AEOLUS

Project Title

An affordable, miniaturised, cloud-connected system powered by deep learning algorithms for comprehensive air quality measurements based on highly integrated mid-IR photonic

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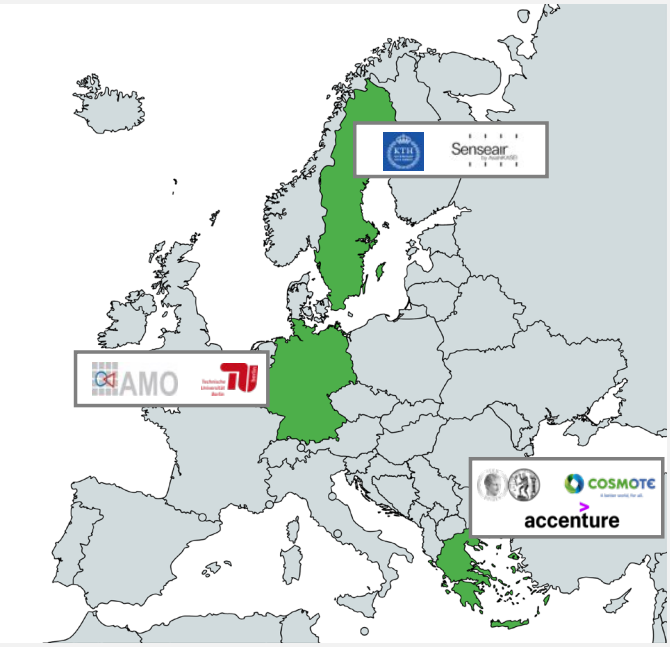

The Challenge

The quality of the air we breathe is a vital asset affecting human health and well-being, as well as environmental resources such as water, soil and forests. According to the World Health Organization (WHO), air pollution is the second leading cause of deaths from noncommunicable diseases (NCDs), after tobacco-smoking, while the severity of indoor and outdoor air quality as a risk factor for NCDs has been widely recognized. In the WHO European Region alone, more than 550.000 deaths in 2016 could be attributed to the joint effects of household and ambient air pollution. The grave consequences of air pollution are measured not only in terms of sickness and death, **but also in terms of lost productivity and hampered economic growth due to significant additional operating costs imposed on business, industry, households, and public services.**

The increasing awareness on air pollution's socioeconomic impacts has instigated several initiatives at an international, national and regional level, aiming at legally binding deals for containing greenhouse gases and other harmful trace gases threatening human health. **Inherent to any policy for air pollution reduction is a mechanism for monitoring, reporting and evaluation of the measures taken.** Observation of gas emissions is a prerequisite for taking appropriate action, because it can give an estimation of current situation, evaluate the effectiveness and efficiency of measures, provide accountability, as well as evaluate the equity of measures.

Currently, air pollution is measured regularly at selected locations, mainly at the largest sources of pollution and in city centres. Accurate air quality monitors are costly and bulky; therefore the number of air pollution stations is limited. To assess the spatial distribution of pollutants, dispersion models are used; however, their accuracy is restricted by virtue of variable traffic distribution as well as micro-meteorological effects of urban geometry such as street canyons. Hence it is imperative that dense pollution monitoring networks are deployed, working in tandem with dispersion models to provide real-time mapping of the spatial and temporal variations of urban air quality with high precision, enabling assessment of exposure at a localized/personal level. As the need to reliably monitor gas emissions is becoming more and more urgent in view of environmental challenges, the demand for 'smart',

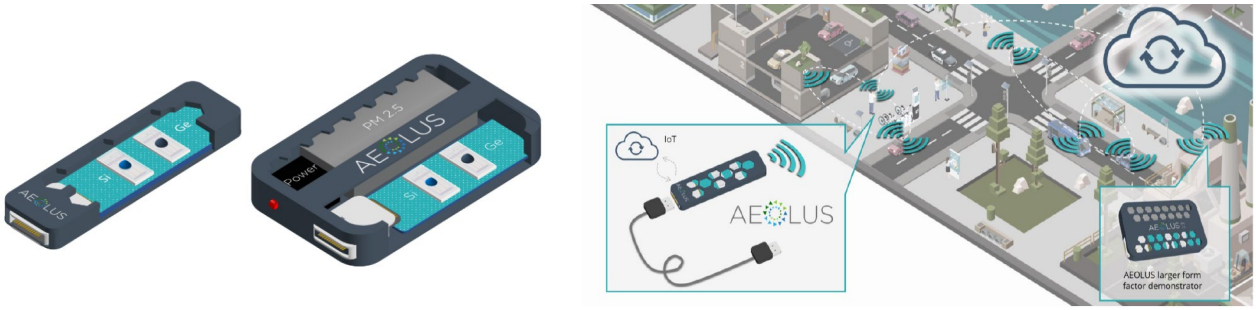

Fig. 1: *AEOLUS holistic solution*

networked and truly affordable gas sensors will only grow. A network of interconnected gas monitors providing a reliable map of pollutants with high temporal and spatial resolution is a powerful tool in the context of the Internet-of-Things (IoT), enabling new environmentally aware concepts and business opportunities such as using Big Data techniques to make 'intelligent' sensing systems.

The Vision

AEOLUS aims to be the first to provide a field-tested holistic air quality solution that is affordable, cloud-connected and 'smart' as well as facilitating and encouraging citizen engagement and its widespread deployment into our communities, to meet the needs of Smart City applications and ultimately pave the way to effect necessary changes in our lives. AEOLUS multi-gas sensor will target gases with prominent importance for environmental sensing regarding air quality and for toxicity in cases of gas leakage.

AEOLUS holistic solution combines a series of key technologies that brings together:

- MID-IR well-proven Absorption Spectroscopy sensing techniques
- sensitivity and selectivity of nondispersive infrared (NDIR) gas sensing approach
- high degree of on-chip integration along with wafer-scale manufacturing
- low-cost and mass fabrication approach in terms of electronics and packaging
- sensor system deployment into existing IoT testbed
- Deep Learning algorithms, fed by plethora of data

Project Objectives

Empowered by its ambitious vision (Fig. 1), AEOLUS aims to develop an affordable multi gas photonic sensor, as well as a cloud connected, Big Data analytics assisted, smart sensing platform. More specifically, AEOLUS will:

- Capitalise on well-established Silicon (Si) platform, develop low cost and miniaturized, allowing for high integration sensing elements with enhanced performance
- Leverage CMOS compatible Germanium on Insulator processes and extend detection range up to ~10 μm
- Use wafer level processes to considerable minimize the sensor's cost and footprint
- Demonstrate a system on chip integrated photonic sensor for multiple gases
- Use well established embedding PCB technologies to ensure proper thermal management
- Develop and validate Deep learning models that will provide emerging patterns, accurate chemometric analysis and predictions
- Leverage IoT testbed and demonstrate supporting IoT services, including air quality visualisation, real time health and safety security alerts, real time commands execution, and gamification
- Validate and Demonstrate affordable AEOLUS multi-gas smart sensing system to TRL7, and propel its comprising technologies beyond the technological 'valley of death'
- Deliver a holistic roadmap and business plan analysis for the path to market of sensing platform and exploitation plan

Technology Exploitation

The success of AEOLUS exploitation strategy relies on the very same elements that make the project a strong candidate for putting the European industry in the driver's seat of the smart environmental sensing market. AEOLUS introduces a clear technology path to deliver an innovative, cloud-connected, smart photonic sensing system with strong exploitation potential. The innovative approach proposed in AEOLUS, which answer directly to market needs and future roadmaps, and the strong commitment of the consortium's industrial members are the key elements of AEOLUS for success. The holistic solution that is proposed is a breakthrough concept that relies on the evolution of individual, well-established technologies and universally accepted trends, thus offering the optimum balance of innovation and risk/maturity/time-to-market. AEOLUS recognizes the necessity to have a clear view of the trends, standards and roadmaps that shape the targeted market sector that will allow its consortium to better position AEOLUS in its likely market and better align the targeted specifications of the developed technology platform. AEOLUS value chain for bringing all project innovations to the market is in place, raising high prospects for rapid commercialization and acquisition of large market shares.

The envisioned industrialization and commercialization lines are associated with:

- Silicon-based gas sensing photonic element
- Germanium-based gas sensing photonic element
- MID-IR integrated broadband thermal source
- Graphene photodetector on silicon substrate
- Advanced modularization through heterogeneous integration of electronic components and functionalities
- Multi-gas detection sensor module
- Machine Learning algorithms
- Artificial Intelligence combination with data, analytics and automation
- IoT services and cloud-based solutions