

# CO<sub>2</sub> Measurement by

- InAsSb photovoltaic detectors
- Mid infrared LEDs

Nov. 2024

---

**CONTENTS**

---

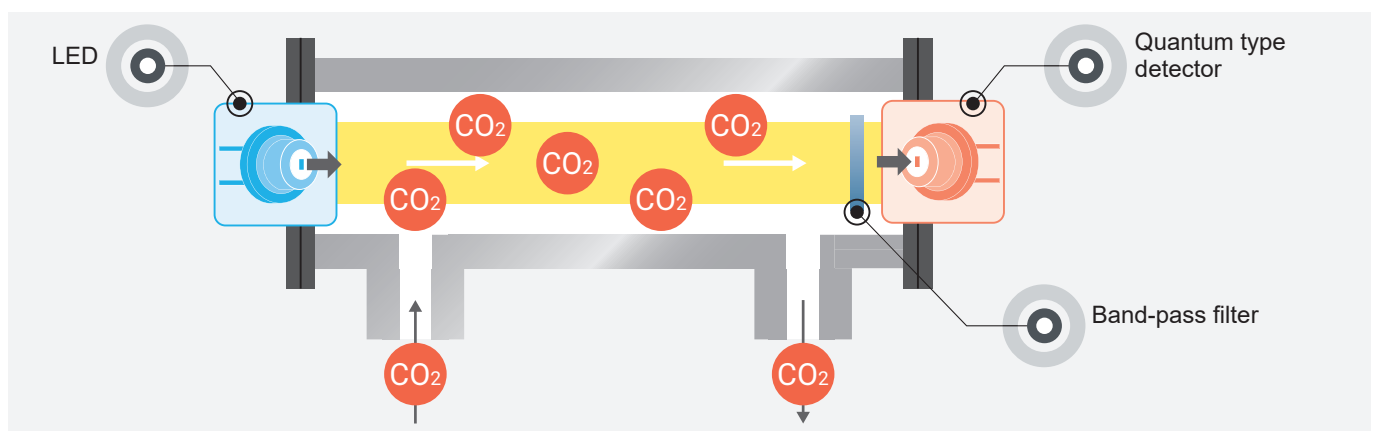
Principle of CO <sub>2</sub> measurement with NDIR method	P.2
Structure of CO <sub>2</sub> measurement	P.3
Example of CO <sub>2</sub> measurement	P.4

# Principle of CO<sub>2</sub> measurement with NDIR method

In recent years, interest in gas analysis has risen due to its potential for application to the greenhouse gas problem and measures against infectious diseases. Hamamatsu Photonics handles photosensors and light sources suitable for gas analysis. Here, we introduce an example of CO<sub>2</sub> measurement using an InAsSb photovoltaic detector and a mid infrared LED.

## ■ NDIR method

NDIR (Non-Dispersive Infrared) detection method uses an optical filter to extract and detect only the wavelengths required for gas measurement. This method offers superior reliability and maintainability due to a simple detection principle, which uses no moving parts. Mostly containing cost-effective optical parts, it is non-dispersive and does not use image sensors. High cost performance optical parts are used in many measuring devices, including but not limited to portable measurement safety (explosive gas detection) devices and fixed environmental measurement devices.

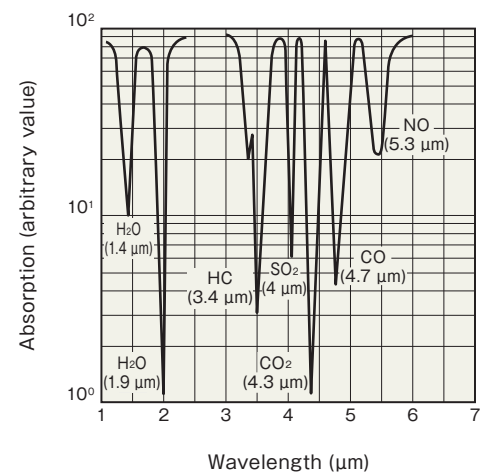


Since there is a CO<sub>2</sub> absorption band near the wavelength of 4.3  $\mu\text{m}$ , light is absorbed by CO<sub>2</sub> when exposed to light in that wavelength region. The amount of light absorbed increases as the CO<sub>2</sub> concentration increases, and the CO<sub>2</sub> concentration can be measured from the change in the signal level of the photosensor due to changes in the amount of light absorption.

Photosensors and light sources commonly used in the NDIR method include a combination of a lamp and a thermal type detector such as a thermopile detector.

Combining a quantum type detector such as an InAsSb photovoltaic detector with a mid infrared LED will contribute to the compactness, high accuracy, and low power consumption of NDIR type gas sensors.

## ■ Gas absorption spectrum



## ■ Light source comparison

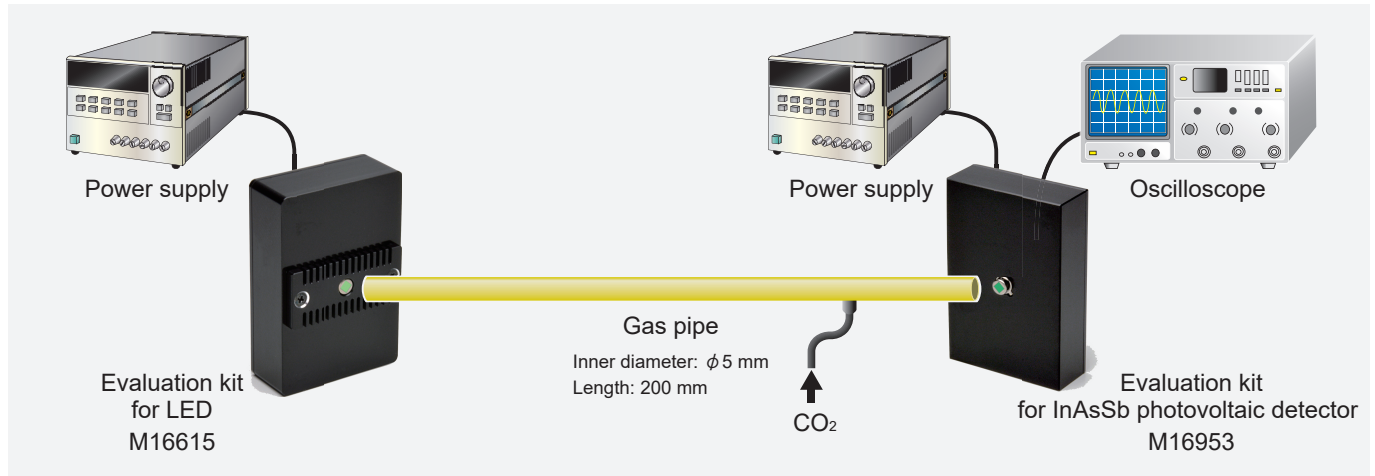
	Wavelength range	Output	Time response characteristics	Power consumption	Lifetime	Cost advantage
LEDs	Narrow	☆☆	☆☆☆	☆☆☆	☆☆☆	☆☆☆
Lamps	Wide	☆☆☆☆	☆☆	☆	☆☆	☆☆

## ■ Photosensor comparison

	Sensitivity	Wavelength dependence	Time response characteristics	Cooling	Cost advantage
Quantum type detectors	☆☆☆	Yes	☆☆☆☆	Required (partially not required)	☆☆
Thermal type detectors	☆☆	No	☆	Not required	☆☆☆

# Structure of CO<sub>2</sub> measurement

## ■ Evaluation configuration (example)



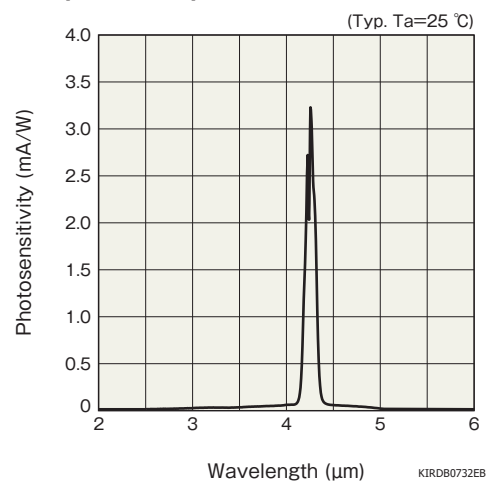
## Evaluation kit for InAsSb photovoltaic detector M16953



- Sensor in use: InAsSb photovoltaic detector P16112-043MF \*1
- Band-pass filter center wavelength: 4.26  $\mu$ m
- Gain: 10<sup>7</sup> V/A
- Frequency characteristics: DC to 80 kHz
- Recommended drive voltage:  $\pm$ 2.5 V

\*1: Click here for details on the InAsSb photovoltaic detector P16112-043MF (sold separately).  
<https://www.hamamatsu.com/jp/en/product/optical-sensors/infrared-detector/inassb-photovoltaic-detector/P16112-043MF.html>

## ■ Spectral response of Built-in Element



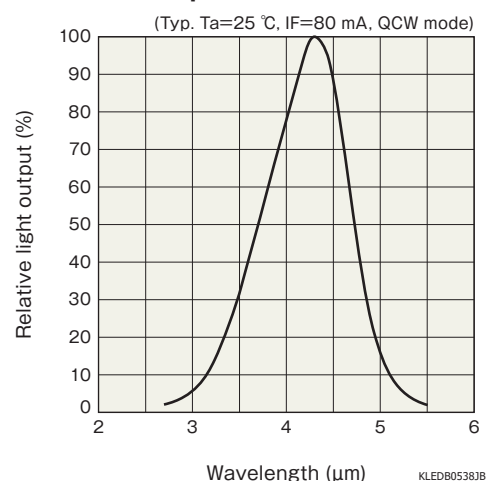
## Evaluation kit for LED M16615



- Sensor in use: Mid infrared LED L15895-0430MA \*2
- Peak emission wavelength: 4.3  $\mu$ m
- Output current: 400 mA
- Output pulse: 10  $\mu$ s
- Output cycle: 1000  $\mu$ s
- Recommended drive voltage: +15 V

\*2: Click here for details on the mid infrared LED L15895-0430MA (sold separately).  
<https://www.hamamatsu.com/jp/en/product/light-and-radiation-sources/led/L15895-0430MA.html>

## ■ Emission spectrum

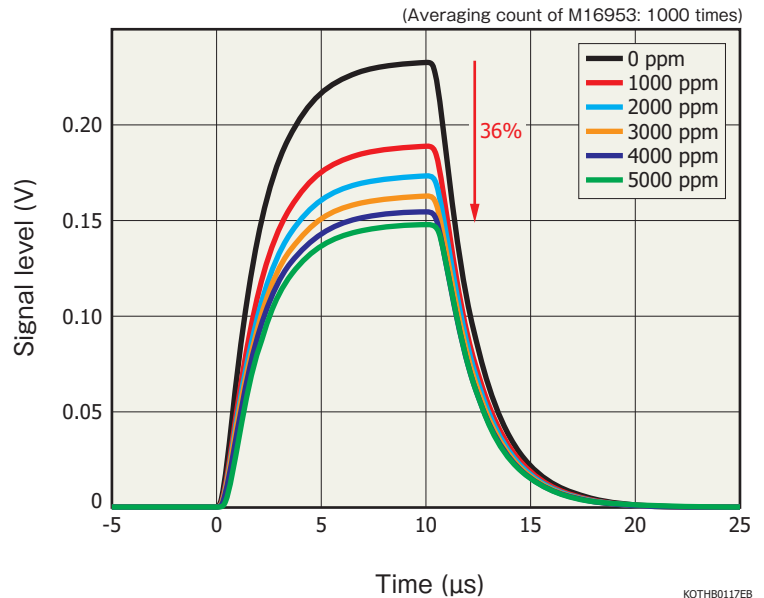


# Example of CO<sub>2</sub> measurement

The following diagram shows the correlation between the results of measuring CO<sub>2</sub> with the structure on page 3 and the signal of the photosensor and the gas concentration.

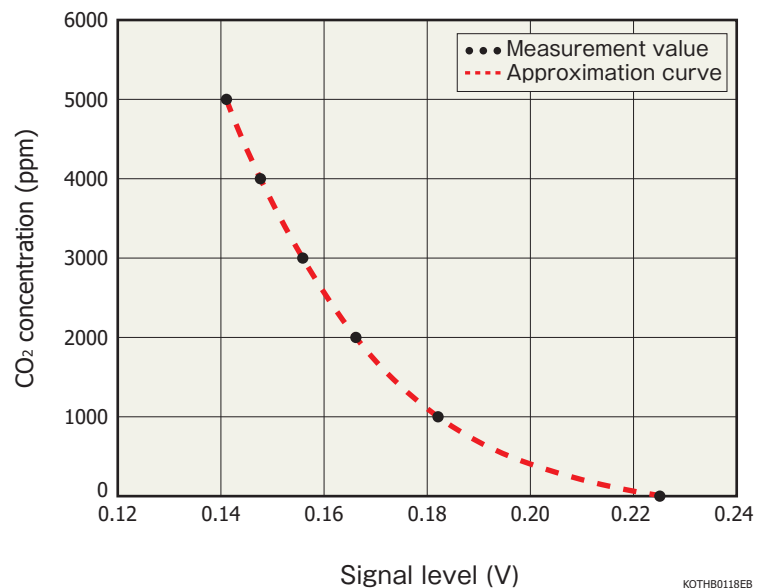
## CO<sub>2</sub> measurement result

As a result of measuring the signal by filling the gas pipe with CO<sub>2</sub> that has a concentration adjusted to 0 to 5000 ppm, we confirmed a 26% signal reduction due to the absorption of CO<sub>2</sub> in the gas pipe.



## Correlation between the signal of the photosensor and gas concentration

Since the signal level from the photosensor versus the gas concentration can be approximated by a polynomial equation such as a cubic equation, the CO<sub>2</sub> concentration can be estimated by measuring the amount of signal from the photosensor.



Hamamatsu offers mid-infrared LED with an emission wavelength of 3.9 μm and InAsSb photovoltaic detectors with a center wavelength of 3.9 μm for reference lights. Conversion to gas concentration with the use of the signal level of the wavelength (3.9 μm), in which CO<sub>2</sub> is not absorbed, makes contribution in measurement under the temperature changing environment and in measurement requiring higher accuracy.

## Reference: CO<sub>2</sub> density and its impact

CO <sub>2</sub> density	Environment state
Approx. 400 ppm	CO <sub>2</sub> in the atmosphere
to 1000 ppm	Well-ventilated room
to 5000 ppm	Poorly ventilated room (headache or drowsiness)
5000 ppm or more	Limit value as a work place (based on regulations in Japan)
Approx. 40000 ppm	CO <sub>2</sub> contained in human exhaled breaths



Product specifications are subject to change without prior notice due to improvements or other reasons. This document has been carefully prepared and the information contained is believed to be accurate. In rare cases, however, there may be inaccuracies such as text errors. Before using these products, always contact us for the delivery specification sheet to check the latest specifications.

The product warranty is valid for one year after delivery and is limited to product repair or replacement for defects discovered and reported to us within that one year period. However, even if within the warranty period we accept absolutely no liability for any loss caused by natural disasters or improper product use. Copying or reprinting the contents described in this material in whole or in part is prohibited without our prior permission.

# HAMAMATSU

[www.hamamatsu.com](http://www.hamamatsu.com)

HAMAMATSU PHOTONICS K.K., Solid State Division

1126-1 Ichino-cho, Higashi-ku, Hamamatsu City, 435-8558 Japan, Telephone: (81)53-434-3311, Fax: (81)53-434-5184

U.S.A.: HAMAMATSU CORPORATION: 360 Foothill Road, Bridgewater, NJ 08807, U.S.A., Telephone: (1)908-231-0960, Fax: (1)908-231-1218 E-mail: [usa@hamamatsu.com](mailto:usa@hamamatsu.com)  
Germany: HAMAMATSU PHOTONICS DEUTSCHLAND GMBH.: Arzbergerstr. 10, 82211 Herrsching am Ammersee, Germany, Telephone: (49)8152-375-0, Fax: (49)8152-265-8 E-mail: [info@hamamatsu.de](mailto:info@hamamatsu.de)  
France: HAMAMATSU PHOTONICS FRANCE S.A.R.L.: 19, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: (33)1 69 53 71 00, Fax: (33)1 69 53 71 10 E-mail: [infos@hamamatsu.fr](mailto:infos@hamamatsu.fr)  
United Kingdom: HAMAMATSU PHOTONICS UK LIMITED: 2 Howard Court, 10 Tewin Road, Welwyn Garden City, Hertfordshire AL7 1BW, UK, Telephone: (44)1707-294888, Fax: (44)1707-325777 E-mail: [info@hamamatsu.co.uk](mailto:info@hamamatsu.co.uk)  
North Europe: HAMAMATSU PHOTONICS NORDEN AB: Torshamnsgatan 35 16440 Kista, Sweden, Telephone: (46)8-509 031 00, Fax: (46)8-509 031 01 E-mail: [info@hamamatsu.se](mailto:info@hamamatsu.se)  
Italy: HAMAMATSU PHOTONICS ITALIA S.R.L.: Strada della Moia, 1 int. 6, 20044 Arese (Milano), Italy, Telephone: (39)02-93 58 17 33, Fax: (39)02-93 58 17 41 E-mail: [info@hamamatsu.it](mailto:info@hamamatsu.it)  
China: HAMAMATSU PHOTONICS (CHINA) CO., LTD.: 1201 Tower B, Jiaming Center, 27 Dongsanhuan Beilu, Chaoyang District, 100020 Beijing, P.R. China, Telephone: (86)10-6586-6006, Fax: (86)10-6586-2866 E-mail: [hpc@hamamatsu.com.cn](mailto:hpc@hamamatsu.com.cn)  
Taiwan: HAMAMATSU PHOTONICS TAIWAN CO., LTD.: 8F-3, No.158, Section 2, Gongdao 5th Road, East District, Hsinchu, 300, Taiwan R.O.C. Telephone: (886)3-659-0080, Fax: (886)3-659-0081 E-mail: [info@hamamatsu.com.tw](mailto:info@hamamatsu.com.tw)