AQUARIUS

Broadband Tunable QCL based Sensor for Online and Inline Detection of Contaminants in Water

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EC contribution: **EUR 3,891,263.75**

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This project is an initiative of the Photonics Public Private Partnership.

Mission of AQUARIUS:

AQUARIUS will provide an on- and inline capable mid-IR sensing solution to meet legal provisions for industrial waste water and drinking water monitoring. Significant enhancement in sensitivity will be achieved by further advancement of the laser source and the detector as well as an innovative combination of sample extraction and preparation with polymer functionalized waveguides. The AQUARIUS sensing solution will be developed along the entire value chain towards integration in industrially proven online devices for water control driven by strong industrial commitment in this consortium.

Motivation:

The supply of sufficient and clean freshwater is under pressure worldwide. However, freshwater is essential for human wellbeing and plays an important role in the world economy, its quality being regulated by national and international legislation. Whereas water is the most abundant substance on the Earth's surface and essential for all forms of life and used in almost every industrial process, directly or indirectly, fresh water comprises only a small fraction of the total amount of water. Therefore, ensuring good quality of this resource is paramount. The quality of fresh water can differ significantly. The variety and concentration of chemical species in the aquatic systems can be quite diversified, presenting a challenge in terms of both water purification strategies and water quality control. These contaminants are a challenge to the water sector. Thousands of these compounds are used every day and new ones are continually put on the market. Increasingly effective laboratory detection techniques are revealing the presence, in surface water for instance, of low concentrations of contaminants, whose presence was previously unknown. To assure a safe environment, novel water monitoring technologies are needed for all types of water including process water, waste water, sewage as well as drinking water. These new technologies shall enable pervasive water monitoring which can replace and compliment currently employed laboratory based offline methods by online or inline monitoring strategies.

Concept:

The AQUARIUS project addresses the development of a new generation of photonic sensing solution, in response to the need for pervasive sensing for a safer environment. In particular components, modules, sub-systems and systems shall be developed for enhanced sensitivity and specificity measurements in water monitoring following the requirements of regulatory bodies, as well as the needs of selected end-users such as waterworks and the oil producing industry. Specifically addressed within the AQUARIUS project is the detection of hydrocarbon contaminations in water (Oil-in-Water contaminations). While most current laboratory with analytical techniques (e.g. mass spectrometry) can in principle handle these tasks, they are often labour and cost intensive as well as time consuming. In most cases they require samples to be taken at e.g. the water works facility and then transferred to the analytical laboratory. Therefore it would be very helpful if on- or even inline analytical sensors with high sensitivity were available, allowing for a reliable and continuous real-time monitoring on site.

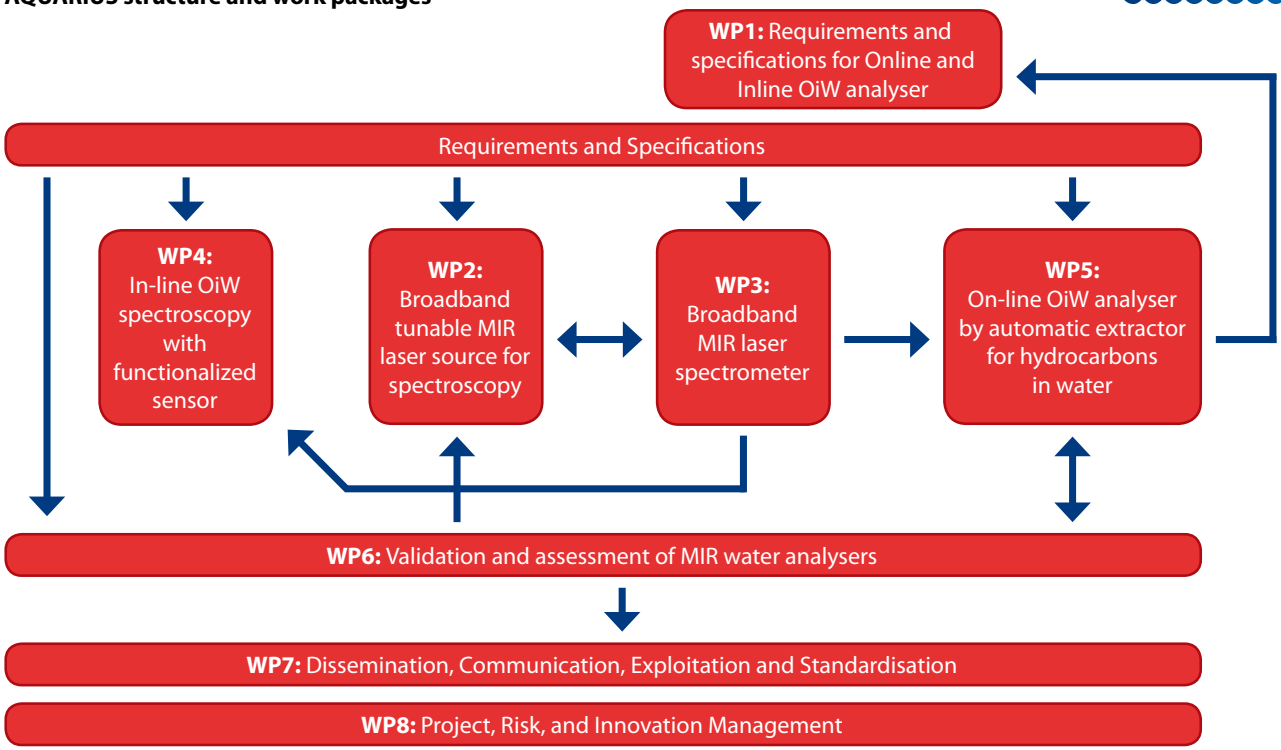
Objectives:

The following key objectives will be addressed by AQUARIUS:

- **Objective 1:** Enhancement of broadband tunable quantum cascade lasers in terms of spectral coverage and noise (TRL increase: from 4 to 6)
- **Objective 2:** Realisation of a fully functional spectrometer sub-system consisting of a µEC-QCL and a fast MCT detector including data acquisition (TRL increase: from 3 to 6)
- **Objective 3:** Advance Oil-in-Water (OiW) monitoring capabilities from offline (state-of-the-art) to online (TRL increase: from 3 to 6)
- **Objective 4:** Test of the online OiW system at industrial end users (TRL 7)
- **Objective 5:** Realisation of integrated optical circuits (IOCs) for waveguide based sensing and inline capable sensing configuration (TRL increase: from 2 to 4)
- **Objective 6:** Assembly and test of the inline OiW system in a laboratory environment (TRL increase: from 2 to 4)

OMV Water Treatment Plant Schönkirchen, Austria

AQUARIUS structure and work packages



Technical Approach:

The AQUARIUS project is planned to run for 36 months and subdivided into eight work packages (WP). Between those work packages there are significant dependencies and expected synergies, which are described shortly in the following:

WP1: Requirements and specifications for Online and Inline OiW analyser

This first WP is a foundation point for AQUARIUS execution. The main objective is to derive requirement definitions and specifications for the system, as well as sub-systems and modules.

WP2: Broadband tunable MIR laser source for spectroscopy

WP2 will provide a miniaturized mid-infrared quantum cascade laser (QCL) module based on an external cavity scheme. The spectral coverage of the laser will be optimized for OiW detection. The focus of this WP will be the design, growth and processing of quantum cascade lasers and optical components for fast spectral scanning within the mid-infrared range.

WP3: Broadband MIR laser spectrometer

WP3 covers the development of a high-speed mid-infrared spectrometer for transmission and attenuated total reflection spectroscopy of OiW samples. The spectrometer will combine the QCL developed in WP2, an ultra-sensitive MCT detector and further components which are necessary to synchronize the laser operation and enable high-speed spectral scans.

WP4: Inline OiW spectroscopy with functionalized sensor

In WP4 a compact demonstrator of a sensing system for fast and direct (inline) mid-IR spectroscopic measurement of liquids shall be developed and optimized for determination of the parameter OiW.

WP5: Online OiW analyser by automatic extractor for hydrocarbons in water

In this work package a system for enhanced online OiW analysis will be designed and developed towards a concept prototype. This task will comprise both, the development of new modules, i.e. an online extractor module and an online transmission spectroscopy module, and the integration of these modules with the broadband MIR laser spectrometer sub-system from WP3 into the final online OiW analyser.

WP6: Validation and assessment of MIR water analysers

This WP will perform validation and assessment of the online and inline OiW analysers. The systems will be tested against the requirement definitions from WP1. This will be done at different stages of development, after availability of the extraction module and with the final analyser systems.

WP7: Dissemination, Communication, Exploitation and Standardisation

This WP obtains input from other WPs, focusing on scientific research and ensures the communication and dissemination of results achieved within the single WPs to the outside parties, as well as to participating entities. WP7 will further support the partners to exploit the achieved results and impact the European and international market. The ethical and societal impact of the project will be closely monitored and reported on.

WP8: Project, Risk and Innovation Management

WP8 will interact with all other WPs in order to ensure a successful project lifetime with respect to risk and innovation management. WP8 shows dependencies to all other WPs, as it coordinates and ensures that the tasks are in line with the project work plan. Furthermore it performs scientific coordination as well, in order to reach the common goal of AQUARIUS.

AQUARIUS

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Consortium:

It is a thoroughly selected mix of partners from five different countries who complement each other with their competencies, experience and ambition at high level. Due to excellent cooperation in the proposal creation, the basis for a very promising collaboration has already been set.