# [[2, Key components of the invention]]

Aspects of the present disclosure include a spectroscopy device that is amenable to miniaturization, including several components. For example, the spectroscopy device includes a light source that may be either broad-spectrum or that may comprise multiple light sources, each operating at a specific wavelength. Additionally, for example, the spectroscopy device includes sensors, such as photodiodes, that may be utilized to measure the intensity of light at these specific wavelengths. Further, for example, the spectroscopy device includes a small cavity or chamber configured to hold the substance under test, allowing for the performance of different types of spectroscopy, including absorption and reflectance spectroscopy, with the orientation of the light source(s) and sensor(s) being adjustable based on the desired type. The spectroscopy device is configured to output an optical spectrum at a discrete set of wavelengths, for example, 24 different wavelengths, which is not a full spectrum that typically requires expensive benchtop equipment. The output spectrum may contain aggregate information about the various molecules present in the substance under test. Signal processing, machine learning, and/or other algorithms may be employed to recover and estimate the composition of the substance based on the measured optical spectrum at the discrete set of wavelengths.

# [[3, Sketches]]

Referring to Figure a(a) and Figure 1(b), an example implementation includes a light source interacting with a sample, wherein the spectroscopy device includes an enhancement cavity and Bragg grating. In this aspect, Figure 1(a) is a schematic representation where multiple light sources having multiple wavelengths emit light towards a circular structure that includes the enhancement cavity and the Bragg grating. The circular structure includes one or more wave guides to channel the light sources, and one or more photodiodes. Figure a(b) is a cross-sectional view of the spectroscopy device in which a sample is provided, where the sample is positioned within the enhancement cavity. Light from the light sources is directed by the waveguide through a first set of the Bragg grating, then through the sample within the enhancement cavity, and then through a second set of Bragg grating to a photodiode. Additionally, the spectroscopy device includes an air outlet and a filter. Aspects of the present disclosure may include the integration of these components to enhance the performance of optical systems, potentially improving the efficiency and effectiveness of light manipulation in various applications.

# [[4, Li's Input]]

Aspects of the present disclosure may include an on-chip photonic sensing device that is based on the enhanced interactions between guided optical modes and the chemical analytes within a high-finesse nano cavity formed by photonic crystals. This device may feature high sensitivity to low concentrations of analytes despite a strong background noise floor, and a high level of identification for distinguishing different chemical species compared to conventional mass spectroscopy methods. On-chip components may further include semiconductor light sources with certain tunability, silicon waveguides, and electro-optic modulators (EOMs), particularly if a two-photon Raman scheme is adopted. Additionally, photonic crystals may be implemented as either a 1D array or a 2D hexagon pattern, along with photodetectors that may operate in the VIS, NIR, and MIR ranges. Such configurations may result in significant advancements in the field of chemical sensing, potentially enabling more precise and efficient detection methods.

# [[5, ]]

Aspects of the present disclosure may include a miniaturized spectroscopy device that addresses prior challenges in achieving high specificity and adequate spectral signal-to-noise ratio (SNR) while performing at multiple wavelengths. Previous attempts may have struggled due to low specificity and the necessity for additional high-quality off-chip optics, which complicated the design and operation. In the present disclosure, the placement of the sample within a cavity, and increasing the number of interactions between the excitation source and the sample, results in a higher spectral SNR at each wavelength. Furthermore, the miniaturization on the chip may allow for the generation of multiple spectral responses in different cavities, reinforcing the sensing capabilities and eliminating the reliance on external optics. This innovative approach may be instrumental in tuning the algorithm for enhanced detection, ultimately overcoming the limitations faced in earlier miniaturization efforts.

# Extracted Images

Image from Slide 1:



Image from Slide 3:

