Towards an Integrated On-chip Mid-infrared Chemical Sensing System

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Abstract

The mid-infrared wavelength range (2.5~12μm) includes the absorption peaks of many important chemicals including environmental and industrial pollutants, toxic agents of interest to homeland security and also the medical drug delivery industry of big pharma. By analyzing the absorption spectrum of a chemical, one can (i) identify the chemical species and (ii) measure its concentration. With a Si CMOS compatible integrated mid-infrared (MIR) platform for sensing, we can envision a network of low-cost sensors for diverse applications. Here we will discuss the main building blocks of an integrated mid-infrared (MIR) sensing platform: the light source, the waveguide sensor and the detector, focusing predominantly on the development of the sensor and detector.

For both, waveguide sensor and photodetector materials, we seek (a) low-cost options with (b) low deposition temperatures for back-end Si-CMOS-compatibility, and (c) robustness against harsh sensing environments. For waveguide sensors to provide good signal to noise ratios, the material must additionally display low absorption and low sidewall scattering losses. Photodetectors must be absorptive at the wavelengths of interest.

We will discuss integration strategies for photodetectors: (i) with a sensor waveguide as well as (ii) with a resonant cavity connectorized to CMOS electronics. The detection of liquids, gases and aerosols using these devices will be discussed. Our work makes us hopeful regarding the future of mid-IR silicon photonic sensor systems.

Short Bio: Dr. Anu Agarwal received her doctoral degree in Electrical Engineering from Boston University in 1994, where she investigated the spatial extent of point defect interactions in silicon.

She has been at MIT's Microphotonics Center since 1994, except for a short (2001-2004) stint at Clarendon Photonics, where she was a part of a team of engineers developing a novel optical filter.

As a Principal Research Scientist at MIT, she is developing integrated Si-CMOS compatible linear and non-linear materials for photonic devices, especially in the mid-IR regime, for hyperspectral imaging and chem-bio sensing, because most chemical and biological toxins have their fingerprints in this range. She has over 100 journal and refereed conference publications, 6 awarded patents and 5 pending patents. Her work on MIR materials and devices is creating a planar, integrated, Si-CMOS-compatible microphotonics platform which will enable on-chip imaging and sensing applications.

Currently, as the Director of the **L**ab for **E**ducation and **A**pplication **P**rototypes (**LEAP**) at MIT, she is eager to educate and prepare students and incumbent employees in local industries for the next generation high-tech jobs in integrated photonics. With funding from the Commonwealth of Massachusetts, she is engaged in setting up more LEAP facilities across the state. All LEAP facilities will be a part of the **A**dvanced **I**nstitute of **M**anufacturing **Photonics Academy** (**AIM Photonics Academy**). The Academy belongs to **AIM Photonics**, the parent organization, which is one of 14 Advanced Manufacturing Institutes that were recently established by the US federal government to promote high tech manufacturing in USA.