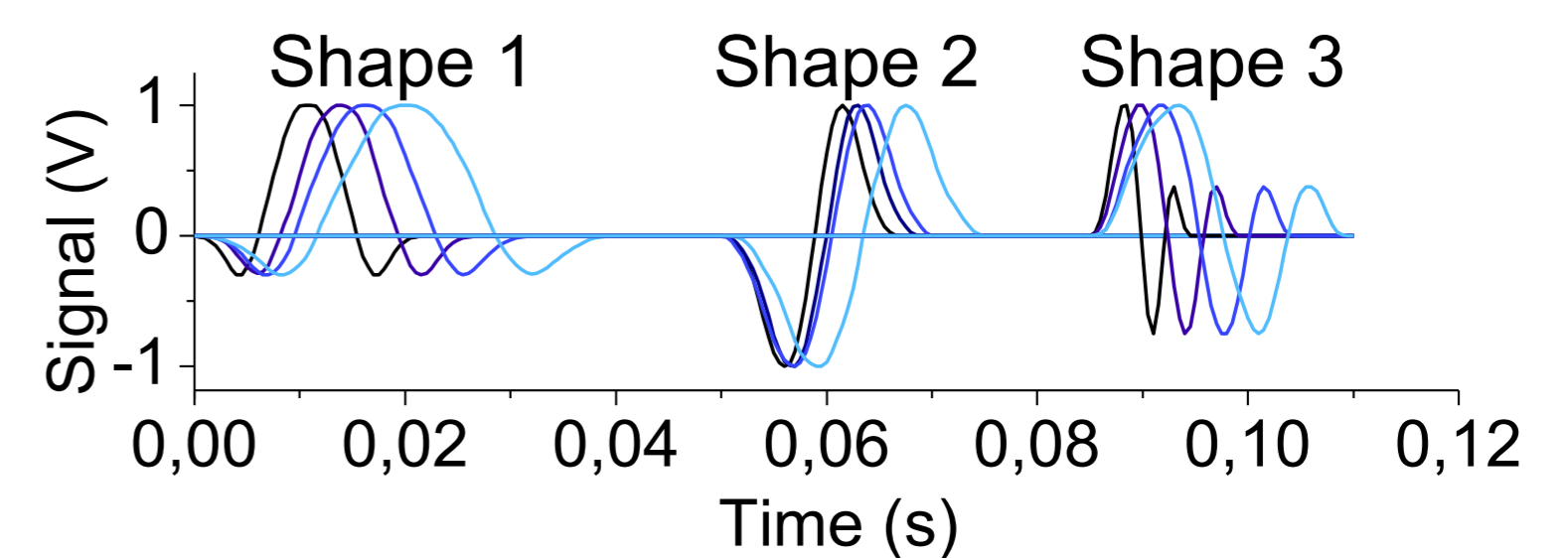


The device was tested with five algae species: the toxin-producing *cyanothecae* and four other species (*nephrochlamys*, *scenedesmus*, *staurastrum*, and *monoraphidium*) with a range of sizes (~10-20  $\mu\text{m}$ ) and shapes.

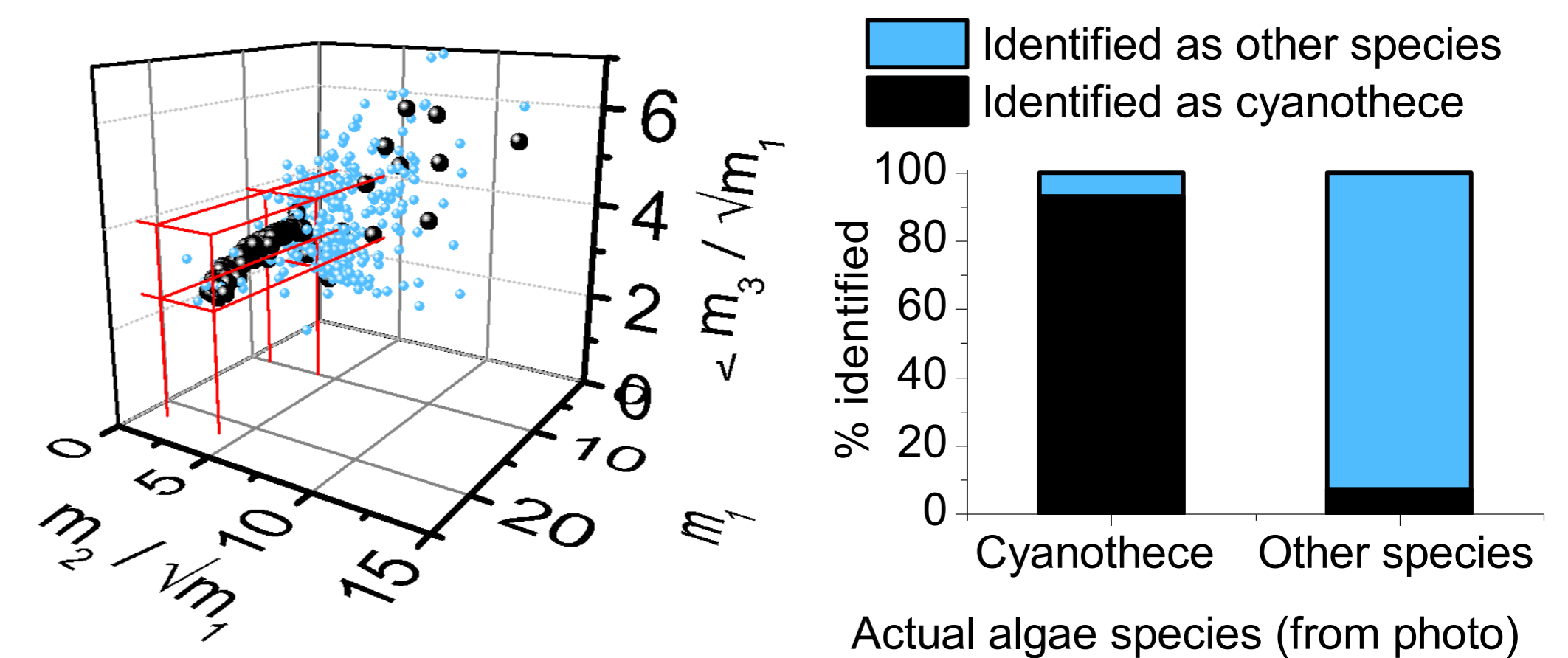


## Results & analysis

Using typical signals from the algae tests, three test function shapes were chosen ( $i=1,2,3$ ) and scaled to four widths ( $j=1,2,3,4$ ):



Each of these twelve test shapes  $f_{ij}$  were convolved against each of the normalized photodetector signals  $h_k(t)$  from the algae. The maximum values  $m_{ik} = \max[f_{ij} * h_k(t)]$  were used to find a "fingerprint" to distinguish the *cyanothecae* (black points) from other algae species (blue points):



Based on these results, a volume in the  $m_i$  space was defined to distinguish the *cyanothecae* algae from the other species (red box in left plot, above). This simple volumetric method correctly distinguished the *cyanothecae* 93% of the time (right, above).

## Conclusion

These results demonstrate this device's promise as a method for algae identification; further work will include the expansion of the algae identification process to identify the other algae in the sample, and the addition of other sensing methods to the chip design to allow for the counting and identification of a wider range of species.

<sup>1</sup>L. Barsanti and P. Gualtieri, *Algae: Anatomy, Biochemistry, and Biotechnology*, (Taylor & Francis, Boca Raton, 2006).  
<sup>2</sup>I. Chorus and J. Bartram, *Toxic cyanobacteria in water: A guide to their public health consequences, monitoring and management*, (W.H.O., 1999).  
<sup>3</sup>Y. Bellouard, A. Said, M. Dugan, and P. Bado, *Opt. Exp.*, **12**, 2120, 2004.  
<sup>4</sup>Y. Bellouard, *et al.*, *Proceedings of SPIE*, **7203**, 2009.  
 The glass chip was manufactured by Translume Inc.