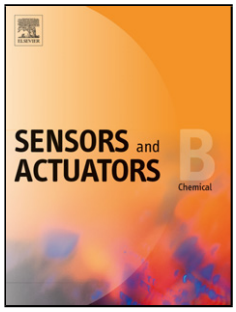

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Highly sensitive and selective gas sensing using the defect mode of a compact terahertz photonic crystal cavity

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Highlights

- A novel method which is fundamentally different from the refractive index sensing is proposed for gas sensing by using the rotational resonances of gases in the terahertz frequencies.
- The HCN is used as the example to demonstrate the high sensitivity of the proposed method.
- Other gases like the CO is mixed with the HCN and our results show that the cavity which is designed for HCN exclusively, indeed only works for HCN.
- The influence of humidity in affecting the terahertz gas sensing is also discussed and demonstrated.

Abstract: The photon energies corresponding to the pure rotational transitions of small polar compounds fall into the terahertz regime, which suggests a high potential of terahertz technology in gas detection, particularly for toxic gases. However, the weak dipole moments caused by pure rotational transitions severely limit the gas detectability at low concentration, leading to the requirement of a long gas cell. Here, we present a highly sensitive and selective detection method using photonic crystal cavity defect mode with the resonance tailored to the characteristic absorption peak of the target gas specimen. The cavity resonance will experience decaying only when the target gas is introduced, and then can be used to exclusively detect the target gas. Numerical calculations show that due to the high dependence of the defect mode transmittance on the specimen absorption at the same frequency, a toxic gas — hydrogen cyanide (HCN) with concentration of only 2ppm in air under the standard atmospheric pressure of 1atm can be identified using a photonic crystal cavity with the overall length around 5mm, two orders of magnitude shorter than the pipe gas cell used in the regular transmission method.

KEYWORDS: Gas Sensor, Terahertz Spectroscopy, Photonic crystal cavity, Fabry-Perot

■ INTRODUCTION