

# Advances in Hollow-Core Fiber Gas Sensing



## AI Overview

Hollow-core fibers, particularly anti-resonant designs, are enabling ultra-sensitive, rapid, and compact gas sensing with minimal sample volumes and enhanced selectivity. Overview of Hollow-Core Fiber Gas Sensing Hollow-core fibers (HCFs) guide light through an air-filled core, allowing long interaction lengths between light and gas while minimizing sample volume. This overcomes limitations of traditional multi-pass cells, which are bulky and mechanically sensitive, and enables compact, field-deployable sensors for industrial, environmental, and biomedical applications. HCFs include photonic crystal fibers (HC-PCFs) and anti-resonant hollow-core fibers (HC-ARFs), both of which support high-sensitivity absorption spectroscopy across visible, near-infrared, and mid-infrared wavelengths. Key Technological Advances Anti-Resonant Hollow-Core Fibers (HC-ARFs) HC-ARFs have emerged as a leading platform due to their low loss, broad transmission windows, and near single-mode operation. They allow efficient light-gas interaction and are compatible with compact laser and detector systems. Enhanced Gas Diffusion and Microfabrication Recent advances include femtosecond laser fabrication of microchannels to accelerate gas diffusion into the fiber core, reducing response times to a few seconds. Surface functionalization with selective coatings improves gas specificity and sensitivity. Integration with Advanced Spectroscopy Techniques HC fibers are now integrated with direct absorption spectroscopy (DAS), photothermal and photoacoustic spectroscopy, and multiplexed Raman spectroscopy, enabling detection of trace gases at ultra-low concentrations. Reflective dual-pass configurations further double the effective path length, enhancing sensitivity while maintaining rapid response. Mid-Infrared Sensing The use of mid-infrared substrates in HC-ARFs allows detection of...

## Article Content

Review Hollow-Core Photonic Crystal Fiber Gas Sensing

Hollow-Core Photonic Crystal Fiber Gas Sensing Ruowei Yu 1, Yuxing Chen 1, Lingling Shui 2 and Limin Xiao 1,3,4,\*

Global Hollow-core Fibers Market Research Report 2024

Hollow core fiber is a type of optical fiber that has a hollow core instead of a solid core. It is made by creating a periodic array of air holes that run along the length of the fiber, which causes

Hollow optical fiber based spectroscopy gas sensing

Abstract In recent years, the advantages of HCF as a gas analysis platform have been continuously explored. Gas sensing technology based on HCF spectroscopy has also developed

Antiresonant hollow-core fiber with rapid gas exchange for mid

This work presents the design, fabrication, and experimental validation of a novel antiresonant hollow-core fiber (ARHCF) with a large core diameter (107  $\mu\text{m}$ ) optimized for rapid mid

Trace gas detection using anti-resonant hollow-core fiber Raman ...

In this work, a Raman spectroscopy gas detection system based on hollow-core anti-resonant fiber (HC-ARF) was developed, along with a multi-stage spatial filtering strategy tailored for

(PDF) Hollow-Core Photonic Crystal Fiber Gas Sensing

In various specialty fibers, hollow-core photonic crystal fibers (HC-PCFs) can overcome the fundamental limits of solid fibers and have attracted intense interest recently.

Hollow-core anti-resonant optical fibers for chemical and biomedical ...

Highlights • Recent advances in hollow-core anti-resonant optical fiber (HC-ARF) were overviewed. • HC-ARF sensors for chemical sensing covering gas and liquid detection via various

Compressing laser pulses to 22 fs with MDSS in hollow-core fibers

So excited to share our recent work on compressing picosecond laser pulses down to 22 fs using Multidimensional Solitary States (MDSS) in molecular gas-filled hollow-core fibers. We investigated ...

Recent Advancement of Anti-Resonant Hollow-Core Fibers for Sensing ...

Both regular and irregular-shaped fibers and their performance in various sensing scenarios are summarized. Finally, the challenges and possible solutions are briefly presented with

Gas sensing inside hollow-core fibers

<p> Laser-based spectroscopy in the infrared region is critical for applications requiring trace-level gas detection with high selectivity. While multi-pass cells are traditionally employed to

Advancements in hollow-core anti-resonant fiber for gas sensing ...

We combine the nodeless antiresonant hollow-core fiber and Raman spectroscopy for enhanced Raman gas sensing in a forward scattering measurement configuration to investigate the

Hollow-Core Photonic Crystal Fiber Gas Sensing

Fiber gas sensing techniques have been applied for a wide range of industrial applications. In this paper, the basic fiber gas sensing principles and the development of different

Review on Hollow-Core Fiber Based Multi-Gas Sensing Using Raman ...

The Raman spectroscopy has been widely used in multi-gas detection due to its advantages in fast response speed and non-destructive detection. This paper reviews the latest research progress of

Review on Hollow-Core Fiber Based Multi-Gas Sensing Using Raman ...

This paper reviews the latest research progress of the multi-gas sensing technology in the Raman spectroscopy, focusing on using the hollow-core fiber to enhance the gas signal intensity.

Review Hollow-Core Photonic Crystal Fiber Gas Sensing

One of the most promising fiber-based gas sensors is based on the mid-infrared (MIR) absorption spectroscopy of hollow core antiresonant fibers (HC-ARFs), which combines the advantages of...

Hollow-Core Photonic Crystal Fiber Gas Sensing

Here, we focus on the review of HC-PCF gas sensing, including the light-guiding mechanisms of HC-PCFs, various sensing configurations, microfabrication approaches, and recent

Numerical optimization of anti resonant hollow core fiber for high ...

The core component of our proposed gas sensor is the anti-resonance hollow-core fiber (AR-HCF). To optimize the fiber's performance for gas sensing applications, we designed a structure ...

#### Advancements in hollow-core anti-resonant fiber for gas sensing ...

This paper reviews the latest research progress of the multi-gas sensing technology in the Raman spectroscopy, focusing on using the hollow-core fiber to enhance the gas signal...

#### Fiber optic volatile organic compound gas sensors: A review

This review assesses recent research advances in fiber optic VOC gas sensors, including various sensing principles, gas-responsive materials, new techniques for sensing material

#### Enhancing Gas Diffusion in Antiresonant Hollow-Core Fiber Gas

In this paper, we analyze the performance of diffusion-based gas distribution in antiresonant hollow-core fiber-based gas absorption cells. Performed theoretical analysis was based

PS-0230730

The Raman spectroscopy has been widely used in multi-gas detection due to its advantages in fast response speed and non-destructive detection. This paper reviews the latest research progress of

#### Structure design and application of hollow core microstructured optical ...

In this paper, the hollow-core microstructured optical fiber gas sensors are divided into two types (interferometric type and absorptive type) according to the sensing principle. The

#### Advancements in hollow-core anti-resonant fiber for gas sensing ...

Hollow-core anti-resonant fibers (HC-ARFs) have emerged as a transformative platform for high-performance gas sensing. This review systematically summarizes recent advances

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