CiS Forschungsinstitut für Mikrosensorik GmbH

STREAM

CERN

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CMOS Image Sensors for the Environment

Callum Wood ESR-07

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Overview

- Project Goals
- Deliverable Report
- Application Requirements
- Secondment Plan – TJ-MALTA
- Future Considerations

Project Goals

- Research into a **portable, multi-functional** radiation detector with **CMOS** image sensors, for environmental applications:

  → Water, soil and plants.

Deliverable Report D-5.3

- Investigation into current state-of-art of using CMOS image sensors in the environment. What is feasible and already in use?
- Examples of commercial webcams detecting alpha (5 meV), beta (0.8 MeV) and gamma (1.6 MeV).

Spectrometers for:

- **Quality of fruits and vegetables** (UV and blue light) using commercial webcams.
- Multispectral imaging systems attached to balloons at 50m altitudes to **map out vegetation and water** – also commercial webcams.
- **Analysis of soil** by attaching gamma-ray spectrometers to tractors.

Deliverable Report D-5.3

Report conclusion:

- Feasibility of using CMOS image sensors is evident by the number of existing examples.
- Commercial sensors may lack quantum efficiency and sensitivity required for industry-level performance.
- **MALTA** prototype (**WP3**) may provide a good match with application requirements, although an optimized CMOS process could be required.

Multi-functional?

- Measure different types of radiation?
- Perform spectroscopy to determine chemical composition?
- Combination of **both** in multiple environments?
- Multiple sensors in one device (+ scintillator and spectrometer)?

Narrow down to a novel application:

Alpha particle detection and analysis of **water** – detection of effluences and pollution using UV spectroscopy.

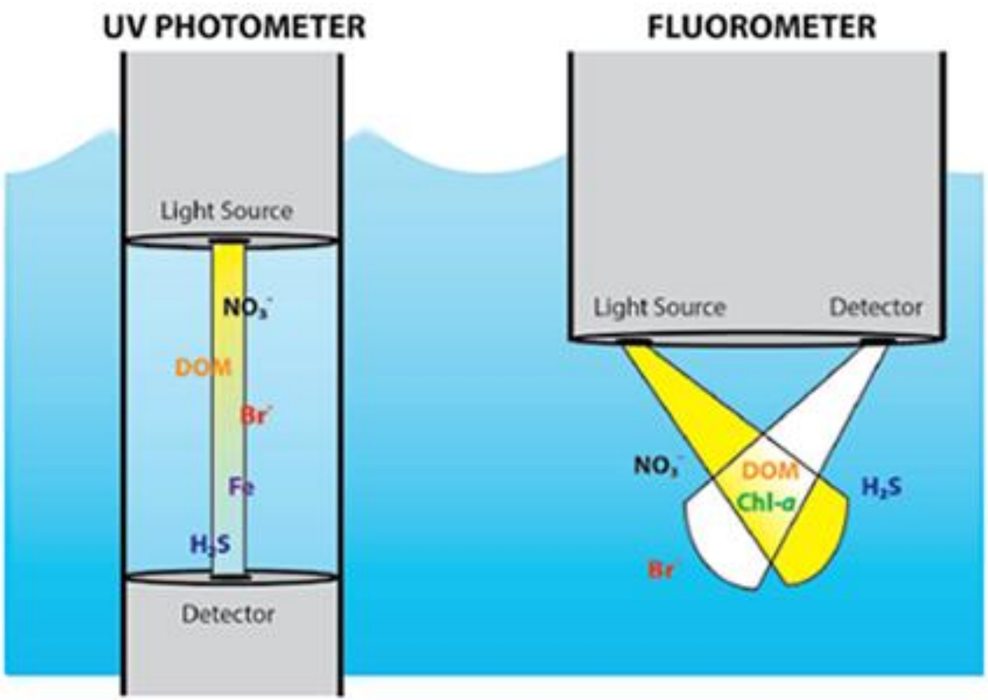
Application Requirements - Alpha Detection

- Alpha source placed in water or dissolved?
  - Plutonium in Nitric acid solution? (safety concerns)
- Blocking by the sample container and possible spectrometer components between sample and sensor.

- Measure luminescence induced by alpha irradiation?
  - Cooled CCD detected luminescence in water, induced by 5.5 MeV alphas from 2 MBq of Am-241 https://doi.org/10.1016/j.nima.2016.02.088

UV-Vis Spectroscopy (200-800 nm)

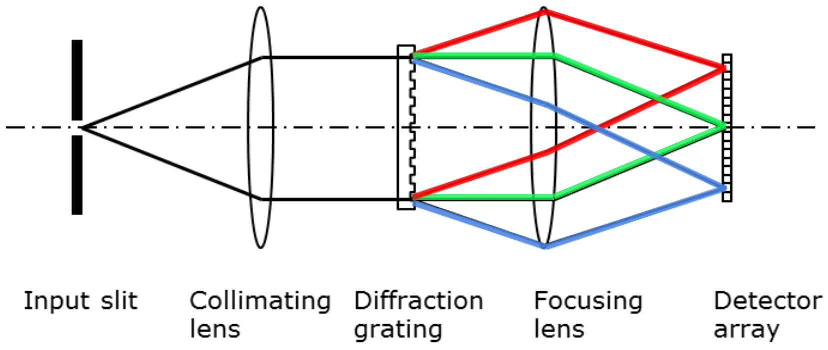
- Nitrate concentration in water. (Absorption spectroscopy)
- Fluorescence – Chlorophyll in plants, bacteria, algae and waste in water (Tryptophan-like fluorescence)



Optical Sensors for Water Quality, Lakeline

Application Requirements – Water Analysis

- Spectroscopic optical elements required (lenses, mirrors, diffraction gratings).
- Ultraviolet LED / broadband light source (Fluorescent lamp or Xenon).
- Can also consider differences in electrical conductivity between clean and polluted water using a conductivity sensor.



Why CMOS image sensors?

- Low power, high speed, commercial process.
- Signal processing on chip – noise reduction.
- Lower capacitance per pixel – improved energy resolution.
- Radiation tolerant (not that necessary for environmental applications compared to HEP).

Experiment Plan

- Test alpha sensitivity/ UV spectroscopy of commercial image sensor (webcam) – acquired from colleagues at CiS.
- Are both possible using the same sensor in a device?
- Simultaneously – or mechanism to change measurement mode?

Experiment Requirements

For experimental testing:

- CMOS image sensor – modified webcam, UV camera etc. ✔
  - Or UV diode – test for alpha detection then consider implementation in CMOS.
- UV Spectrometer (UV LED + slit + grating + lenses…) ◻
- Alpha source ✔ and samples of chemicals in water ◻ (perhaps effluence/waste not necessary).

Device Development Requirements

For a working device:

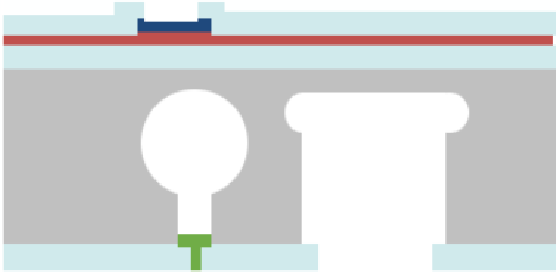
- All components integrated together – sensor with electronics/PCB, sample holder and housing.
- Spectrometer optical components & design – optimal dimensions.
- Portable power supply – battery.
- Connection for PC or internal dedicated computer – raspberry pi?

Secondment: Cooling Channel in MALTA

CERN, 1 Month in March/April (TBD)

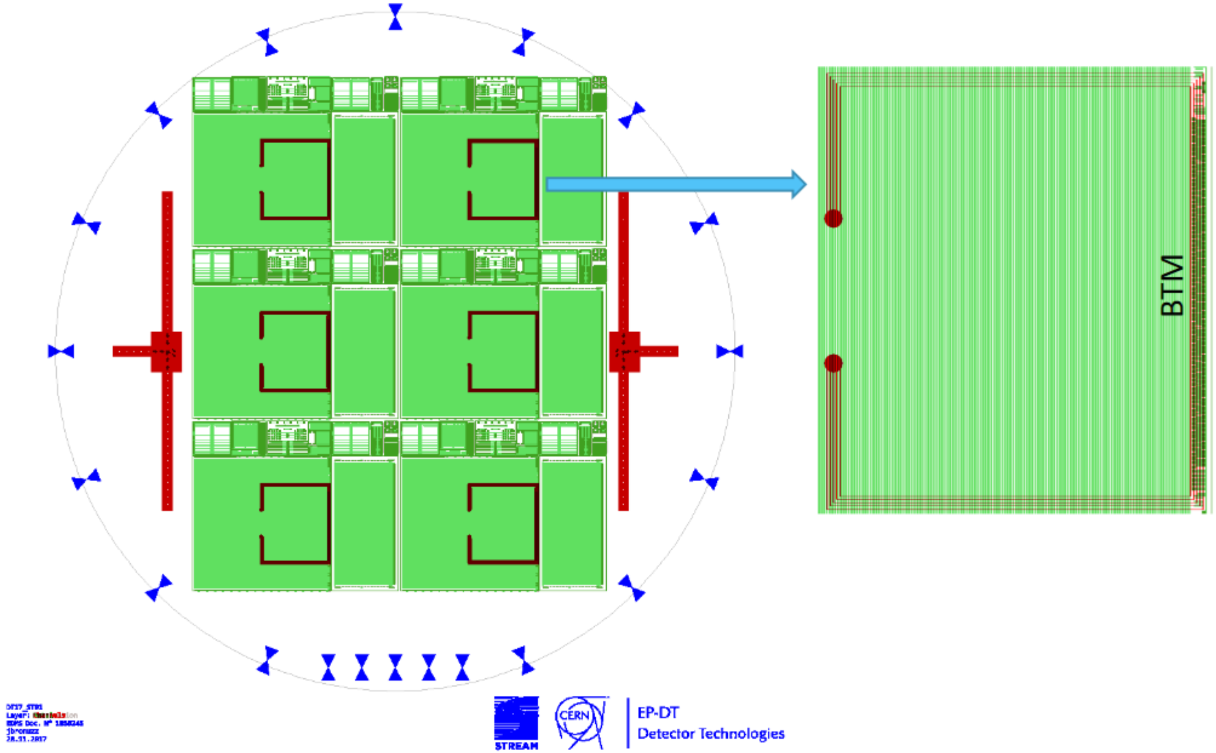
Cooling Micro-channel:

- Designed to pump CO2 to cool sensor.
- **Fairly homogeneous layout** could allow a liquid source to be supplied across the chip – direct detection of beta? (alpha is unlikely)



Microchannels and module integration, Alessandro Mapelli

Secondment: Cooling Channel in MALTA



J. Bronuzzi, A. Mapelli, P. Riedler

- Safety risks for using radioactive liquid/vapor.
- Detection of radiation in water: is it feasible, **benefits compared to standard practice?**

Future Considerations

If time allows (until mid-August 2019):

- Extend functionality – alpha/beta/gamma radiation.
- Detect plastic micro-particles (luminosity/turbidity).
- Autonomous operation (Internet of Things) – WiFi/Bluetooth.
- Integrated screen, or readout to PC/Tablet/Smartphone.

Thank you for listening.