Ammonia Chemiresistive Sensor

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Assignees: National Institute for Research and Development in Microtechnologies - IMT Bucharest
Valahia University of Targoviste

Inventors: Bogdan-Cătălin Șerban, Octavian Buiu, Marius Bumbac, Cristina Mihaela Nicolescu

Field of invention:

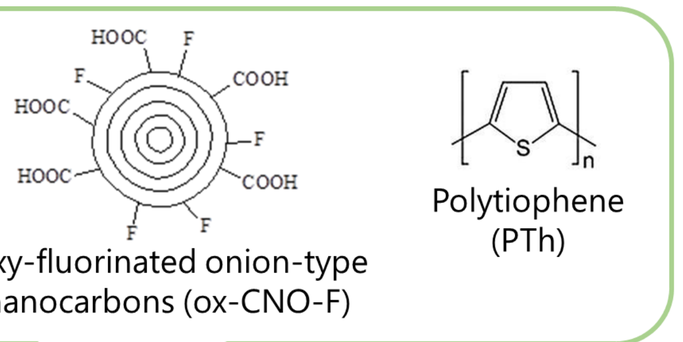
Food waste is produced throughout the whole food supply chain, from agricultural production down to household consumption. Considering the environmental issues, composting is considered a reliable food waste treatment technology, however it relates to various gaseous mixture emissions, with ammonia being the main component. Ammonia, is a smelling, irritant and toxic gas. The NH_3 short term exposure limit for a concentration as low as 35 ppm, is 15 minutes, while severe nose and throat irritation occurs at 500 ppm, and higher NH_3 concentrations may cause failure of the respiratory tract.
Monitoring the ammonia concentration in both industrial and ambient premises is of a notable importance.

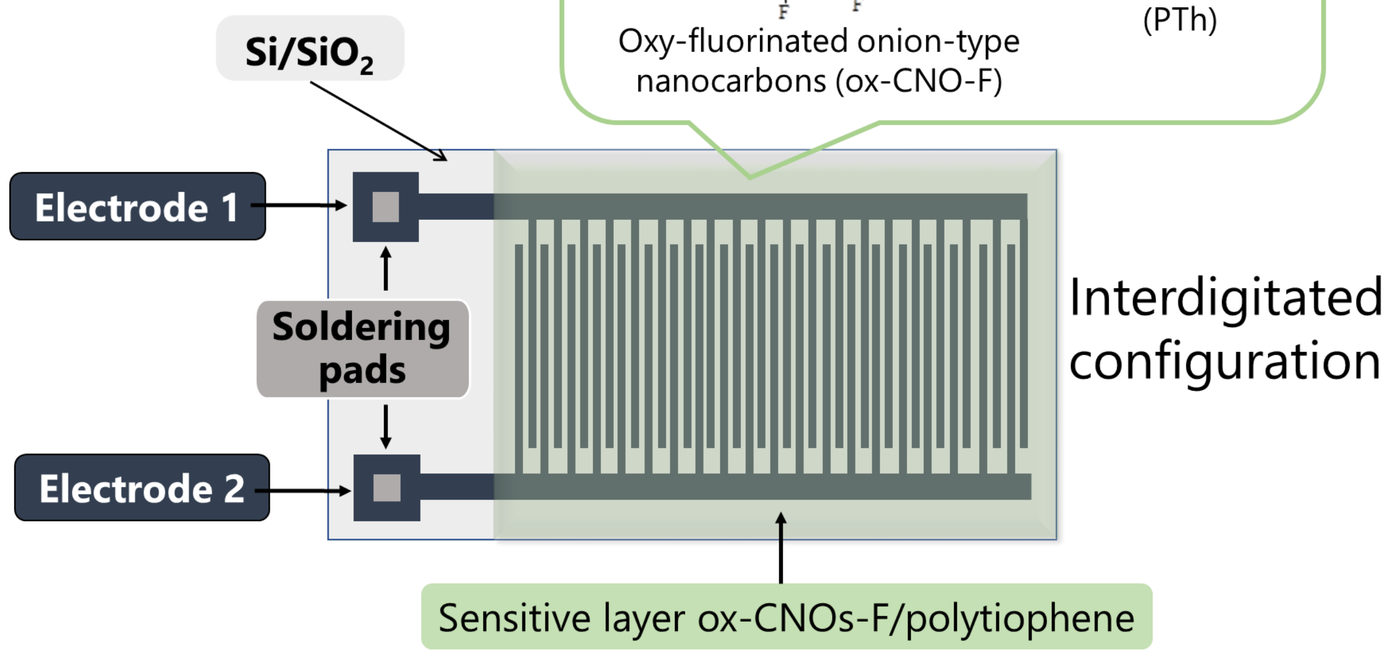
Original approach:

The invention describes new resistive sensors for monitoring ammonia concentration, and the corresponding design and manufacturing method.

- Ammonia sensitive layers that ensure the functional role of the sensing device are binary nanocomposites containing oxy-fluorinated onion-type nanocarbon materials (ox-CNO-F) and polythiophene (PTh).
- Synthesis method of ox-CNOs-F consists of treating the onion-type carbonaceous materials in plasma environments of F_2-N_2, and Ar-O_2
- Polythiophene is synthetized *in-situ* through polymerization of the monomer (thiophene) in the presence of $FeCl_3$ as oxidant
- The binary nanocomposite ox-CNO-F / PTh is obtained by ultrasonication followed by a thermal treatment
- Oxy-fluorinated onion-type nanocarbon materials and polythiophene are p-type semiconductors, and when ad/absorption of NH_3 molecules occurs, the number of voids decreases, and therefore the resistance of these materials proportionally increases

Ammonia sensor architecture





Sensor Design:

- functionalization of onion-type nanocarbon materials in F_2-N_2/ and Ar/O2 plasma offers the advantage of ensuring an optimal C:F and C:O ratios, and this is achieved by varying the exposure time, and the plasma power; thus, a significant sensitivity and a decrease of the hysteresis are obtained;
- sensitive layer is deposited on a dielectric substrate that may be either glass, thermally oxidized silicon wafer (Si/SiO_2), PET, or Kapton, with a thickness between 50 microns and 5 millimeters;
- electrodes may be manufactured from the same material (gold, platinum), or from different materials, and can be linear or having an interdigitated configuration;
- deposition method of the electrodes on the dielectric substrate may be direct printing, sputtering or evaporation.

Advantages:

- binary nanocomposites of ox-CNO-F/ PTh offer notable advantages in NH_3 resistive detection
- ox-CNO-F offers high specific surface / volume ratio and notable resistance variation of the sensitive layer at contact with NH_3 molecules;
- polythiophene shows high affinity for ammonia molecules, and resistance variation of the sensitive layer upon contact with NH_3;
- due to electron-attracting effect, fluorine atoms increase the surface polarity of the nanocarbon material, creating temporary dipoles facilitating the interaction with NH_3 molecules
- wide temperature range operation, chemical and thermal stability;
- quick response of the sensor to variations in the ammonia concentration value;
- reversibility and superior mechanical properties.

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