INTEGRATED MID-IR WAVEGUIDE SENSOR FOR LASER BASED TRACE ANALYSIS IN AQUEOUS SOLUTIONS

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On-chip Sensors
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SENSING CONCEPT (H2020 AQUARIUS)

- Continuous monitoring of hydrocarbons in water
- ppm's for industrial applications and sub-ppm for drinking water.
- One of the proposed system is an in-line sensor

AQUARIUS

System validation

KWR
Watercycle Research Institute

System validation

OMV

OiW analyser

QUANTARED
TECHNOLOGIES

Coordination/
Technology Projection

TECHNIKON
TECHNOLOGIA

Exchangeable Sensing Chip

PROJECT GOAL: DETECTION OF OIL-IN-WATER

EXCHANGEABLE SENSING CHIP

GE-ON-SI PLATFORM

SEM image of a waveguide port

2 μm Ge-on-Si measured loss for $w=3.3 \mu\text{m}$

STRONG WATER ABSORPTION

• • •
Hydrocarbons

Propagating
mode

MESOPOROUS ENRICHMENT COATING

Selective
coating

Hydrocarbons

Propagating
mode

OPTICAL INTERFACING

Selective
coating

Hydrocarbons

Propagating
mode

OPTICAL INTERFACING

MICROLENSES INTEGRATED IN THE SUBSTRATE

WAVEGUIDE PLATFORM

In-house fabrication

“Mid-IR Sensing Platform for Trace Analysis in Aqueous Solutions based on a Germanium-on-Silicon Waveguide Chip with Mesoporous Silica Coating for Analyte Enrichment” Submitted to Optics Express by Nuria Teigell Benítez et Al.

OPTICAL INTERFACING PERFORMANCE

Simulated in-coupling performance

~360nm 1dB BW.

~640nm 3dB BW

Simulated optical interfacing

* Gaussian input, total output

QCL spectra

Measured input-output

~340nm 1dB BW.

~500nm 3dB BW

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PASSIVE CHIP EXCHANGE

SENSING PERFORMANCE

Recorded spectra for 133ppm of Toluene in water

Time response profiles

Noise floor = 0.02 A.U.
LOD ($3 \times \text{Noise}$) = 7ppm

Enrichment factors for 70 ppm toluene:

- 870 on ATR crystal with ~500nm thick layer
- 760 for AQUARIUS Chip

CONCLUSIONS

- ❑ An “ATR-on-a-chip” sensing platform enabling in-line water sensing in the long-wave mid-IR was presented
- ❑ A broadband, trough substrate and position tolerant optical interfacing was demonstrated
- ❑ Fast and easy chip exchange possible
- ❑ Successful integration of hydrophobic mesoporous coating
- ❑ The achieved LOD for toluene in water was 7ppm with a noise floor of 0.02 A.U
- ❑ Promising for achieving sub-ppm LOD's
- ❑ Achieved fast time responses pave-the-way for continuous monitoring
- ❑ Detection of multiple organic contaminants in water is possible
- ❑ The sensing platform can be adapted to different applications

THANKS FOR YOUR ATTENTION

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SENSING PERFORMANCE

Multiple analytes

Shall show these results????

Gas phase

PROCESS FLOW