Metasurface infrared emitter for CO_2 sensing

Keywords: Metamaterials, Plasmonics, Environmental analysis

Hideki T. Miyazaki
Optical Materials Field / Plasmonics Group
MIYAZAKI.Hideki@nims.go.jp | https://samurai.nims.go.jp/profiles/miyazaki_hideki

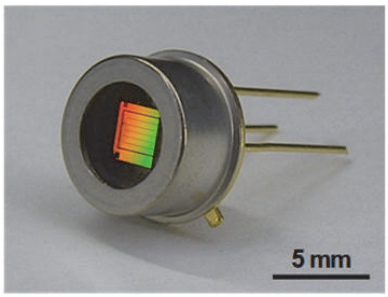
Background

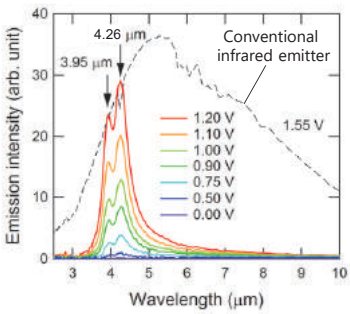
- CO_2 concentration is optically measured on the basis of molecule-specific infrared absorption.
- However, wide band radiation of conventional infrared emitters leads to wasteful consumption of energy and has restricted the battery life of portable sensors.

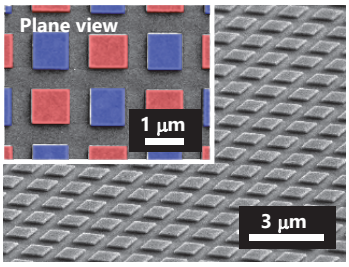
Aim

- Metasurfaces made of arrayed sub-wavelength-sized plasmon cavities enables engineered thermal emission of only necessary wavelengths.
- This is employed for infrared emitters for CO_2 sensing with reduced energy consumption.

Advanced Research Topics







Electron micrographs of the metasurface

Overview

- 4.26- and 3.95-μm radiation necessary for CO_2 measurement is generated by applying voltage
- Suppressing unnecessary radiation reduced the power required for achieving identical output
- This device can be regarded as a metasurface, a type of metamaterials
- Fabricated by mass-productive nanoimprinting
- Crucial for reliable gas alarms

Principle

- 4.26- and 3.95-μm radiation is thermally excited in rectangular plasmon cavities (optical antennas)
- Arrayed vertical (shown in blue) and horizontal (red) cavities yield unpolarized radiation
- Nearly perfect blackbody radiation at two wavelengths is achieved by optimizing the period
- Heated up to 300°C by an air-bridged heater
- Applicable to other gasses by tailoring dimensions

Publications

- H. T. Miyazaki et al., Appl. Phys. Lett. **105**, 121107 (2014).
- H. T. Miyazaki et al., Sci. Technol. Adv. Mater. **16**, 035005 (2015).
- H. T. Miyazaki and M. Iwanaga, Rev. Laser Eng. **44**, 10 (2016).

Applied area and future prospects

- Portable CO_2 sensors with long battery life
- Optical gas alarms free of false detection
- Infrared heaters only for specific targets
- Two granted patents

Issues for technology transfer

- Material optimization for high intensity radiation
- Further improvement of energy efficiency by optimizing thermal conduction design