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New Sensing Layer For Gravimetric Carbon Dioxide Sensor

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Scope:

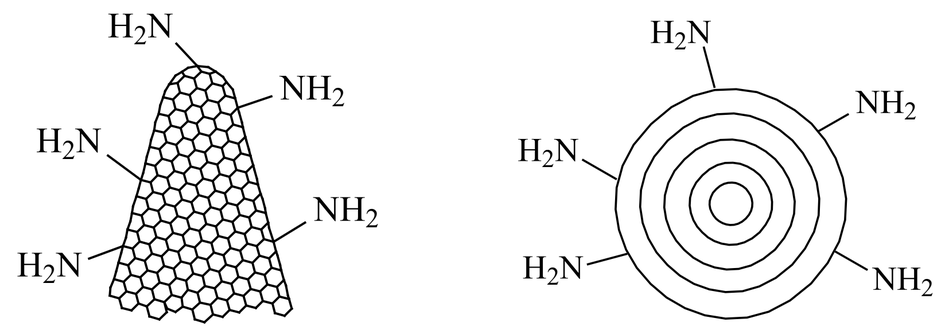
Development of new sensing layers to be integrated in gravimetric CO2-sensors of the SAW (surface acoustic wave) type, by the use of functionalized nanocarbon materials with amino groups.
Detection and measurement of CO2 are of a high importance in many fields, such as demand control ventilation, food industry, geological research, green chemistry, agriculture, chemical industry, environmental monitoring, etc.

Original approach:

- sensitive layers containing carbon nanohorns functionalized with amino groups (CNHs-NH_2), and carbon nano-onions functionalized with amino groups (CNOs-NH_2) interact with CO_2 molecules
- functionalization procedures applied, in argon – nitrogen – hydrogen plasma, provide high selectivity of the nanocarbon materials for carbon dioxide detection; nitrogen radicals N• react with hydrogen atoms (also produced in plasma) to generate primary amino groups
- adsorption and absorption of CO_2 molecules modify the mechanical and electrical properties of the sensing layer, and thus leading to changes in properties of the acoustic wave
- the degree of change in the propagation velocity and frequency of the acoustic wave is proportional with the amount of the CO_2 that is ad/absorbed in the functionalized nanocarbon film
- a "delay line" sensing structure, with a double delay line to compensate for the thermal drift
- the new sensing layer for CO_2 detection is integrated in a SAW-type sensor with a quartz piezoelectric substrate, and interdigital transducers

Manufacturing of the sensing layer:

- grafting the -NH_2 groups to CNHs, and CNOs in Ar-N_2-H_2 plasma
- optimization of nitrogen percentage in the functionalized nanocarbon materials through optimized exposure time, and plasma's power and composition
- successive washing of CNHs-NH_2, and CNOs-NH_2 in solvents (ethanol, acetone, deionized water)



a) structure of CNHs-NH_2 b) structure of CNOs-NH_2

Figure 1. Structure of the functionalized nanocarbon materials used in the development of the new-CO_2 sensitive layer

- preparation of the dimethylformamide solution containing functionalized nanocarbon material to be deposited on the sensor's substrate (room temperature 12h - ultrasonication, and, respectively, spin coating 60 s @ 2000 rpm)
- successive thermal treatments (90 minutes @ 100 °C, then 10 minutes @ 200 °C)

Advantages of the new CO_2-sensing layer:

- superior mechanical properties;
- presence of the functionalized nanocarbon materials confers a high specific surface/volume ratio to the sensitive layer;
- very good affinity for CO_2 molecules insured through their interactions with the amino groups in the CNHs-NH_2, and CNOs-NH_2 structure;
- significant variation of the sensitive layer's resistance upon contact with CO_2 molecules ("electric loading");
- fast response of the sensor to variation of the CO_2 concentration values;
- good reversibility;
- detection at room temperature.

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