Crimson Publishers
Wings to the Research

Mini Review

Surface Plasmon Resonance Biosensors for Cancer Diagnosis based on Metal-Graphene-WSe2 Structure

Alireza K* and Soraya Z

Department of Physics, Shiraz University of Technology, Iran

ISSN: 2770-6745

***Corresponding author:** Alireza Keshavarz, Department of Physics, Shiraz University of Technology, Shiraz, Iran

Submission: September 05, 2024
Published: November 22, 2024

Volume 5 - Issue 1

How to cite this article: Alireza K* and Soraya Z. Surface Plasmon Resonance Biosensors for Cancer Diagnosis based on Metal-Graphene-WSe2 Structure. Biodiversity Online J. 5(1). BOJ. 000604. 2024.
DOI: 10.31031/BOJ.2024.05.000604

Mini Review

Surface Plasmon Resonance (SPR) sensors are highly sensitive optical sensors used for real- time and label-free measurement of chemical and biological parameters. They are particularly important in medical diagnostics, especially for detecting cancer. SPR sensors work based on the propagation of charge density oscillations called Surface Plasmon Waves (SPWs) along the metal-dielectric interface. This interaction is very sensitive to changes in the refractive index of the surrounding environment, allowing for the detection of various analytes. The traditional SPR sensor setup uses the Kretschmann structure, where a thin metal film is coated on a prism. This setup has been extensively researched and used because of its simplicity and efficiency. However, to improve the performance of SPR sensors, additional layers with specific optical properties, such as graphene and two-dimensional Transition Metal Dichalcogenides (TMDCs) like WSe2, are added on top of the metal layer. These materials enhance the sensitivity and selectivity of the sensors, making them more suitable for detecting small changes in the refractive index, which is crucial for cancer diagnostics.

Theoretical background

The detection mechanism in SPR biosensors relies on changes in the refractive index of the sample. When light is incident at a specific angle on the metal-dielectric interface, it excites SPWs, leading to a sharp dip in the reflected light intensity [1]. The position and intensity of this dip depend highly on the refractive index of the sample, making it possible to detect even minute changes. The reflectivity of the Kretschmann structure is typically calculated using the ABCD matrix method, which provides a systematic approach to analyze multi-layer optical systems. This study examines a new SPR structure, which includes an SF10 prism, a 50nm gold layer, two layers of graphene, and two layers of WSe2. The purpose of this structure is to diagnose cancer by comparing the refractive index of normal and cancerous cells [2]. The refractive index of normal cells is around 1.353, whereas for cancerous cells, it varies from 1.370 to 1.400. With a high sensitivity of 230.14deg/RIU for water as the sample environment, this structure can effectively differentiate between these two cell types based on their refractive index [3].

Results and discussion

The optimized reflectivity for cancer cells within the refractive index range of 1.370 to 1.400 was found to be between 0.8096 and 0.8560 (a.u.), compared to 0.4890 (a.u.) for normal cells. This significant difference in reflectivity provides a clear signal for distinguishing between healthy and cancerous cells. The incorporation of graphene and WSe2 layers enhances the sensor's performance by increasing the interaction of SPWs with the sample, thus improving the overall sensitivity and accuracy of the biosensor. Graphene, known for its excellent electrical conductivity and strong interaction with SPWs, contributes to the increased sensitivity of the sensor [4]. Meanwhile, WSe2, a TMDC material, adds to the optical contrast due to its unique refractive index and absorption properties. The combination of these materials with the traditional metal layer significantly enhances the sensor's ability to detect cancerous cells at early stages, where the refractive index changes are minimal but critical [5].

Applications and future work

The structure discussed in this paper presents a promising approach for the development of highly sensitive SPR biosensors tailored for cancer diagnosis. The ability to detect subtle changes in the refractive index of cells allows for early diagnosis, which is crucial for effective treatment. Moreover, the modularity of the SPR sensor design means that it can be adapted for detecting other types of biomolecules or diseases by simply altering the functional layers [6-8]. Future research could focus on optimizing the thickness and material properties of the graphene and WSe2 layers to further enhance the sensitivity of the sensor. Additionally, integrating microfluidic systems with SPR biosensors could lead to the development of lab-on-a-chip devices, enabling real-time and on-site diagnostics. This would revolutionize the field of biosensing, making it more accessible and effective for various medical applications [9,10].

Conclusion

The use of metal, graphene, and WSe2 in SPR biosensors represents a significant advancement in achieving the sensitivity and selectivity needed for cancer diagnosis. This technology shows promise in differentiating between normal and cancerous cells based on changes in their refractive index, highlighting its potential for early disease detection. With additional refinement and advancement, SPR biosensors have the potential to become a crucial tool in medical diagnostics, delivering fast and accurate results for various conditions.

References

1. Masson JF (2017) Surface plasmon resonance clinical biosensors for medical diagnostics. ACS Sensors 2: 16-30.
2. Liu PY, Chin LK, Ser W, Chen HF, Hsieh CM, et al. (2016) Cell refractive index for cell biology and disease diagnosis: Past, present and future. Lab Chip 16: 634-644.
3. Ghayoor R, Zangenehzadeh S, Keshavarz A (2022) Design of high-sensitivity surface plasmon resonance sensor based on nanostructured thin films for effective detection of DNA hybridization. Plasmonics 17: 1831-1841.
4. Keshavarz A, Zangenehzadeh S, Hatef A (2020) Optimization of surface plasmon resonance-based biosensors for monitoring hemoglobin levels in human blood. Applied Nanoscience 10: 1465-1474.
5. Zangenehzadeh S, Keshavarz A, Zamani N (2020) Performance enhancement of surface plasmon resonance biosensors based on noble metals-graphene-ws2 at visible and near-infrared wavelengths. Plasmonics 15: 309-317.
6. Xu Y, Ang YS, Wu L, Ang LK (2019) High sensitivity surface plasmon resonance sensor based on two-dimensional MXene and transition metal dichalcogenide: A theoretical study. Nanomaterials 9(2): 165.
7. Kreno LE, Hupp JT, Van Duyne RP (2010) Metal–organic framework thin film for enhanced localized surface plasmon resonance gas sensing. Analytical chemistry 82: 8042-8046.
8. Schasfoort RB (2017) Handbook of surface plasmon resonance. Royal Society of Chemistry.
9. Verma R, Gupta BD, Jha R (2011) Sensitivity enhancement of a surface plasmon resonance-based biomolecules sensor using graphene and silicon layers. Sensors and Actuators B: Chemical 160(1): 623-631.
10. Ouyang Q, Zeng S, Jiang L, Hong L, Xu G, et al. (2016) Sensitivity enhancement of transition metal dichalcogenides/silicon nanostructure-based surface plasmon resonance biosensor. Sci Rep 6: 1-13.

