Technology Offer

Touchless Positioning Interface: The Precise Nanosheet Moisture Sensor

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Abstract

This innovative nanosheet-based sensor offers remarkably high sensitivity and rapid response times, making it ideal for advanced touchless positioning interfaces (TPI) and environmental monitoring. By utilizing 2D nanosheet materials, the sensor achieves sub-centimeter spatial resolution and can detect gases and humidity with remarkable accuracy. It is based on a nanosheet of active material ($H_3Sb_3P_2O_{14}$) that changes its electrical or optical properties upon exposure. Its ability to resolve rapid environmental changes is an advancement for touchless interaction, enabling applications in consumer electronics, smart home technologies, and healthcare monitoring. With a response range spanning over five orders of magnitude and compatibility with various substrates, this invention represents a significant advancement in sensor technology.

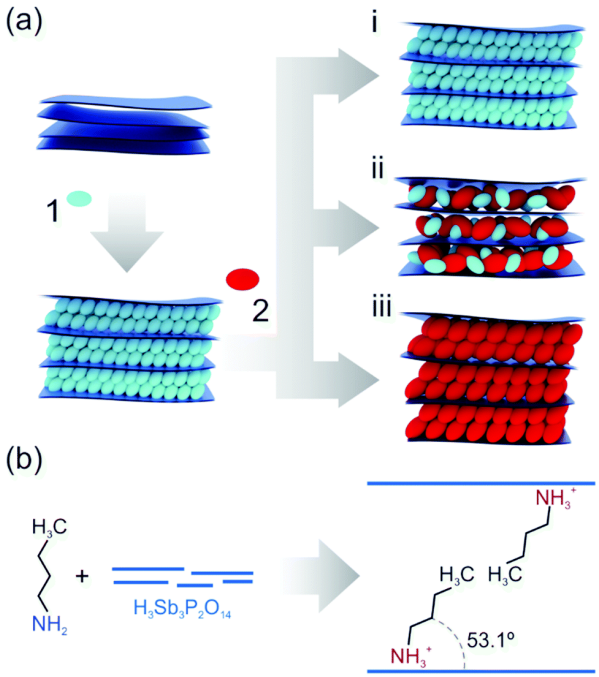

Figure 1: (a) Schematic representation of the two-step vapor-phase amine intercalation process in $H_3Sb_3P_2O_{14}$ nanosheets. Step 1 introduces the first amine (light blue), followed by Step 2, which replaces or co-intercalates with a second amine (red). Outcomes include no exchange (i), co-intercalation (ii), or complete replacement (iii). (b) Reaction mechanism showing amine molecules interacting with $H_3Sb_3P_2O_{14}$ layers, forming tilted bimolecular arrangements through acid–base reactions (Däntl et al., 2020).

Background

The rapid evolution of digital technologies, from smartphones to smart home systems, demands innovative and intuitive touchless control solutions. In this context, humidity sensors are promising candidates for use in smart TPI which operate based on local variations in the humid environment around the human finger. However, the existing devices, such as resistive and capacitive sensors fail to meet the demands for rapid response, high resolution, and sensitivity, especially in applications requiring precise environmental detection or touchless operation. Current technologies often exhibit delays and lack the spatial accuracy required for these tasks. This innovation addresses these gaps by using a nanosheet of active material that enables fine-tuned environmental sensing with fast and reliable responses through changes in its electrical or optical properties, suitable for multiple technological applications, such as smart home technologies and healthcare monitoring.

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The core of this invention is a highly sensitive moisture and gas sensor based on 2D nanosheets. These ultra-thin layers change their physical and chemical properties—such as resistivity, size, or refractive index—when exposed to environmental changes. This responsiveness enables precise detection of humidity, gases like CO_2, or solvent vapors.

The sensor uses a vapor-phase amine intercalation process, where amine molecules are inserted between the nanosheet layers ($H_3Sb_3P_2O_{14}$) (Fig. 1). This technique fine-tunes the interlayer spacing at a sub-Å scale (Däntl et al., 2020), directly impacting the sensor's sensitivity, polarity, and optical properties. The result is a highly customizable sensor with a response range spanning over five orders of magnitude and a recovery time of just a few seconds.

The planar design allows for integration into compact devices, while its reversible amine exchange process ensures reusability and adaptability for varied applications, from touchless interfaces to environmental monitoring.

Advantages

- High Sensitivity: Detects environmental changes with remarkable accuracy and sub-centimeter spatial resolution over a wide range.
- Rapid Response: Quick adaptation to environmental fluctuations, with response times in seconds.
- Compact Design: Ultra-thin nanosheets enable integration into various device architectures.
- Versatile Detection: Recognizes specific gases and compounds (e.g., CO_2, solvent vapors) and humidity variations.

Potential applications

- TPIs for digital devices, such as smartphones and tablets.
- Gas detection systems for industrial and environmental monitoring.
- Smart and privacy windows for adaptive transparency and privacy control.
- Wearable Sensors for healthcare and fitness tracking.
- Resistive relative humidity sensors for industrial and consumer applications.

Patent Information

PCT (*WO2016102139A1*; 26.11.2015), active in EP, US, JP, CN, KR

Publications

Däntl, M., et al. "*Customizing H3Sb3P2O14 nanosheet sensors by reversible vapor-phase amine intercalation*", Nanoscale Horiz. 5 (2020).

Däntl, M. (2022). *Insights into the amine intercalation behavior of layered antimony phosphate thin films and their application in one-dimensional photonic crystals* (Doctoral dissertation, lmu).

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