CLAIMS

What is claimed is:

1. A method for detecting characteristics of a gas, comprising:

(a) sweepingly directing a beam of light through the gas to a target surface on which the beam of light is scattered;

(b) acquiring the scattered light scattered from the target surface; and

(c) processing the acquired scattered light to determine the characteristics of the gas, wherein the characteristics of the gas comprise at least one of a temperature of the gas and an amount of at least one ingredient of the gas,

wherein the gas comprises one of an exhausted plume from a vehicle or factory plant, leaked gas from an oil well or gas resource, and unidentified gas from an unknown source; and

wherein the target surface is one of a road surface of a road having at least one lane, a drill surface of oil well or gas resource and a surface having the unidentified gas,

wherein the processing step comprises:

characterizing an absorption line from the acquired scattered light;

obtaining a half-width at half-maximum (HWHM) of the absorption line; and

determining the temperature of the gas from the obtained HWHM with a relationship of:

$$T_{gas} = T_0 \left[\frac{b_L^0(T_0)}{b_L^0(T_{gas})}\right]^{\frac{1}{n}},$$

wherein T_{gas} is the temperature of the gas, T_0 is a standard temperature, $b_L^0(T_0)$ is a standard HWHM corresponding to the standard temperature, $b_L^0(T_{gas})$ is the obtained HWHM, and n is a coefficient of temperature dependence of an air-broadened halfwidth.

2. The method of claim 1, wherein the acquiring step comprises:

acquiring an image from the scattered light; and

wherein the processing step comprises:

obtaining a plurality of pixels from the acquired image, each pixel having a pixel area projected onto the road, wherein each of the at least one lane of the road

correspond to a group of the pixels;

characterizing an absorption rate of light of each pixel from the acquired image;

calculating optical mass of each pixel from the characterized absorption rate of the pixel; and

for each of the at least one lane, identifying whether the gas exists on the lane based on the optical mass of the corresponding group of the pixels.

3. The method of claim 1, wherein the HWHM is obtained from the absorption line of the exhausted plume with low ambient concentration, and wherein the exhausted plume with low ambient concentration is carbon monoxide (CO) or nitric oxide (NO).

4. The method of claim 1, wherein the directing step comprises:

spin-sweepingly directing the beam of light along an optical path to the target surface such that the optical path spin-forms a cone geometry covering the target surface.

5. The method of claim 4, wherein the processing step further comprises:

(a) processing the acquired scattered light to obtain information corresponding to the cone geometry;

(b) identifying whether the gas exists in the cone geometry based on the information corresponding to the cone geometry; and

(c) if the gas exists, determining at least one of a location of the gas on the target surface, a flow rate of the gas, at least one ingredient of the gas, and an absolute amount of the gas.

6. A device for detecting characteristics of a gas, comprising:

(a) a light source configured to emit a beam of light through the gas to a target surface on which the beam of light is scattered;

(b) a detector configured to acquire the scattered light scattered from the surface; and

(c) a processor configured to process the acquired scattered light to determine the characteristics of the gas, wherein the characteristics of the gas comprise at least one of a temperature of the gas and an amount of at least one ingredient

of the gas,

wherein the gas comprises one of an exhausted plume from a vehicle or factory plant, leaked gas from an oil well or gas resource, and unidentified gas from an unknown source; and

wherein the target surface is one of a road surface of a road having at least one lane, a drill surface of oil well or gas resource and a surface having the unidentified gas,

wherein the processor is configured to determine the temperature of the gas by:

(a) characterizing an absorption line from the acquired scattered light;

(b) obtaining a half-width half-maximum (HWHM) of the absorption line; and

(c) determining the temperature of the gas from the obtained HWHM with a relationship of:

$$T_{gas} = T_0 \left[\frac{b_L^0(T_0)}{b_L^0(T_{gas})}\right]^{\frac{1}{n}},$$

wherein T_{gas} is the temperature of the gas, T_0 is a standard temperature, $b_L^0(T_0)$ is a standard HWHM corresponding to the standard temperature, $b_L^0(T_{gas})$ is the obtained HWHM, and n is a coefficient of temperature dependence of an air-broadened half-width.

7. The device of claim 6, further comprising a positioning optics configured to sweepingly direct the beam of light emitted by the light source through the gas to the target surface.

8. The device of claim 7, wherein the detector is configured to acquire an image from the scattered light, and the processor is configured to process the acquired image to perform functions of:

(a) obtaining a plurality of pixels from the acquired image, each pixel having a pixel area projected onto the road, wherein each of the at least one lane of the road correspond to a group of the pixels;

(b) characterizing an absorption rate of light of each pixel from the acquired image;

(c) calculating optical mass of each pixel from the characterized absorption rate of the pixel; and

(d) for each of the at least one lane, identifying whether the gas exists on the lane based on the optical mass of the corresponding group of the pixels.

9. The device of claim 6, wherein the HWHM is obtained from the absorption line of the exhausted plume with low ambient concentration, and wherein the exhausted plume with low ambient concentration is carbon monoxide (CO) or nitric oxide (NO).

10. The device of claim 6, further comprising a positioning optics configured to spin-sweepingly direct the beam of light through the gas to the target surface such that an optical path between the positioning optics and the target surface spin-forms a cone geometry covering the target surface.

11. The device of claim 10, wherein the positioning optics comprises an X-Y galvanometer or a spinning mirror.

12. The device of claim 10, wherein the processor is configured to further perform functions of:

(a) processing the acquired scattered light to obtain information corresponding to the cone geometry;

(b) identifying whether the gas exists in the cone space based on the information corresponding to the cone geometry; and

(c) if the gas leak exists, determining at least one of a position of the gas on the target surface, a flow rate of the gas, at least one ingredient of the gas, and an absolute amount of the gas.