

Executive Summary

“An innovative optical fibre device for Micro-pollutants and Greenhouse Gas Monitoring”

Over the last century, the world's population has increased rapidly leading to an exponentially expansion of industrial manufacturing plants. A by-product of manufacturing is the emission of pollutants into the atmosphere and also river. Fine particles in atmosphere generated from power plants, motor vehicles, and residential wood burning can bypass the nose and throat and penetrate deep into the lungs and some of them can enter to the circulatory system. Studies in the past decade have found that an exposure of fine particle can cause a premature death from heart and lung disease. The report by World Health Organization (WHO) in 2016 showing that the ambient air pollutant due to exposure to fine particulate matter of 2.5 microns are responsible for an estimated 4.2 million premature deaths every year.

Thailand is one of the countries in southeast Asia (ASEAN) that air quality especially in the capital (Bangkok) has been obviously getting worse in the beginning of 2019. The pollution level (PM_{2.5}) and greenhouse gas (CO, CO, NO₂) remains at hazardous level in many areas of Bangkok and the surrounding provinces. Experts conclude that the combustion from diesel engines, burning of biomass and industrial activities are the main causes of the situations from both inside country and neighbouring countries. According to a report by the Bangkok Metropolitan Administration (BMA) Health Department, it is showing that nearly 40,000 people in the two main districts of Bangkok have gone to hospitals to receive treatment for respiratory diseases since September 2019.

Therefore, the research on the development of air quality monitoring and take mitigating actions to reduce air pollution are of interest. Many air quality sensing methods have been developed over the past decade. While these techniques are widely used for gas sensing applications, monitoring methods based on optics have proven to be an ideal method for remote and real-time particles and gas monitoring. The proposed particles and gas monitoring system in this project include 3 optical systems.

1. Fiberized SPR sensor using the kretschmann configuration for CO₂ and CH₄ detection by depositing a selective material on metal surface of SPR system.
2. Hollow-core polymer optical fiber specific absorption characteristics of CO₂ and CH₄ occurring in the mid-IR region spanning from 2 to 12 microns. The concentration of gas can be deduced from absorption measurements by knowing the absorption strength of ethylene at specific optical frequencies. This approach eliminates functionalization procedure and necessity of regular recalibration. The absolute measurement will be achieved by 1) implementing a reference arm isolated from the environment; 2) using a reference at wavelength far from the peak, or 3) using modulation techniques commonly found in gas sensing.
3. Fiber Bragg grating will be used for fine particles trapped monitoring for PM_{2.5} detection.

Two simultaneous factors were established within the last decade which enabled this project in this timeline. (a) Advances in the field of photonics and nanotechnology, that enabled the wavelength selectivity proposed in this project. (b) The enormous leap in manufacturing techniques which enabled autonomous technologies and the next generation of compact air-pollutant monitoring. The novel fiber particle and gas sensor proposed in this project offers a step change in both physical size and power consumption compared to existing commercially available gas sensing technology, making it an ideal candidate for low-cost surveying and exploration missions.