

Microfluidic chip development for an autonomous field deployable water quality analyser

Objective

- This work presents the ongoing development of a microfluidic chip for a low cost field deployable phosphate analyser for water
- The phosphate analyser is a fully integrated system incorporating fluid handling, microfluidic technology, colorimetric chemical detection, and real time wireless communications in a compact and rugged portable device

Motivation

- Increased demand for environmental monitoring has resulted in the need for *in situ* real time measurements
- The European Union Water Framework Directive calls for continuous monitoring of natural water bodies by 2015 [1]
- Low cost, widely distributed, autonomous sensors are required to provide the necessary spatial and temporal resolution

Air Bubble Problem & Solution

- The system is designed to operate autonomously in remote locations for extended periods of time, so robustness of the microfluidics in the presence of air bubbles is essential
- Air bubbles form in the system plumbing due to pressure changes during pumping and temperature changes during normal operation
- Air bubble entrapment within the optical cuvette obscures the light transmission path and produces erroneous readings
- The problem was solved by using a small air pump in the system to flush the optical cuvette after each measurement cycle

Future Work

- Development of a low cost chip to replace the existing micromilled PMMA chip
- Elimination of the need for specialist tooling from the chip manufacturing process
- Long term field trials to evaluate system performance

References

- [1] Directive 2000/60/EC of the European parliament and of the council of 23 October 2000 establishing a framework for community action in the field of water policy, *Official Journal L*, 327/1, 2000.
- [2] C.M. McGraw, S.E. Stitzel, J. Cleary, C. Slater, D. Diamond. Autonomous microfluidic system for phosphate detection *Talanta*, 71(3): 1180-1185, 2007.
- [3] J. Cleary, C. Slater, C. McGraw, D. Diamond. An autonomous microfluidic sensor for phosphate: on-site analysis of treated waste water, *IEEE Sensor Journal*, 8(5): 508-515, 2008.
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SiCA Phosphate System

- A prototype field deployable autonomous phosphate analyser has been developed as previously reported in [2]. The system has been extensively field trialled both in natural waters and at waste water treatment plants [3]
- The SiCA Phosphate System is a commercial version of the prototype system. The sensing system is based on the molybdenum yellow method for phosphate detection. The system is capable of autonomously performing wet chemistry and complex analytical measurements at remote locations

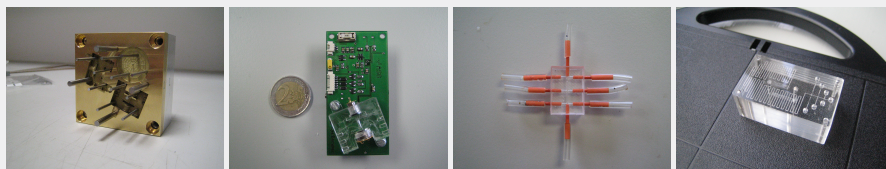


Microfluidic Chip Development

The issues facing the use of microfluidic devices for *in situ* environmental monitoring are well documented in [4]. Mixing, reaction and detection are carried out in the microfluidic chip of the phosphate system. A number of manufacturing approaches were investigated:

- **Injection Moulding:** poor cuvette surface finish, significant bubbles problems, ease of mass production
- **PDMS casting:** excellent surface finish, good bubble performance, basic tooling required, basic chip internal structures
- **Micromilled PMMA:** good surface finish, greatest flexibility in chip design, expensive to manufacture, specialist tooling required

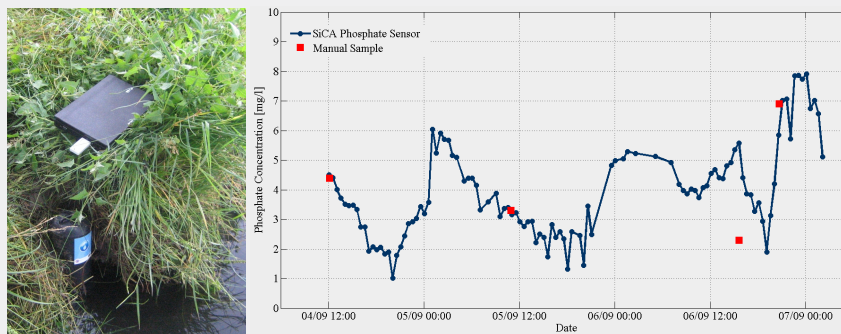
Micromilled PMMA chips have been used to date during microfluidic chip development and initial field trialling of the system. Work is ongoing to develop a low cost replacement for the micromilled PMMA chip.



L to R: Injection Mould, Injection Moulded Chip & Detector, PDMS Casting, Micromilled PMMA

Field Validation Study

The sensor was tested *in situ* at Broadmeadow water estuary, Swords, Co. Dublin for a 62 hour trial period. The sensor performed 124 measurements during the trial. Four manual samples were collected for lab analysis. A correlation coefficient (R^2) of 0.9706 indicates good correlation between phosphate concentrations reported by the sensor and lab analysed samples. The data shows highly elevated phosphate levels which are attributed to inputs from agriculture, municipal waste water discharges and septic tanks. Significant variations are caused by varying discharges, tidal variations and weather conditions.



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