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Nano carbon matrix for NO_2 sensor with surface acoustic waves

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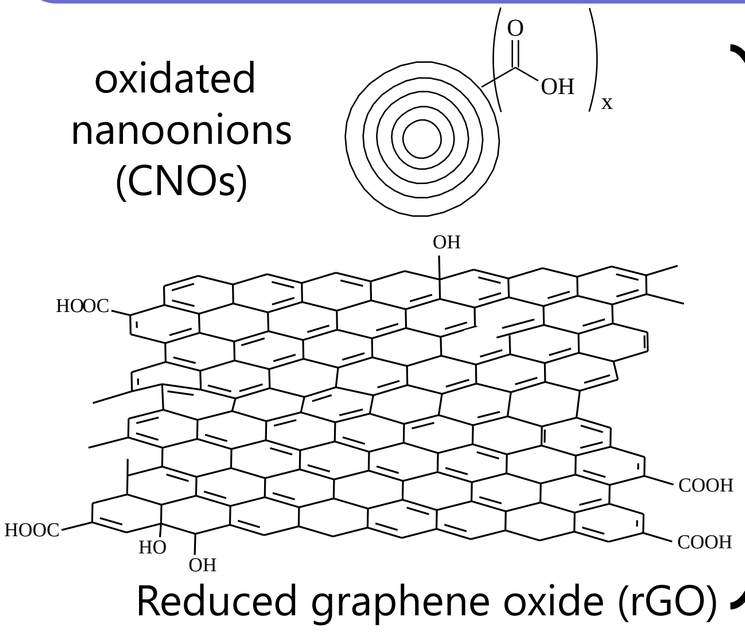
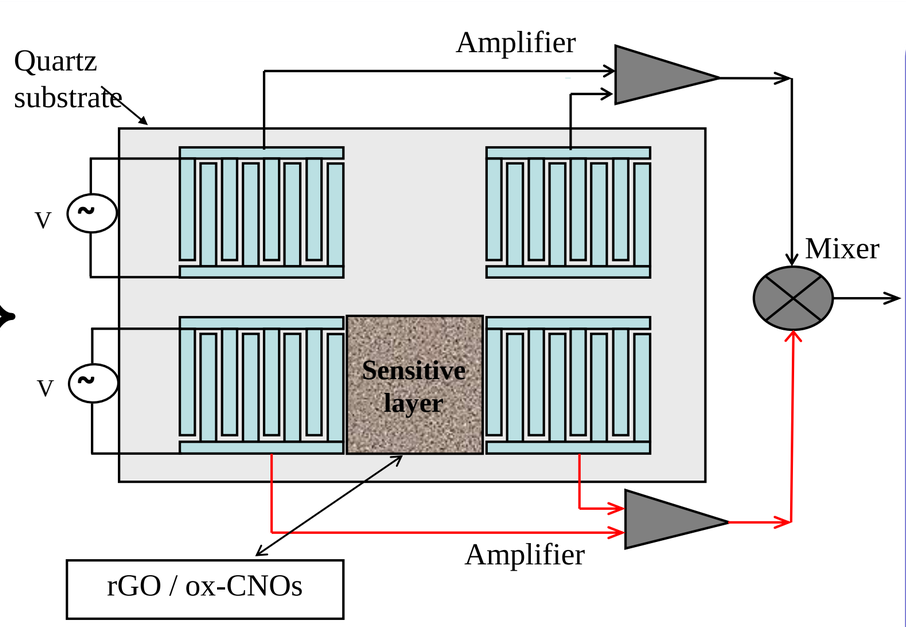
Field of Invention

Nitrogen dioxide, a reddish-brown gas with a strong, suffocating odor, is one of the most toxic air pollutants. This gas is a major cause of morbidity and mortality worldwide, even at low concentrations, if there is repetitive or long-term exposure. The population exposed to this type of pollutant has dyspnea, irritation of the respiratory tract, lung dysfunction. Long-term exposure to a low concentration can destroy lung tissue leading to pulmonary emphysema. The people most affected by exposure to this pollutant are children. Combustion of fossil fuels, diesel engines, forest fires and industrial activities are the most important sources of nitrogen dioxide pollution. Considering the high degree of toxicity, the market of nitrogen dioxide sensors has seen a substantial development in recent years.





Sensing structure

The sensitive layers made of rGO / ox CNOs are deposited on the piezoelectric quartz substrate by the drop casting method or by the spin coating method.

Original approach

The sensitive films described in this invention are used in the design of a surface acoustic wave (SAW) sensor.
A surface acoustic wave device is usually composed of a piezoelectric substrate, a pair of interdigital transducers, as well as a layer sensitive to the analyzed gas. The electrical signal, applied to one of the transducers, generates a surface acoustic wave that propagates to the other transducer, the mechanical wave being converted into an electrical signal. The invention refers to sensitive layers made of new binary nanocomposites oxidized onion-type nanocarbon materials (oxCNOs) / oxide of reduced graphene (rGO).
The sensor used is a "delay line sensor" type, dual, made on a quartz piezoelectric substrate. The sensor presents a dual delay line to compensate the thermal drift.

Sensor manufacturing

- The quartz substrate is cleaned for 10 minutes in the ultrasonic bath using sequentially equal volumes of acetone, ethanol and finally deionized water;
- CNOs are synthesized from nanodiamond, by thermal treatment at 1650 ^{0}C, in a helium atmosphere; Synthesis of ox CNOs (hydrophilic) nanocarbon materials is carried out by reacting with 3M nitric acid, at reflux, for 48 h.

Sensor manufacturing

- 2 mL graphene oxide dispersion in water - 1mg/mL is subjected to ultrasound for two hours;
- 10 mg of oxidized onion-type nanocarbon materials are added to the previously prepared dispersion. The mixture is stirred for 3 hours, at room temperature on a magnetic stirrer;
- The obtained solution is deposited by the drop casting method on the quartz substrate;
- The sensitive layer obtained, deposited on the substrate, is dried in an oven, at 50 ^{0}C, in vacuum, for 60 minutes.

Advantages of the proposed sensing layer

- Both onion-type oxidized nanocarbon materials and reduced graphene oxide are p-type semiconductors
- When the sensitive layer is exposed, the physisorbed and chemisorbed molecules of NO_2 (oxidizing gas) will act as electron acceptors, increasing the concentration of holes in the nanocarbon material and thus leading to a decrease in resistance.
- The use of onion-type oxidized nanocarbon materials (ox-CNOs) / reduced graphene oxide (rGO) binary nanocomposite matrices confers several notable advantages:
- both oxidized onion-type nanocarbon materials and reduced graphene oxide give a high specific surface / volume ratio, as well as a variation in the resistance of the sensitive layer upon contact with them ("electric loading");
- π-π type interactions between reduced graphene oxide and oxidized onion-type nanocarbon materials ensure mutual homogeneous distribution in the sensitive layer;

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