Investigation of Dielectric and Sensing Behavior of Anodic Aluminum Oxide Filled by Carbyne-Enriched Nanomaterial

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Anodic aluminum oxide (AAO) is a promising material for sensor applications due to its unique nanoporous structure and high surface area. This study investigates enhancing AAO's sensing capabilities by incorporating carbyne-enriched nanomaterials. This research aimed to create a novel surface acoustic wave (SAW) sensor with improved performance characteristics. AAO films were fabricated using a two-step anodization process, followed by carbyne-enriched coating deposition via ion-assisted pulse-plasma deposition. The dielectric properties of the resulting composite material were characterized using impedance spectroscopy, while the sensing performance was evaluated by exposing the sensor to various ethanol concentrations. The results showed a significant increase in capacitance and dielectric permittivity for the carbyne-filled AAO compared to pristine AAO, along with a 5-fold improvement in sensitivity to ethanol vapor. The increased sensitivity is attributed to the synergistic combination of the AAO's high surface area and the carbyne's unique electrical properties. This work demonstrates the successful fabrication and characterization of a novel high-sensitivity gas sensor, highlighting the potential of carbyne-enriched AAO for advanced sensor applications.

References

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[2] S. Nagaoka, K. Yoshida, Y. Hirota, Y. Komachi, M. Takafuji, H. Ihara, Colloids Surf. A Physicochem. Eng. Asp. 640 (2022) 128438.
[3] H. Zhang, M. Zhou, H. Zhao, Y. Lei, Nanotechnology 32 (2021) 502006.

Figures

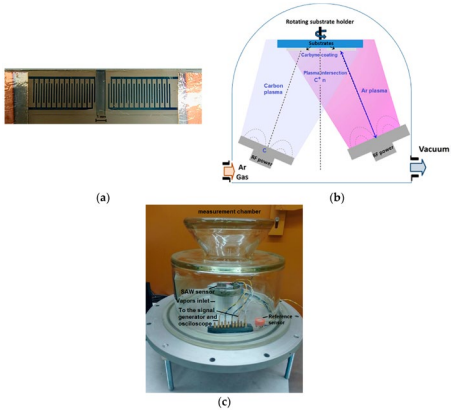

Figure 1: Fabrication and testing of the sensor: (a) photo of the fabricated sample with AAO between the IDT electrodes, filled by carbyne-enriched material, (b) deposition chamber, and (c) measurement setup.

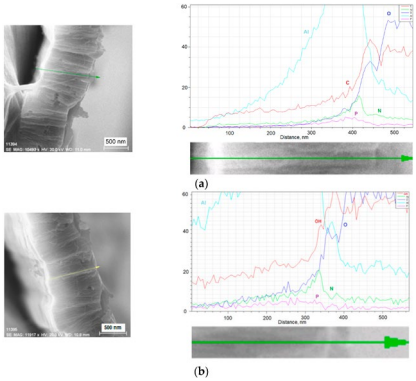

Figure 2: SEM image and EDX analysis of (a) carbyne-filled AAO sample and (b) non-coated AAO sample.

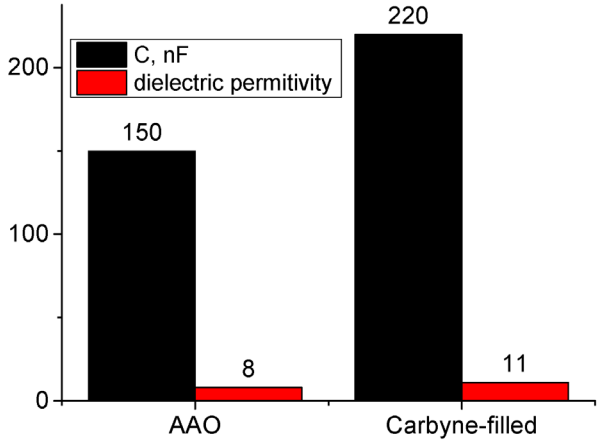

Figure 3: Comparison between the dielectric properties (permittivity and capacitance) of AAO and carbyne-filled AAO f = 1 kHz).

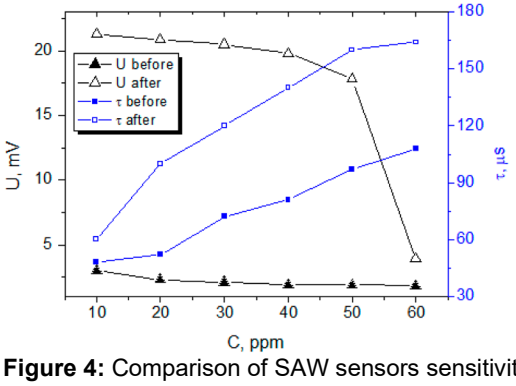

Figure 4: Comparison of SAW sensors sensitivity and response time after using carbyne-filled AAO sensing layer and before that when using non-structured carbyne.