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# FLUORINATED CARBON NANOHORNS AND REDUCED GRAPHENE OXIDE AS SENSING MIXTURE FOR CHEMIRESISTIVE $NO_2$ SENSORS

Bogdan Catalin Serban[1], Octavian Buiu[1], Marius Bumbac[2], Cristina Mihaela Nicolescu[3], Mihai Brezeanu[4]

[1]IMT Bucharest, National Institute for Research and Development in Microtechnologies, 126A Erou Iancu Nicolae, 077190 Voluntari, Romania
[2]Valahia University of Targoviste, Faculty of Sciences and Arts, , 13 Sinaia Alley, 130004 Targoviste, Romania
[3]Valahia University of Targoviste, Institute of Multidisciplinary Research for Science and Technology, 13 Sinaia Alley, 130004 Targoviste, Romania, cristina.nicolescu@valahia.ro
[4]National University of Science and Technology POLITEHNICA Bucharest, Romania, Faculty of Electronics, Telecommunications and IT, 1-3 Iuliu Maniu Blvd., district 6, 061071, Bucharest, Romania

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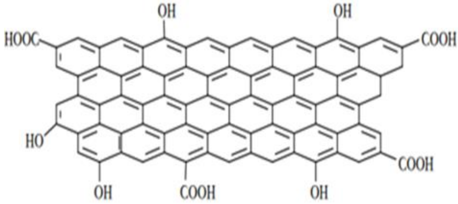
### *Introduction*

Present study focuses on the development and understanding of $NO_2$ sensing device that utilize a sensitive layer composed of fluorinated carbon nanohorns (CNHs-F) and reduced graphene oxide (rGO). The relationship between the chemical properties of $NO_2$ and the nanocomposite matrix using the Hard Soft Acid Base (HSAB) theory were used as criteria to choose the composition of the sensing layer. According to the HSAB theory, $NO_2$ molecules are classified as soft acids, while nanocarbon materials (such as CNHs-F and rGO) are considered soft bases due to their benzenoid structures. The HSAB theory helps to explain why $NO_2$ molecules interact with the CNHs-F-rGO matrix (Figure 1). The theory posits that soft acids preferentially interact with soft bases, which would predict a favorable interaction between $NO_2$ and the sensitive layer, leading to a measurable change in resistance that correlates with $NO_2$ concentration levels. This interaction underlies the sensing mechanism of your device.



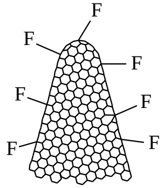




**Figure 1**. Structure of reduced graphene oxide (rGO) and fluorinated carbon nanohorns (CNHs-F).

***Materials and methods***

The fluorination of carbon nanohorns is carried out in F2-Ar plasma.

The functionalization of nanocarbon materials in plasma has the advantage (by selecting the type of plasma, optimizing the exposure time, as well as its power) that it can ensure an optimal C: F atomic ratio, synchronously conferring appropriate sensitivity, hysteresis reduction, and an optimal deg. of hydrophobicity.

The sensor substrate is made of Kapton and has a size of 5 mm, the electrodes being made of gold. The width of the electrodes is about 200 microns, with a separation of 6 mm between them. The electrodes can be linear or have an interdigitated configuration (Figure 2).

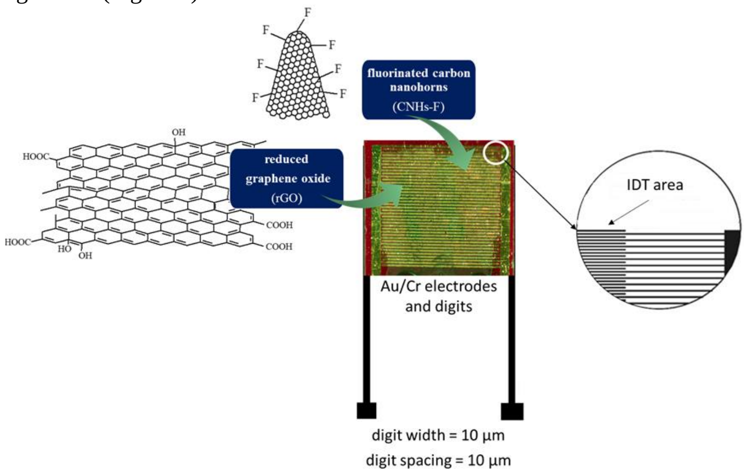



**Figure 2.** Interdigitated electrode with sensing layer made off fluorinated carbon nanohorns and reduced graphene oxide.

The $NO_2$ monitoring capability is investigated by applying a constant current between the two electrodes and measuring the voltage at different values of the $NO_2$ concentration to which the sensitive layer of the nanocomposite matrix type fluorinated carbon nanohorns (CNHs-F) - reduced graphene oxide (rGO).

***Results and conclusions***

The proposed resistive sensor for monitoring the concentration of nitrogen dioxide consists of a dielectric substrate, metal electrodes, and a sensitive layer made up of a thin film of a binary nanocomposite matrix of the rGO - CNHs-F. Resistive is characterized by the fact that the electrodes used can be made of the same material (gold, aluminum, chrome) or different materials. The sensing architecture presented in the study is made by drop casting a mixture of rGO and CNHs-F on an interdigitated gold electrode. The presence of fluorine atoms minimizes the effect of humidity on the resistance variation of the sensitive layer due to their hydrophobic effect.