DOI: http://doi.org/10.21698/simi.2025.ab03

ARGON PLASMA TREATED CARBON NANO-ONIONS – PVA NANOCOMPOSITE AS SENSING FILM FOR RESISTIVE HUMIDITY SENSOR

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Keywords*: argon plasma treatment, carbon nanoonions, nanocomposite, polyvinyl alcohol, resistive sensor*

Introduction

In recent decades, relative humidity (RH) sensors have gained significant attention due to their critical role in a wide range of commercial and industrial applications. RH is a key factor in the transmission of infectious agents and viruses. Consequently, maintaining optimal RH levels in hospitals and buildings has become essential for public health. This paper presents the RH detection performance of a resistive sensing structure based on a nanocomposite matrix composed of argon plasma-treated carbon nano-onions (CNO) and polyvinyl alcohol (PVA) in a 1:1 weight ratio.

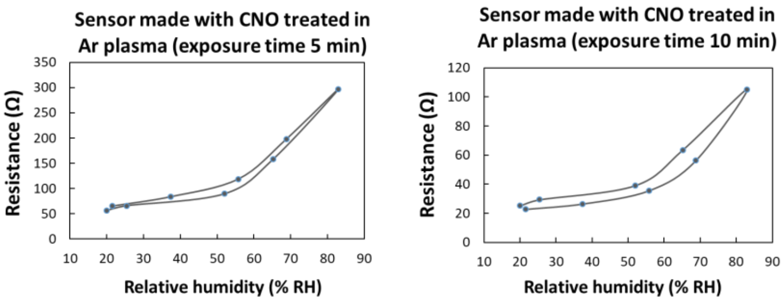
Materials and methods

The synthesis of the sensitive film based on the CNO-PVA nanocomposite, with a 1:1 mass ratio (w/w), was carried out as follows. Functionalized carbon nano-onions synthesis were synthesized using argon (Ar) plasma treatment at a pressure of 1 bar, inside a nickel reactor, at room temperature. The injection time was 3 minutes, with exposure times of 5 and 10 minutes. Preparation of argon plasma treated CNOs dispersion was done by dissolving 2 mg of the nanocarbon material in 5 mL of ethanol and by stirring four hours at room temperature. Separately, a PVA solution was prepared by dissolving 2 mg of polymer in 15 mL of deionized water. This solution was stirred in an ultrasonic bath at 90°C for six hours. The CNO dispersion was then added to the prepared polymer solution and stirred in an ultrasonic bath for another six hours. The resulting dispersion was deposited onto the sensing structure using the "spin coating" method. The sensing film underwent annealing at 80°C for three hours in a vacuum. Finally, the sample was dried at 363 K for one hour. The fabricated device was placed in a controlled testing chamber to measure its resistance changes in response to RH. Dry nitrogen gas was passed through a series of bubblers containing demineralized water to achieve precise RH variations.

Results and conclusions

The surface topography of the sensing film, based on the OLC-PVA nanocomposite, was analyzed using scanning electron microscopy (SEM).

The electrical resistance of the sensing film increased with relative humidity (RH) across the entire RH range (Figure 1). At low to moderate RH levels, the resistance showed a gradual increase, while at higher RH levels, the increase became significantly steeper. All experimental results were correlated with the type of plasma used and the exposure time.



(a) (b)

Figure 1. Resistance *vs*. %RH for resistive devices with argon plasma treated CNOs/PVA nanocomposite as sensing layer

The findings from the electrical and wetting investigations indicate that pure argon (Ar) plasma has a significant impact on the surface properties of the nanocarbon layers. Pure Ar plasma treatments resulted in a noticeable increase in surface electrical resistance, with a rise of approximately 6.6% after 5 minutes of plasma exposure and 13.2% after 10 minutes. In static contact angle experiments, an even more pronounced effect was observed, with hydrophilization of the sensing structure attributed to the formation of oxygen-based functional groups (such as carbonyl and carboxyl groups) after exposure of the sensing layer to the atmosphere.

Several sensing mechanisms were identified and discussed based on the recorded data. Additionally, the hysteresis characteristics of the chemoresistive device were analyzed. It is important to note that all sensing measurements were conducted at room temperature.

Acknowledgment

Authors from Valahia University of Targoviste, Romania (www.valahia.ro) would like to acknowledge the financial support of the project CNFIS-FDI-2025-F-0421 financed by the Romanian Ministry of Education and Research.