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Dielectric Modulated Dielectric Stack Gate-All-Around Engineered Plasma Assisted Carbon Nanotube Field Effect Transistor (DS-GAAE-PACNTFET) biosensor for breast cancer detection

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Abstract

Cancer stands as a formidable health challenge worldwide, with its pervasive impact on human health and quality of life. Current diagnostic methods for cancer, including clinical exams, mammography, ultrasonography, and biopsies, sometimes require advanced tools like MRI and PET scans. However, their reliance on sophisticated equipment and expert interpretation limits their widespread use for early cancer detection. This emphasizes the need for innovative biosensing technologies capable of detecting specific malignant cancer biomarkers at clinically significant levels. In this work, a novel design for a biosensor named Dielectric Stack Gate-All-Around Engineered Plasma Assisted Carbon Nanotube Field Effect Transistor (DS-GAAE-PACNTFET) biosensor has been proposed for the identification of biomarkers linked to breast cancer cells. This work is based on a Plasma-Assisted Carbon Nanotube Field Effect Transistor in which CNT is grown using PECVD technique and used as a channel of FET. Various other device engineering techniques such as dual metal Gate-All-Around structure and Dielectric stack of SiO_2 and HfO_2 have been used. A comparative analysis of DS-GAAE-PACNTFET was performed using a Silicon Gate All Around FET (Silicon-GAA-FET) based biosensor. Early detection of breast cancer is made possible by the immobilization of Biomolecules MDA-MB-231 and HS578t into the dual-sided nanocavity, which alters the electrical properties of the proposed CNTFET-based biosensor. The DS-GAAE-PACNTFET sensor demonstrates a drain ON current sensitivity of 236.9 nA and a threshold voltage sensitivity of 285.58 mV for HS578t cancer cells. Malignant MDA-MB-231 breast cells exhibit a higher drain ON current sensitivity of 343.35 nA and a corresponding threshold voltage sensitivity of 293.23 mV. The exceptional sensitivity and structural resilience of the DS-GAAE-CNTFET biosensor establish it as a promising candidate for early breast cancer detection.

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