Photonic integrated chips for agricultural sensing

- Microchips to detect gas using light
- Optimize, design, fabrication, testing of the laser
- Near infrared-1550 nm wavelength range

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Motivation and results

Current Challenges

- Electrochemical sensors suffer from selectivity, reproducibility, scalability, longevity
- Rack-sized optical spectrometers are accurate but expensive and non-portable

Potential of photonic integrated circuit(PIC)-Based Solutions

- Wide tunability from integrated lasers
- Reduced cost via multi project wafer runs & compact footprint
- Multi-gas detection with a single laser device
- Leverages matured material platform developed in 1550 nm range

Requirements for Tunable Lasers in Multispecies Gas Sensors

Wide tuning (≈40 nm) covers gases in telecom band: NH_3, CO_2, CH_4, C_2H_2
Continuous tunability: smooth wavelength access without mode hops or irregularities → essential for absorption spectroscopy
Spectral linewidth: laser linewidths (few MHz) well-matched to narrow gas absorption dips (hundreds MHz–GHz)

Results

Continuous tuning Methodology [1]

- Novel tuning algorithm for continuous and widely tunable laser filter
- Intra-cavity tunable filter design ensuring mode-hop free tuning over FSR
- 30 nm tuning range at 1550 nm with stable transmission

Optimization-Driven Tuning [2, 4, 3, 5]

- Automated tuning routines applied to indium phosphide tunable filters and lasers
- 40 nm tuning range covered using stochastic optimization

Compact widely tunable laser [6, 7]

- Realized on indium phosphide membrane-on-silicon platform
- Compact footprint (0.13 mm^2) with optimized filter for single-mode operation
- 29 mA threshold, 3.6 dBm output power, 1.8% wall plug efficiency
- Side-mode suppression 30–44 dB, 40 nm tuning (1555–1595 nm)

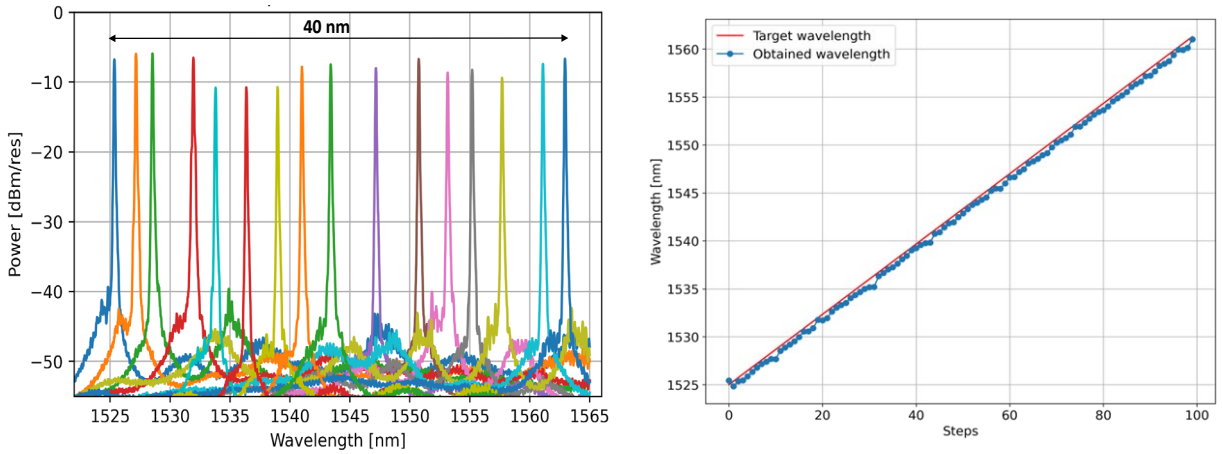


Figure: Tuning spectra of integrated laser based on InP material platform

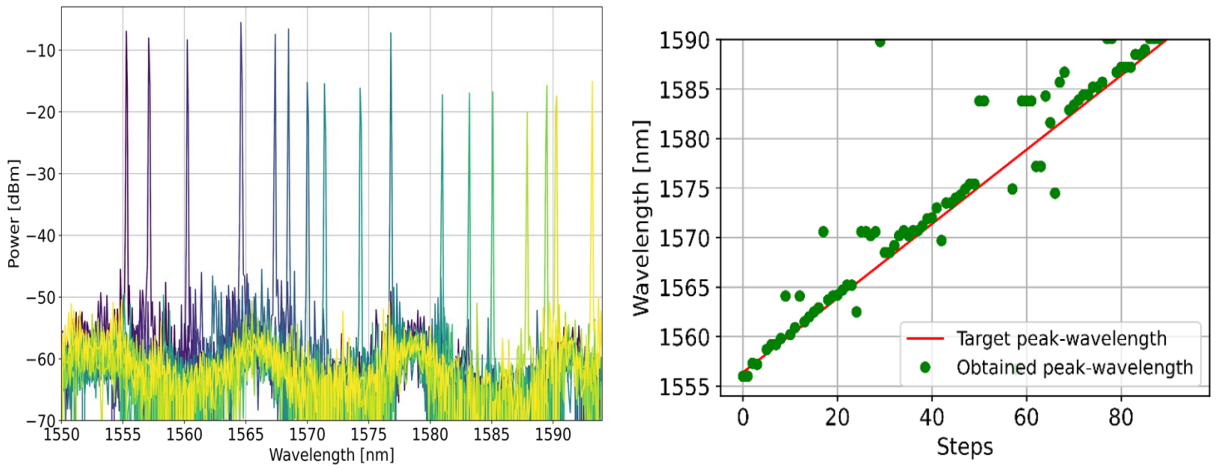
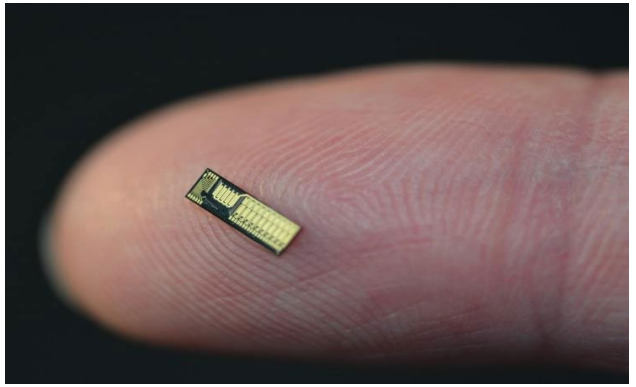
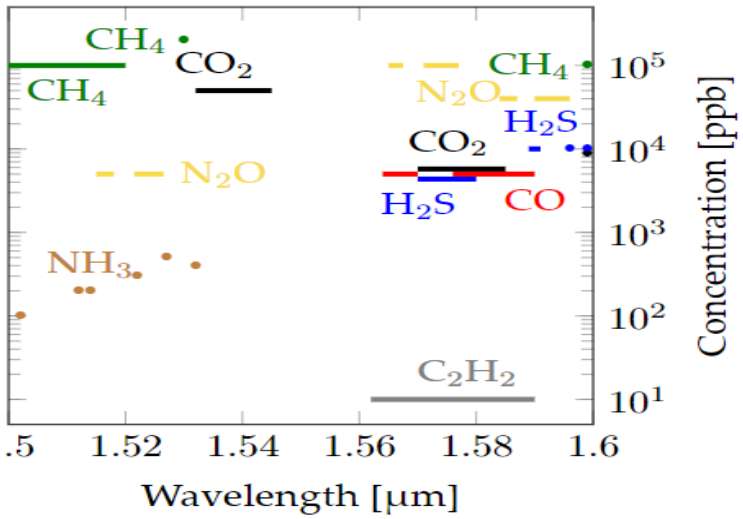


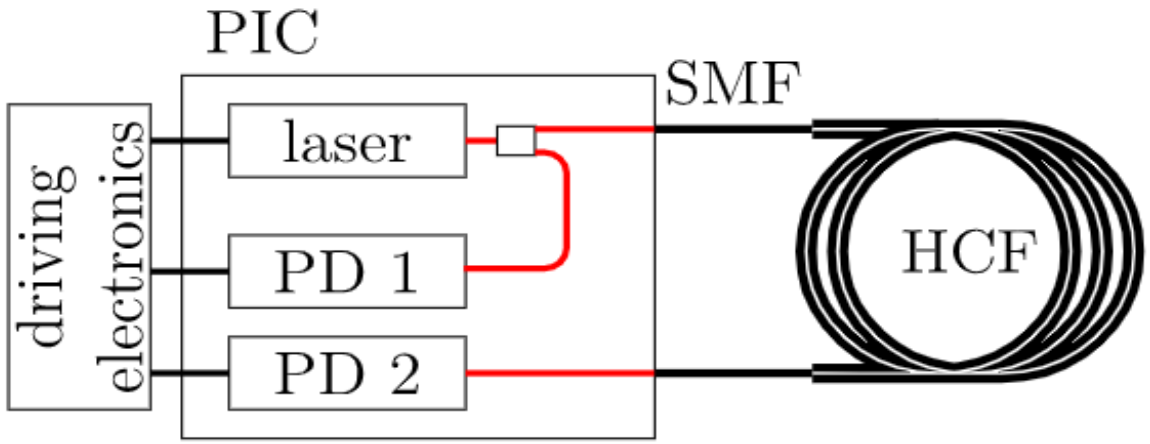
Figure: Tuning spectra of integrated laser based on InP membrane on Si material platform

Impact on agricultural systems

- Compact and energy-efficient sensors
- Multi-gas detection on one platform
- High sensitivity down to ppb levels







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