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QUATERNARY OXIDIZED CARBON NANOHORNS - BASED NANOHYBRID FOR RESISTIVE HUMIDITY SENSOR

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INTRODUCTION

• The present invention relates to the RH sensing response of a resistive sensor employing a sensing layer based on quaternary nanohybrid composition comprising or consisting of $CNH_{OX}/SnO_2/ZnO/PVP$ at 1.5/1/1/1 w/w ratio to 3/1/1/1 w/w ratio. When employed as RH sensing layers, these quaternary nanohybrid compositions exhibit several significant advantages:
• Oxidized carbon nanohorns (CNH_{OX}) (**FIG 1**) have high specific surface area/volume ratio, water molecules affinity and show rapid electrical resistance variation when RH varies from 0% to 90%.
• The nanometric tin (IV) oxide (SnO_2) nanopowder exhibits good RH sensitivity. CNH_{OX} have p-type electrical conduction (through holes), while SnO_2 is a n-type metallic oxide semiconductor (through electrons). By adding SnO_2 to CNH_{OX}, one will obtain islands of p-n semiconductor heterojunctions embedded in PVP (a dielectric material) that increase the sensitivity of the sensitive layer.
• Zinc oxide (ZnO) nanopowder exhibits good RH sensitivity. Both ZnO and SnO2 are n-type electrical conductors. The ZnO – SnO2 nanocomposite has sensing properties superior to each of the single oxides, because each of the oxides interacts differently with the oxidized carbon nanohorn material, leading to alterations in the pore distribution, which increase the specific surface area;
• Polyvinylpyrrolidone (PVP) is a hydrophilic polymer with excellent binding properties, which enables its employment in sensing structures with either flexible or rigid substrate;
• Detection at room temperature, low response time, low cost, small size, simplicity in manufacture.

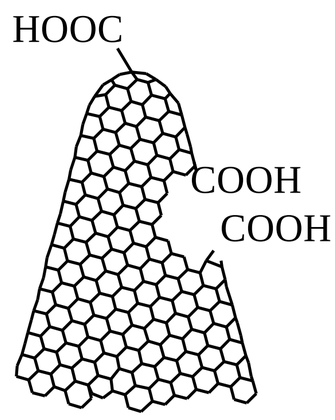

FIG 1 – Structure of oxidized carbon nanohorns (CNH_{OX})

MATERIALS, METHODS, RESULTS

• The interdigitated (IDT) sensing structure (**FIG 2**) can be manufactured on Lexan, Kapton, or glass. The dielectric substrate may have a thickness from 5 to 50 μm. The electrodes can be made from the same material or can be formed of different materials. The electrodes can be made from conductive materials such as gold and chromium. A dispersion formed in isopropyl alcohol of a nanohybrid sensing layer described above, at different w/w ratios, was deposited on the IDT structure using the drop casting method (**FIG 3**).
• The RH sensing capability of the proposed sensitive layers was investigated by applying a current between the two electrodes and measuring the voltage at different RH values.
• Measurements were performed in humid nitrogen at RT and compared with the response of a commercial capacitive RH humidity sensor, provided with signal-processing and signal-amplifying electronics (**FIG 4** and **FIG 5**). From the detection principle point of view, the resistance of the sensitive layer varies with the RH level.

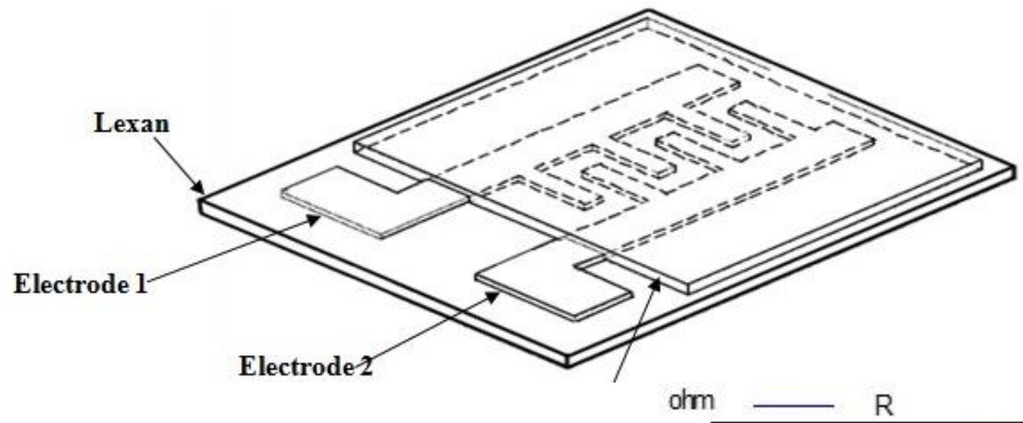

FIG 2 – IDT sensing structure

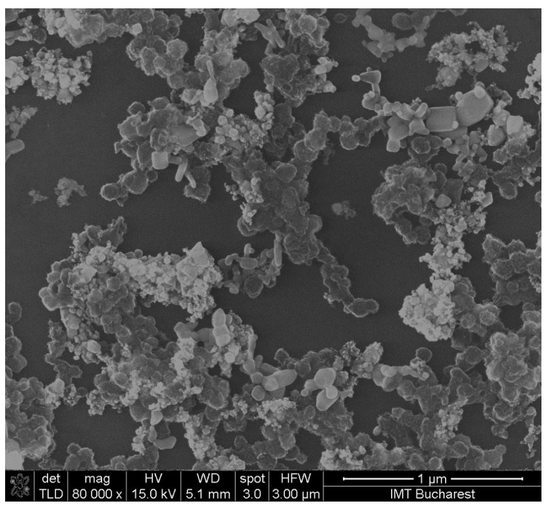

FIG 3 - SEM image for $CNH_{OX}/SnO_2/ZnO/PVP$ at 1.5/1/1/1 nanohybrid composition

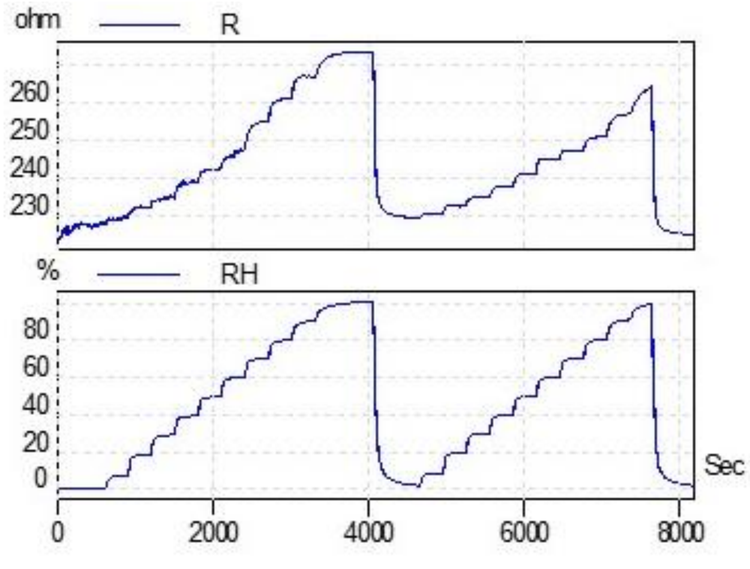

FIG 4 – R Curve: Response of the sensor employing $CNH_{OX}/SnO_2/ZnO/PVP$ at 1.5/1/1/1 as sensing layer
RH Curve: Response of Sensirion RH sensor

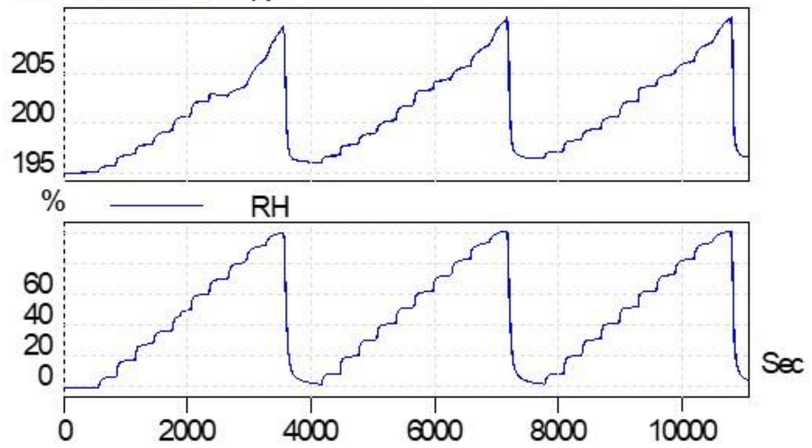

FIG 5 – R Curve: Response of the sensor employing $CNH_{OX}/SnO_2/ZnO/PVP$ at 3/1/1/1 as sensing layer
RH Curve: Response of Sensirion RH sensor

CONCLUSIONS

- The IDT sensing structure presented in this work exhibits a linear response and good RH sensitivity when varying RH from 0% up to 90% in humid N2 environment. The sensor response time and stability are comparable to that of a commercially available RH sensor.

ACKNOWDLEGMENT

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