

# Improved Glucose Detection in Urine Using a Silver-Based Plasmonic Sensor with Ni and TiO<sub>2</sub> Thin Films in the Kretschmann Configuration

Yuant Tiandho<sup>1</sup>, Erna Julianti<sup>2</sup>, Zamziri<sup>2</sup>, Putri Cahyani<sup>1</sup>, and Fitri Afriani<sup>1</sup>

<sup>1</sup> Department of Physics, Faculty of Science and Engineering, Universitas Bangka Belitung, Bangka, Indonesia

<sup>2</sup> Department of Nursing, Faculty of Medicine and Health Sciences, Universitas Bangka Belitung, Bangka, Indonesia

## ABSTRACT

Surface plasmon resonance (SPR) sensors have emerged as powerful tools for label-free and real-time detection of biomolecules, yet their performance often depends on optimizing the sensing structure. This work proposes and analyzes a silver-based SPR sensor in the Kretschmann configuration, enhanced with thin layers of Ni and TiO<sub>2</sub>, for non-invasive glucose detection in urine. The optical response was calculated using the transfer matrix method, while sensitivity and figure of merit (FOM) were employed as performance indicators. The incorporation of ultrathin Ni and TiO<sub>2</sub> layers atop the silver film induces a pronounced shift in the SPR toward higher incidence angles, accompanied by an enhanced angular response to refractive index variations, thereby indicating improved sensitivity. However, further increases in the thickness of these layers lead to an excessive redshift of the resonance dip toward the extreme angular range, reducing resonance definition and ultimately limiting the sensor's detection capability. The results show that the introduction of Ni and TiO<sub>2</sub> significantly improves both sensitivity and spectral sharpness, with the optimal BK7/Ag(30 nm)/Ni(14 nm)/TiO<sub>2</sub>(5 nm) structure achieving a maximum sensitivity of 432 deg/RIU. This configuration detected glucose concentrations as low as 0.625 g/dL, corresponding to a refractive index change of only 0.001 RIU. Finite-difference time-domain analysis further confirmed that the performance enhancement originates from stronger localization of the electric field at the TiO<sub>2</sub> interface, as evidenced by the presence of the Ni layer. These findings demonstrate the effectiveness of Ni and TiO<sub>2</sub> layers in enhancing plasmonic responses and highlight the strong potential of this sensor design for practical biomedical applications. In particular, the proposed structure offers a promising pathway for developing simple, non-invasive urine-based glucose monitoring systems.

## Paper History

Received Nov 21, 2025

Revised Feb 15, 2026

Accepted March 25, 2026

Published May 13, 2026

## Keywords

Biosensor;

Glucose;

Surface plasmon resonance;

Silver;

Thin film

## Author Email

[yuant@ubb.ac.id](mailto:yuant@ubb.ac.id)

[fitri-afriani@ubb.ac.id](mailto:fitri-afriani@ubb.ac.id)

[erna.julianti08@gmail.com](mailto:erna.julianti08@gmail.com)

[@gmail.com](mailto:@gmail.com)

[zim2.fagih11@gmail.com](mailto:zim2.fagih11@gmail.com)

[putricahyani0704@gmail.com](mailto:putricahyani0704@gmail.com)

[@gmail.com](mailto:@gmail.com)

## 1. Introduction

Diabetes mellitus is a chronic metabolic disease that has become a primary global health concern due to its rapidly increasing prevalence. According to the International Diabetes Federation (IDF), the number of individuals living with diabetes reached 537 million in 2021 and is projected to rise to 643 million by 2030 if effective interventions are not implemented [1], [2]. In Indonesia, the burden of this disease is particularly alarming, with a projected prevalence of 9.94% in 2024, placing the country as the fifth highest in terms of diabetes cases worldwide [3]. This condition reduces patients' quality of life and substantially strains national

healthcare and economic systems, with treatment costs estimated at 500 billion rupiah annually.

One of the key challenges in diabetes management is the lack of timely, continuous, and highly accurate monitoring of blood glucose levels. Conventional methods, such as electrochemical-based glucometers, while practical, still exhibit significant limitations. These methods are invasive, requiring capillary blood samples, requiring recurrent replacement of disposable sensor strips, and generating electrode waste that may contribute to environmental contamination by toxic metals [4]. These shortcomings highlight the urgent need for next-generation biosensing technologies that are highly sensitive, selective, user-friendly,

**Corresponding author:** Yuant Tiandho, [yuant@ubb.ac.id](mailto:yuant@ubb.ac.id), Department of Physics, Faculty of Science and Engineering, Universitas Bangka Belitung, Bangka, Indonesia

**Digital Object Identifier (DOI):** <https://doi.org/10.35882/ijeemi.v8i3.292>

**Copyright** © 2026 by the authors. This work is an open-access article and licensed under a Creative Commons Attribution-ShareAlike 4.0 International License ([CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)).

environmentally sustainable, and capable of enabling non-invasive or semi-non-invasive glucose detection [5].

In recent years, several alternative biofluids such as tears, sweat, and saliva have been explored for non-invasive glucose monitoring. However, these approaches often require wearable devices, continuous microfluidic extraction systems, or direct skin and ocular contact, which may introduce signal instability, biofouling, and user discomfort. In contrast, urine sampling is simple, painless, and does not require continuous body contact with devices. Importantly, under hyperglycemic conditions, glucose excreted in urine produces measurable changes in refractive index, making urine particularly suitable for refractive-index-based sensing platforms such as surface plasmon resonance (SPR). Therefore, urine-based glucose detection offers a practical, physically compatible pathway for developing reliable, non-invasive monitoring systems.

In this context, SPR-based biosensors have emerged as a promising alternative. Plasmonic-based sensors enable real-time, label-free monitoring of highly sensitive analytes by detecting variations in the refractive index at the metal-dielectric interfaces [6], [7]. Such variations manifest as shifts in the reflectance minima in the Kretschmann configuration, arising from interactions between surface plasmons and the target analyte [8], [9]. Given these advantages, SPR has been extensively explored for detecting biomolecules, including proteins, viruses [10], [11], and disease biomarkers. However, its application to non-invasive glucose detection in urine remains underdeveloped, particularly due to the inherently small refractive index changes associated with glucose in complex biological fluids. This limitation necessitates optimizing sensor design and material engineering to achieve higher sensitivity [12], [13], [14].

Previous studies have demonstrated that modifying the plasmonic active layer with additional functional layers can significantly enhance SPR sensor performance. Incorporating a nickel (Ni) layer has been reported to improve optical coupling and detection capabilities in cancer biosensing applications [15]. At the same time, titanium dioxide (TiO<sub>2</sub>) thin films have shown potential to increase sensitivity in detecting viruses such as dengue [16] and chikungunya [17]. Building on these insights, this study proposes the design of an SPR biosensor in the Kretschmann configuration using silver (Ag) as the primary plasmonic material [18], whose performance is further enhanced by integrating Ni and TiO<sub>2</sub> layers. The synergistic interaction between the complex refractive index of Ni and the high refractive index of TiO<sub>2</sub> is expected to amplify the local electric field at the sensor-analyte

interface, thereby significantly improving the detection sensitivity for glucose in urine [19].

Despite extensive progress in SPR-based biosensing, previous studies have predominantly explored single-metal configurations or simple bilayer modifications, such as Ag/TiO<sub>2</sub> structures to improve chemical stability and field confinement, or bimetallic systems including Ag/Ni to tailor plasmonic damping and coupling characteristics. However, these investigations generally focus on isolated layer combinations or limited parameter variations, without systematically examining the synergistic interaction among Ag, Ni, and TiO<sub>2</sub> within a unified multilayer framework.

Moreover, most reported SPR configurations for glucose sensing either target blood-based detection or rely on functional biochemical coatings, while studies addressing refractive-index-based glucose detection in urine using hybrid plasmonic multilayers remain limited. In particular, a comprehensive thickness-dependent optimization of the Ag/Ni/TiO<sub>2</sub> structure including the identification of feasible and infeasible resonance regions and evaluation of both sensitivity and figure of merit (FOM) has not been reported in detail. Therefore, this study addresses this research gap by integrating Ni and TiO<sub>2</sub> as functional enhancement layers in an Ag-based SPR platform and systematically investigating their coupled influence on plasmonic confinement and sensing performance. The novelty of this work lies in demonstrating that controlled multilayer coupling between Ag, Ni, and TiO<sub>2</sub> significantly enhances electric-field localization at the sensing interface and improves refractive-index sensitivity for detecting small glucose-induced variations in urinary refractive index. This approach provides a more rigorous design strategy for high-performance SPR biosensors and contributes toward the development of practical non-invasive glucose monitoring systems.

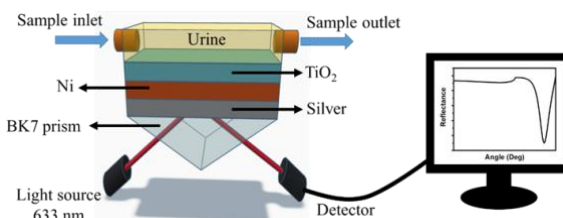


Fig. 1 SPR sensor structure design

The main contributions of this work are summarized as follows:

1. A novel multilayer SPR sensor design is proposed by integrating Ag, Ni, and TiO<sub>2</sub> within a unified

- Kretschmann configuration, enabling synergistic plasmonic coupling that has not been systematically explored in previous studies.
2. A comprehensive thickness-dependent optimization of the Ag/Ni/TiO<sub>2</sub> structure is conducted, including the identification of feasible and non-feasible resonance regions and the evaluation of both sensitivity and FOM.
  3. An enhanced non-invasive glucose-sensing strategy is demonstrated by improved electric-field localization at the sensing interface, enabling the detection of small refractive-index variations in urine with high sensitivity.

## II. Methods

The proposed SPR sensor was designed using the Kretschmann configuration, consisting of a BK7 prism as the optical coupling medium and a thin Ag film as the primary plasmonic layer. Additional Ni and TiO<sub>2</sub> layers were introduced above the Ag film to enhance optical confinement and sensing performance (Fig. 1). A p-polarized (TM) monochromatic He-Ne laser source with a wavelength of 633 nm was directed through the BK7 prism toward the multilayer structure at an incident angle  $\theta$ . The reflected beam intensity was calculated as a function of incident angle to obtain the angular reflectance spectrum. At a specific resonance angle, momentum matching occurs between the incident photons and the surface plasmon wave propagating along the metal-dielectric interface. This coupling results in a pronounced dip in the reflectance curve, which serves as the sensing signal. Variations in glucose concentration in the urine-sensing medium alter the refractive index, resulting in measurable shifts in the resonance angle. A schematic representation of the overall sensor structure and optical geometry is provided in. The transfer matrix method (TMM) was employed to model the reflectance spectra of the multilayer system [20]. This method is widely used in thin-film optics because it allows accurate computation of reflection for stratified media with arbitrary thicknesses and complex refractive indices. For a multilayer structure consisting of  $N$  layers sandwiched between the incident medium (BK7 prism) and the sensing medium (urine), the electromagnetic wave propagation can be described as follows. The measurable quantity of interest is the reflectance for p-polarized light, obtained from the squared magnitude of the reflection coefficient as written in Eq. 1 [21], [22]:

$$R_p = |r_p|^2 \quad (1)$$

The resonance angle ( $\theta_{res}$ ) is identified as the angle at which  $R_p$  reaches its minimum, corresponding to maximum coupling between the incident light and the

surface plasmon mode. Explicitly, Eq. 2 describes the reflection coefficient for p-polarized light, which is derived from the overall transfer matrix  $M$  of the multilayer system [23],

$$r_p = \frac{(M_{11} + M_{12}q_{sm})q_0 - (M_{21} + M_{22}q_{sm})}{(M_{11} + M_{12}q_{sm})q_0 + (M_{21} + M_{22}q_{sm})} \quad (2)$$

where  $q_0$  and  $q_{sm}$  represent the wave impedance parameters of the incident medium (BK7 prism) and sensing medium (urine), respectively. The multilayer stack comprising Ag, Ni, and TiO<sub>2</sub> films is represented by a global transfer matrix obtained by multiplying the characteristic matrices of each layer as written in Eq. 3 [24],

$$M = \prod_{j=1}^N M_j \quad (3)$$

For the  $j^{th}$  layer with thickness  $d_j$ , refractive index  $n_j$ , and propagation constant in the z-direction  $k_{zj}$ , the characteristic matrix is written as Eq. 4 [24],

$$M_j = \begin{pmatrix} \cos \beta_j & -iq_j \sin \beta_j \\ -\frac{i}{q_j} \sin \beta_j & \cos \beta_j \end{pmatrix} \quad (4)$$

where  $\beta_j = \frac{2\pi}{\lambda} n_j d_j \cos \theta_j$  is the phase thickness, and

$q_j = \frac{n_j}{\cos \theta_j}$  is the wave impedance parameter for p-polarized light. The internal propagation angle  $\theta_j$  in each layer is determined using Snell's law, which is defined in Eq. 5 [23],

$$n_j \sin \theta_j = n_0 \sin \theta \quad (5)$$

Where  $n_0$  is the refractive index of the incident medium (BK7 prism), and  $\theta$  is the external incident angle. The propagation constant  $k_{zj}$  within each layer is derived as Eq. 6 [24],

$$k_{zj} = \frac{2\pi}{\lambda} \sqrt{n_j^2 - n_0^2 \sin^2 \theta} \quad (6)$$

where  $\lambda$  is the operating wavelength. In the reflectance calculations performed using the TMM, the primary input is the complex refractive index of each layer in the SPR sensor structure. At the operating wavelength of 633 nm, the BK7 prism was assigned a refractive index of 1.5151 [25]. The thin metallic and dielectric layers were characterized by their respective optical constants, namely Ag: 0.06656 + 4.0452i [26], [27], Ni: 0.0319 + 2.963i [28], and TiO<sub>2</sub>: 2.5837 [29]. The sensing medium was modeled as urine with different glucose concentrations, where the corresponding refractive indices are summarized in Table 1. The refractive indices listed in Table 1 were adopted from the literature sources indicated [9], [30], which reported experimentally measured values of the urine refractive

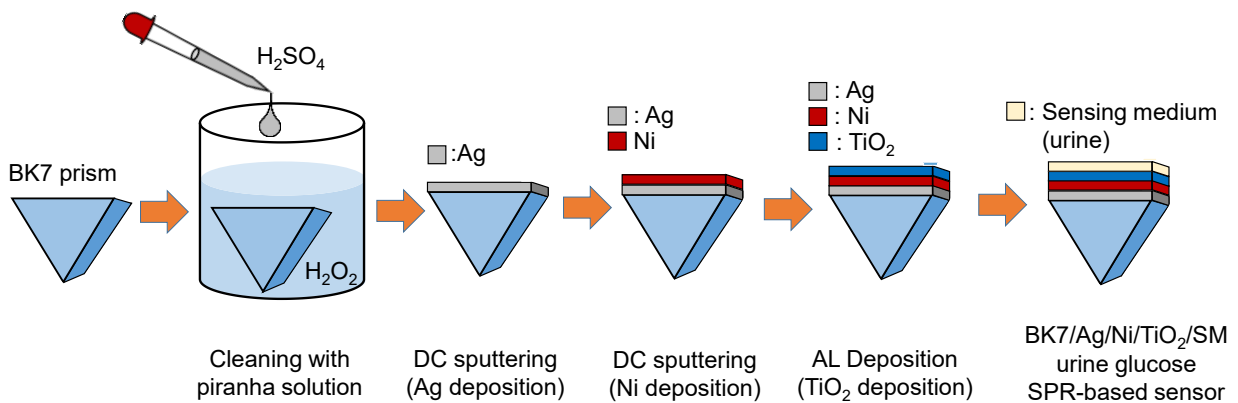
index as a function of glucose concentration. These data provide a physiologically relevant basis for numerical modeling of the SPR response to glucose-induced changes in urine refractive index. This approach enabled systematic evaluation of the effects of material layers and glucose concentration on the sensor's optical response.

**Table 1. Refractive index of urine containing glucose [9], [30]**

Glucose concentration	Refractive index
0 – 15 mg/dL (normal)	1.335
0.625 g/dL	1.336
1.25 g/dL	1.337
2.5 g/dL	1.338
5 g/dL	1.341
10 g/dL	1.347

To quantitatively evaluate the sensor performance for glucose detection in urine, two standard metrics were employed: (i) sensitivity and (ii) figure of merit (FOM). Sensitivity refers to the SPR sensor's ability to detect small changes in the analyte's refractive index. It is defined as Eq. 7 [31],

$$S = \frac{\Delta\theta_{res}}{\Delta n} \quad (7)$$



**Fig. 2 Conceptual schematic of the proposed SPR sensor structure and its potential fabrication route**

The incorporation of Ni and TiO<sub>2</sub> layers results in a noticeable shift in the plasmonic resonance toward higher incident angles. More importantly, these additional layers enhance the SPR sensor's sensitivity, as evidenced by the sharper, more responsive resonance behavior shown in Fig. 3. The SPR sensor based on the BK7/Ag/SM configuration exhibits a sensitivity of 123.09 deg/RIU with a corresponding FOM of 50.97 /RIU. Incorporation of a Ni interlayer, forming the BK7/Ag/Ni/SM structure, significantly

enhances sensing performance, increasing sensitivity and FOM to 141.38 deg/RIU and 56.67/RIU, respectively. Notably, further modification by introducing a TiO<sub>2</sub> layer in the multilayer configuration BK7/Ag/Ni/TiO<sub>2</sub>/SM results in a substantial improvement in sensitivity, reaching 172.99 deg/RIU. However, this enhancement is accompanied by a slight reduction in FOM to 50.69 /RIU. This decrease can be attributed to the reflectance curve, which increases its FWHM and adversely affects detection accuracy. Therefore, careful optimization of the multilayer

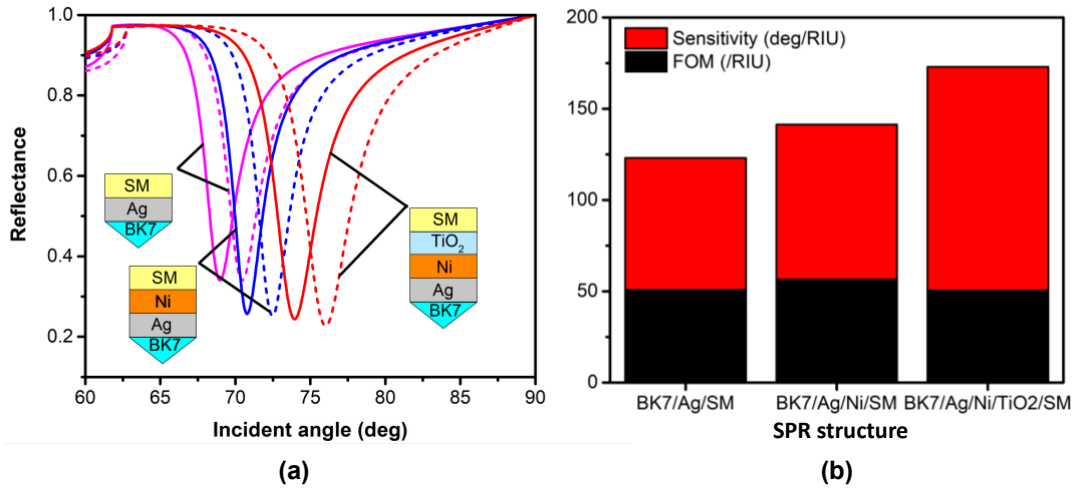
$$FOM = \frac{S}{FWHM} \quad (8)$$

where FWHM denotes the full width at half minimum of the resonance dip. The FWHM was determined from the reflectance versus incident angle curve by calculating the angular separation between the two angles at which the reflectance equals,  $R_{min} + (R_{max} - R_{min})/2$  where  $R_{min}$  corresponds to the minimum reflectance at the SPR angle and  $R_{max}$  represents the baseline reflectance. A higher FOM indicates improved detection resolution and precision.

### III. RESULTS

Fig. 2 illustrates the schematic configuration of the proposed SPR sensor along with a feasible fabrication route. The multilayer structure can be sequentially fabricated by depositing a thin Ag film as the primary plasmonic layer, followed by a Ni interlayer deposited via DC sputtering, and then coating with a TiO<sub>2</sub> thin film. The sensor surface can then be functionalized with appropriate receptors for glucose detection in urine.

structure is essential to achieve a balanced performance, ensuring both high sensitivity and a superior FOM for reliable sensing applications.

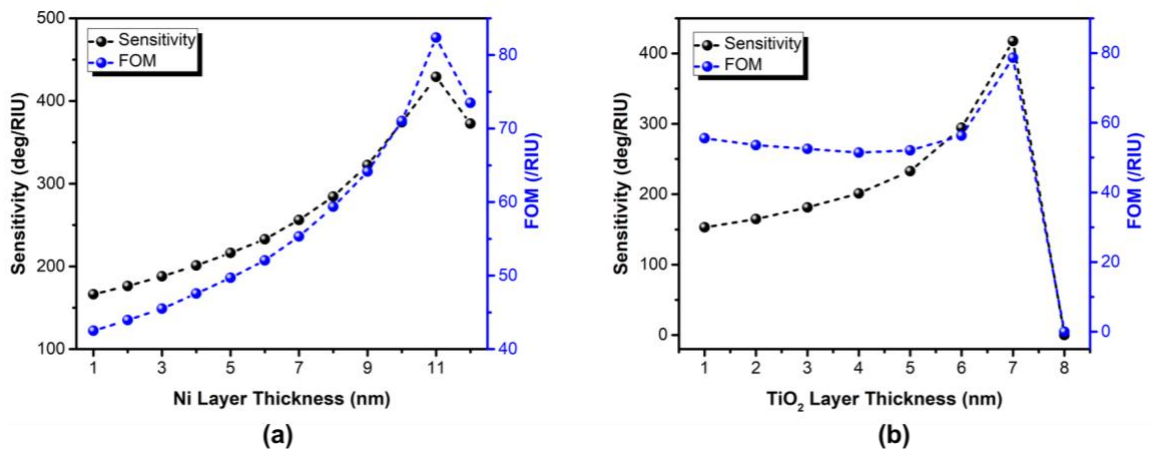


**Fig. 3** Performance enhancement of SPR sensor via Ni and TiO<sub>2</sub> layer addition (a) SPR curve (solid line: normal urine, n=1.335; dashed line: urine containing glucose, n=1.347); (b) Bar chart comparison of sensitivity and figure of merit (FOM) for different multilayer configurations.

Fig. 4 presents the variation of sensitivity and FOM as functions of Ni and TiO<sub>2</sub> layer thicknesses. Increasing the thickness of these layers initially improves both sensitivity and FOM due to enhanced plasmonic coupling and field confinement; however, excessive thickness results in significant performance degradation, characterized by broadened resonance curves and reduced sensitivity. In the first case, this study investigates the effect of Ni layer thickness on the sensitivity and FOM of the SPR sensor within the range of 1–12 nm. For the BK7/Ag/Ni/TiO<sub>2</sub>/SM configuration, the sensitivity values corresponding to this thickness

variation are 166.33, 176.31, 187.96, 201.26, 216.23, 232.87, 256.15, 284.43, 322.69, 374.25, 429.15, and 372.59 deg/RIU, respectively. A consistent increasing trend is observed up to a thickness of 11 nm, beyond which the sensitivity slightly decreases. Similarly, the FOM values are 42.50, 43.95, 45.49, 47.56, 49.69, 52.08, 55.32, 59.37, 64.15, 71.02, 82.37, and 73.49 /RIU, indicating optimal performance at a Ni thickness of 11 nm.

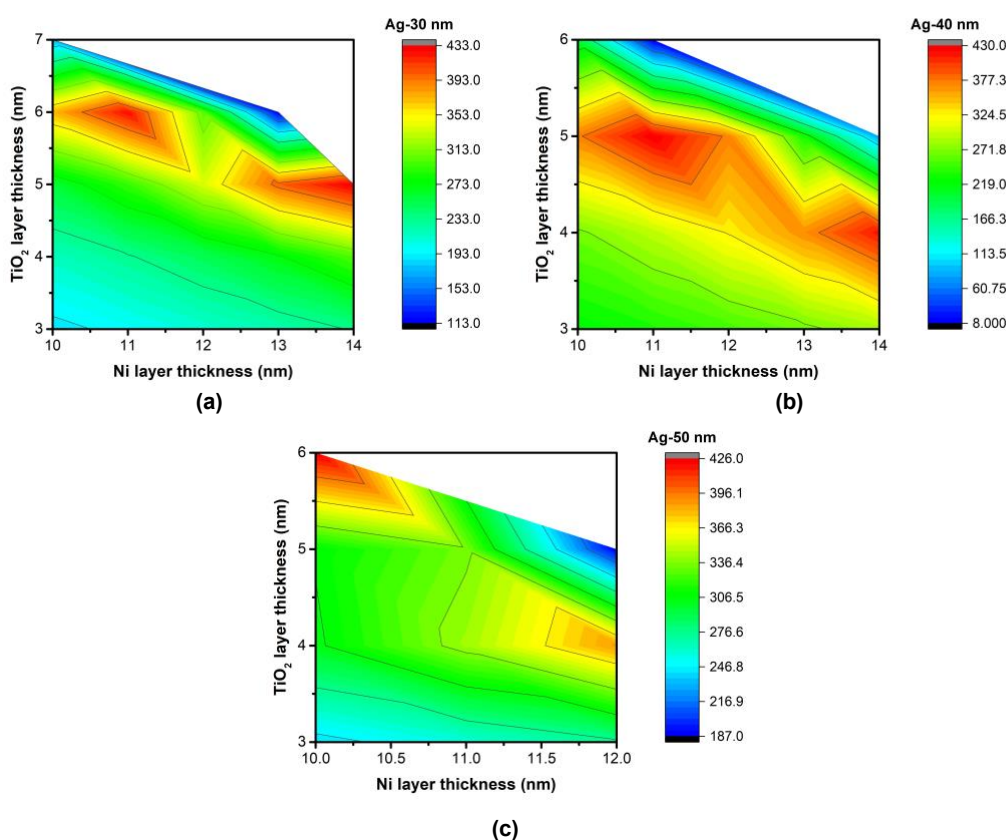
Furthermore, the influence of the TiO<sub>2</sub> layer thickness (1–8 nm) on the sensing performance of the BK7/Ag/Ni/TiO<sub>2</sub>/SM structure is also evaluated. The



**Fig. 4** Effect of thickness of (a) Ni and (b) TiO<sub>2</sub> layer on performance detection of SPR sensor.

corresponding sensitivity values are 153.03, 164.67, 181.30, 201.26, 232.87, 294.41, 417.50, and 0 deg/RIU, respectively. The zero-sensitivity observed at a TiO<sub>2</sub> thickness of 8 nm is attributed to the formation of an extremely shallow reflectance dip, making it indistinguishable and thus undetectable. Meanwhile, the FOM values for these variations are 55.55, 53.57, 52.50, 51.44, 52.08, 56.30, 78.63, and 0/RIU, indicating a significant enhancement prior to degradation at higher thicknesses. These results highlight the critical role of layer-thickness optimization in achieving superior sensing performance, as excessive thickness may degrade resonance characteristics despite initial improvements.

A comprehensive optimization of the multilayer structure is shown in Fig. 5, where the thicknesses of Ag, Ni, and TiO<sub>2</sub> are varied simultaneously. The optimal configuration is identified as Ag (30 nm)/Ni (14 nm)/TiO<sub>2</sub> (5 nm), achieving a maximum sensitivity of 432 deg/RIU. For the SPR structures with Ag layer thicknesses of 40 nm and 50 nm, the maximum sensitivities achieved are 429 deg/RIU and 425 deg/RIU, respectively. These results indicate that an Ag thickness of 40 nm provides slightly superior sensing performance compared to 50 nm, suggesting a more optimal balance between plasmon excitation and damping at this thickness.



**Fig. 5** Sensitivity of optimization structure based on variation of Ni layer thickness, TiO<sub>2</sub> and Ag thickness.

**Error! Reference source not found.** depicts the angular shift of the SPR reflectance dip under the optimal configuration for urine samples with glucose concentrations ranging from normal levels up to 10 g/dL. The resonance angle shows a linear dependence on glucose concentration, indicating reliable, predictable sensor performance. Linear regression analysis reveals that the relationship between the

resonance dip position ( $y$ ) and glucose concentration ( $x$ ) is given by  $y = 82.8758 + 0.51251x$ , with a coefficient of determination ( $R^2$ ) of 0.995, indicating excellent linearity and a strong correlation. Furthermore, the maximum FWHM is observed at a glucose concentration of 5 g/dL, with a value of 5.88 deg, suggesting a slight broadening of the resonance curve at higher analyte concentrations. To further

elucidate the sensing mechanism, the electric field distribution of the optimized structure was analyzed

using the finite-difference time-domain (FDTD) method, as shown in Fig. 7. The results reveal a strong enhancement and localization of the electric field within the active multilayer region, particularly at the TiO<sub>2</sub> interface, before decaying into the sensing medium. This field confinement plays a crucial role in amplifying the interaction between the evanescent field and the analyte, thereby improving sensing performance. It is observed that the maximum electric field intensity occurs at the interface between the TiO<sub>2</sub> layer and the sensing medium, reaching 1.24 a.u. This indicates strong field confinement at the sensing interface, which is crucial for enhancing light-matter interaction and improving the sensitivity of the SPR sensor.

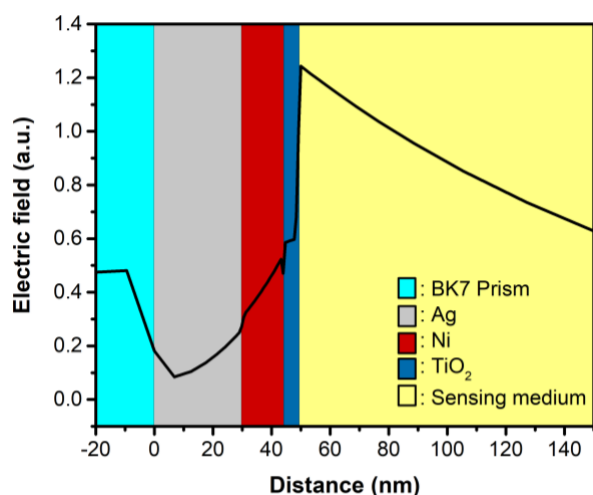


Fig. 6 Distribution of the electric field in the optimized SPR sensor

#### IV. DISCUSSION

Fig. 2 illustrates the proposed fabrication method for the designed SPR sensor structure. This scheme demonstrates the conceptual design and highlights its strong feasibility and potential for practical fabrication and implementation. The fabrication begins with cleaning the BK7 prism using a piranha solution to ensure complete removal of contaminants from the prism surface prior to Ag deposition [33], [34]. The Ag layer can then be deposited using the DC sputtering technique [35], which allows precise thickness control by adjusting deposition parameters such as power and deposition time. Subsequently, a Ni thin film can be deposited on top of the Ag layer using the same method, where the thickness is optimized to enhance sensor stability and detection performance [36]. For the

TiO<sub>2</sub> layer, several deposition techniques are available. Still, atomic layer deposition (ALD) offers the most promising approach due to its ability to produce ultrathin films with excellent uniformity and atomic-level thickness control [37]. In this process, TiCl<sub>4</sub> is introduced as a precursor, followed by inert-gas purging and exposure to H<sub>2</sub>O, thereby generating controlled chemical reactions that release byproducts such as HCl. These ALD cycles are repeated until the desired TiO<sub>2</sub> thickness is achieved with high precision. Once the multilayer structure is fabricated, the sensor can detect glucose in urine by allowing the sample to flow over the sensing surface [38]. The detection principle relies on monitoring plasmonic resonance conditions, which are observed as changes in the reflectance dip concerning the incident angle of the p-polarized He-Ne laser excitation [18].

Adding Ni and TiO<sub>2</sub> layers is crucial in improving the sensing performance compared to a simple Ag-based configuration. While Ag provides strong plasmonic excitation, it suffers from oxidation and structural instability [39] in biological environments such as urine. A Ni layer enhances chemical stability and improves adhesion between Ag and TiO<sub>2</sub>, reducing degradation over time. Meanwhile, the TiO<sub>2</sub> coating not only protects the metallic layers but also enhances electric-field confinement near the sensing surface due to its high refractive index, thereby increasing the sensor's sensitivity and the figure of merit (FOM) [40]. These combined effects explain the superior performance predicted by simulation results and further justify the proposed multilayer design for practical glucose detection applications.

The detection performance of three different SPR sensor structures BK7/Ag/SM, BK7/Ag/Ni/SM, and BK7/Ag/Ni/TiO<sub>2</sub>/SM was compared as an initial analysis. As shown in Fig. 3(a), the reflectance curves indicate that adding Ni and TiO<sub>2</sub> layers on top of the Ag film shifts the resonance dip toward larger incident angles. This shift occurs because the optical properties of the multilayer structure become more complex, leading to stronger coupling interactions that govern plasmonic resonance [41]. A more detailed evaluation of sensing performance, particularly sensitivity and FOM, is presented in Fig. 3(b). The results clearly reveal that the inclusion of Ni and TiO<sub>2</sub> layers enhances both parameters compared to the simple Ag-based configuration. The increase in sensitivity demonstrates that the sensor is more responsive to small refractive-index variations induced by glucose in the sensing medium, while the higher FOM reflects sharper

resonance characteristics and improved resolution for distinguishing analyte concentrations. These findings confirm that the multilayer configuration offers superior detection capabilities and highlight the potential of further optimization of Ni and TiO<sub>2</sub> thicknesses to achieve even higher performance in practical glucose sensing applications.

In the extended analysis of the influence of Ni and TiO<sub>2</sub> layer thickness on sensing performance (Fig. 4), the Ni thickness was varied in 1-nm increments to evaluate its effect on sensitivity and FOM. The results indicate that both sensitivity and FOM increase with Ni thickness up to an optimal value of approximately 11 nm. Beyond this thickness, performance declines.

This behavior can be attributed to the dual role of the Ni layer. At an optimal thickness, Ni enhances plasmonic coupling by modifying the interfacial field distribution between Ag and the dielectric layers. However, further increases in thickness lead to stronger absorption due to Ni's relatively large imaginary component of the complex refractive index, resulting in increased damping losses and a degradation of resonance sharpness; consequently, both sensitivity and FOM decrease at higher thicknesses.

For the TiO<sub>2</sub> layer, the FOM shows a different trend from that of Ni. As the TiO<sub>2</sub> thickness increases, the FOM shows a gradual, nearly monotonic increase, with a more pronounced enhancement around 7 nm, driven by a significant increase in sensitivity. This behavior is attributed to improved optical impedance matching and stronger confinement of the evanescent field at the sensing interface, resulting from TiO<sub>2</sub>'s high absolute refractive index.

However, at higher thicknesses, the reflectance spectrum exhibits broader, shallower resonance dips with less distinct minima, indicating weakened plasmon coupling and reduced resonance quality. Consequently, further increases in thickness do not yield meaningful performance gains, underscoring the importance of optimizing the TiO<sub>2</sub> layer thickness.

Building on these findings, a systematic optimization was conducted to investigate the combined influence of Ni, TiO<sub>2</sub>, and the plasmon-generating Ag layer, as summarized in Fig. 5. Regions without contour coloration correspond to parameter combinations for which no distinct resonance dip was observed. In this study, a resonance was considered unreliable when the reflectance curve did not exhibit a clear local minimum or when the dip depth was insufficient to determine a well-defined resonance angle and FWHM. Under such conditions, accurate sensitivity calculation becomes infeasible.

This parametric study identified the optimal configuration with an Ag thickness of 30 nm, Ni thickness of 14 nm, and TiO<sub>2</sub> thickness of 5 nm, yielding a maximum sensitivity of 432 deg/RIU. This optimized structure balances field confinement and resonance sharpness, delivering superior sensing performance. Consequently, this design was selected for the subsequent analysis of reflectance spectral changes as a function of glucose concentration in urine samples. Importantly, this systematic thickness-dependent optimization of hybrid Ag/Ni/TiO<sub>2</sub> multilayers for glucose detection in a realistic biological medium has not been reported previously, thereby addressing a research gap and reinforcing the novelty of the present study.

The performance enhancement mechanism can be interpreted from the complex refractive indices incorporated in the TMM model. Ag, characterized by a large negative real permittivity and relatively small imaginary component, supports strong surface plasmon resonance with sharp resonance curves. The insertion of a thin Ni layer, possessing a larger imaginary component of refractive index, introduces controlled plasmon damping and modifies the field distribution at the metal–dielectric interface. This affects the absorption profile and slightly shifts the resonance condition.

Meanwhile, TiO<sub>2</sub> exhibits a high real refractive index with negligible absorption in the visible range. The high real part enhances optical impedance matching and strengthens the confinement of the evanescent field toward the sensing medium. As a result, the overlap between the plasmonic field and the analyte region increases, thereby improving sensitivity. Therefore, the combined effects of the real and imaginary components of Ni and TiO<sub>2</sub> directly govern the resonance angle shift, electric field confinement, and overall sensing performance within the TMM framework.

**Error! Reference source not found.**(a) presents the reflectance spectra generated by the optimized SPR sensor configuration for varying glucose concentrations in urine. Increasing glucose concentration induces a progressive shift of the resonance dip toward higher incident angles, consistent with the increasing refractive index of the sensing medium. This shift arises from modifications to the surface plasmon wave vector, which alter the momentum-matching condition.

In addition to the angular shift, the resonance minima become progressively deeper as glucose content increases. This behavior can be attributed to enhanced coupling efficiency between the incident electromagnetic wave and the surface plasmon mode as the dielectric permittivity increases. Improved field

overlap at the metal–dielectric interface results in stronger energy transfer into the plasmonic mode, thereby producing deeper reflectance dips.

A detailed analysis of the dip position, its width (characterized by the FWHM), and the minimum reflectance is summarized in [Error! Reference source not found.\(b\)](#). The resonance angle shows a linear dependence on glucose concentration, confirming the consistent, predictable response of the proposed multilayer SPR configuration.

Notably, the sensor demonstrates detectable resonance shifts at glucose concentrations as low as 0.625 g/dL, corresponding to an approximate refractive index variation of 0.001 RIU relative to normal urine conditions. This result highlights the high refractive index resolution of the optimized BK7/Ag/Ni/TiO<sub>2</sub> structure. The linear regression analysis of glucose concentration versus resonance yields a coefficient of determination ( $R^2$ ) of 0.995, confirming excellent linearity of the sensing response. This high  $R^2$  value quantitatively supports the claim that the proposed multilayer SPR structure delivers consistent, predictable detection performance across the investigated concentration range.

Overall, these findings demonstrate that the engineered hybrid multilayer configuration effectively balances plasmon confinement and resonance sharpness, offering improved sensing performance compared to conventional single-metal SPR structures. To further clarify the role of the additional Ni and TiO<sub>2</sub> layers in enhancing detection performance, [Fig. 7](#) presents the spatial distribution of the electric field amplitude across the optimized multilayer structure, obtained from finite-difference time-domain (FDTD) simulations. The profile is evaluated at the resonance angle corresponding to the minimum reflectance dip, where surface plasmon excitation is maximized. The horizontal axis represents the distance along the direction normal to the interfaces. At the same time, the background color segmentation indicates the different material layers and their respective thicknesses, namely BK7 prism, Ag (30 nm), Ni (14 nm), TiO<sub>2</sub> (5 nm), and the sensing medium.

The results demonstrate a pronounced enhancement of the electric field near the metal–dielectric interface, with the maximum field amplitude observed in the TiO<sub>2</sub> and sensing medium region. The Ag layer supports the primary plasmon excitation, while the Ni interlayer modifies interfacial damping and coupling, thereby redistributing and strengthening the localized field. Meanwhile, the high-refractive-index TiO<sub>2</sub> layer promotes stronger field penetration into the sensing medium, increasing the overlap between the evanescent plasmon field and the analyte. This

synergistic interaction among Ag, Ni, and TiO<sub>2</sub> enhances electromagnetic field localization at the sensing interface, leading to stronger light–analyte interaction. Consequently, incorporating Ni and TiO<sub>2</sub> into the conventional Kretschmann-type SPR configuration results in improved field confinement and superior sensing performance compared to a single-metal Ag structure.

## V. Conclusion

This study aimed to develop and optimize a multilayer silver-based SPR sensor in the Kretschmann configuration for non-invasive glucose detection in urine by incorporating Ni and TiO<sub>2</sub> thin films. The results demonstrate that the proposed structure significantly enhances sensing performance, with the optimized configuration Ag (30 nm)/Ni (14 nm)/TiO<sub>2</sub> (5 nm) achieving a maximum sensitivity of 432 deg/RIU. Furthermore, the sensor can detect refractive index changes as small as 0.001 RIU, corresponding to low glucose concentrations (down to 0.625 g/dL), indicating high detection sensitivity for urine-based analysis. The performance enhancement is attributed to improved plasmonic coupling and strong electric-field localization at the TiO<sub>2</sub> interface, as confirmed by FDTD analysis. These findings highlight the effectiveness of combining Ni and TiO<sub>2</sub> layers to amplify the SPR response and enable reliable detection of small changes in refractive index. Future work will focus on experimental validation of the proposed design, integration into portable user-friendly diagnostic platforms, and further exploration of this multilayer approach to detect other clinically relevant biomarkers in biological fluids.

## Acknowledgment

This research was funded by Universitas Bangka Belitung through the University-Level Research Grant (PDTU) scheme (Contract No. 2164G/UN50/M/PP/2025).

## Data Availability

No datasets were generated or analyzed during the current study.

## Author Contribution

Y. Tiandho: conceptualization, methodology, software, investigation, writing – original draft, funding acquisition; E. Julianti: methodology, validation, project administration, writing – review & editing; Zamziri: conceptualization, formal analysis, validation, resources, writing – review & editing; P. Cahyani: software, investigation, data curation, writing – review &

editing, F. Afriani: conceptualization, methodology, formal analysis, investigation, writing – review & editing. All authors reviewed and approved the final version of the manuscript and agreed to be responsible for all aspects of the work, ensuring integrity and accuracy.

#### Declarations

##### Ethical Approval

This study does not involve human participants or animal subjects. Therefore, ethical approval and informed consent were not required.

##### Consent for Publication Participants.

Consent for publication was given by all participants

##### Competing Interests

The authors declare no competing interests.

#### References

- [1] M. J. Hossain, M. Al-Mamun, and M. R. Islam, "Diabetes mellitus, the fastest growing global public health concern: Early detection should be focused," *Heal. Sci. Reports*, vol. 7, no. 3, pp. 5–9, 2024, doi: 10.1002/hsr2.2004.
- [2] A. H. M. Almawgani, S. A. Taya, M. G. Daher, I. Colak, F. Wu, and S. K. Patel, "Detection of glucose concentration using a surface plasmon resonance biosensor based on barium titanate layers and molybdenum disulphide sheets," *Phys. Scr.*, vol. 97, no. 6, p. 65501, 2022, doi: 10.1088/1402-4896/ac68ad.
- [3] M. Wahidin *et al.*, "Projection of diabetes morbidity and mortality till 2045 in Indonesia based on risk factors and NCD prevention and control programs," *Sci. Rep.*, vol. 14, no. 1, pp. 1–17, 2024, doi: 10.1038/s41598-024-54563-2.
- [4] N. Salsabiila, M. Morsin, S. Nafisah, N. L. Razali, F. Mahmud, and Z. Tukiran, "Mini Review of Glucose Detection Using Plasmonic Sensor," *Emerg. Adv. Integr. Technol.*, vol. 4, no. 1, pp. 38–49, 2023, doi: 10.30880/eamit.2023.04.01.006.
- [5] M. Nasehi, M. Saeedi, J. Ghanavi, and M. K. Moravvej-Farshi, "Glucose Sensing Based on the Interaction of Gold Nanoparticles@Linoleic Acid With the Glucose," *IEEE Sens. J.*, vol. 22, no. 7, pp. 7169–7176, 2022, doi: 10.1109/JSEN.2022.3151221.
- [6] G. Gumilar *et al.*, "Performance enhancement strategies for surface plasmon resonance sensors in direct glucose detection using pristine and modified UiO-66: effects of morphology, immobilization technique, and signal amplification," *J. Mater. Chem. A*, vol. 10, no. 12, pp. 6662–6678, 2022, doi: 10.1039/d1ta08741j.
- [7] Y. Tiandho, R. Jonuarti, B. Yulianto, and Suprijadi, "Investigation of silver@gold nanorod for waterborne pathogen detection: An integration of finite difference time domain method and response surface methodology," *Opt. Laser Technol.*, vol. 176, p. 110942, 2024, doi: 10.1016/j.optlastec.2024.110942.
- [8] G. Alagu Vibisha, M. G. Daher, S. M. Habibur Rahman, Z. Jaroszewicz, K. B. Rajesh, and R. Jha, "Designing high sensitivity and high figure of merit SPR biosensor using copper and 2D material on CaF2 prism," *Results Opt.*, vol. 11, no. March, p. 100407, 2023, doi: 10.1016/j.rio.2023.100407.
- [9] Y. Tiandho, F. Afriani, N. L. W. Septiani, G. Gumilar, Suprijadi, and B. Yulianto, "Enhancing urine glucose sensing performance through the introduction of two dimensional-transition metal dichalcogenides and gold nanoparticles into silver/UiO-66 chip of surface plasmon resonance," *Nanotechnology*, vol. 35, no. 18, 2024, doi: 10.1088/1361-6528/ad12ed.
- [10] E. Mauriz, "Trends and Challenges of SPR Aptasensors in Viral Diagnostics: A Systematic Review and Meta-Analysis," *Biosensors*, vol. 15, no. 4, pp. 1–20, 2025, doi: 10.3390/bios15040245.
- [11] V. Kumar, R. Kumar, S. Pal, and Y. K. Prajapati, "Development of surface plasmon resonance sensor utilizing GaSe and WS2 for ultra-sensitive early detection of dengue virus," *Optik (Stuttg.)*, vol. 313, no. May, p. 171975, 2024, doi: 10.1016/j.ijleo.2024.171975.
- [12] S. Das, R. Devireddy, and M. R. Gartia, "Surface Plasmon Resonance (SPR) Sensor for Cancer Biomarker Detection," *Biosensors*, vol. 13, no. 3, p. 396, 2023, doi: 10.3390/bios13030396.
- [13] N. Mudgal, A. Saharia, A. Agarwal, J. Ali, P. Yupapin, and G. Singh, "Modeling of highly sensitive surface plasmon resonance (SPR) sensor for urine glucose detection," *Opt. Quantum Electron.*, vol. 52, no. 6, pp. 1–14, 2020, doi: 10.1007/s11082-020-02427-0.
- [14] M. Mishra, S. Senapati, A. Yadav, and S. K. Tripathy, "BaTiO3 boosted silver-based SPR sensor for efficient urine-glucose detection in pre-diabetic and early-diabetic stages," *Sensors Actuators A Phys.*, vol. 379, no. July, p. 115895, 2024, doi: 10.1016/j.sna.2024.115895.
- [15] Shivangani *et al.*, "Design and Analysis of Surface Plasmon Resonance Sensor Utilizing Silver, Nickel, and Black Phosphorous for Various Cancer Detection," *Plasmonics*, 2025, doi: <https://doi.org/10.1007/s11468-025-02961-1>.
- [16] S. Das, T. Prava Mondal, K. Kumar Roy, R. Reza Mahmud, M. Shariful Islam, and B. Barua, "Design and Optimization of an SPR-Based Biosensor with Ultra-High Sensitivity Using a Hybrid Structure for

- Accurate Dengue Virus Detection,” *Plasmonics*, no. June, 2025, doi: 10.1007/s11468-025-03107-z.
- [17] Y. Singh *et al.*, “Highly Sensitive Plasmonic Biosensor for the Detection of Chikungunya Virus Employing TiO<sub>2</sub> and BP/WS<sub>2</sub> Heterostructure,” *Plasmonics*, vol. 19, no. 6, pp. 3233–3241, 2024, doi: 10.1007/s11468-024-02242-3.
- [18] L. Mahmudin *et al.*, “Silver nanoparticles-based localized surface plasmon resonance biosensor for Escherichia coli detection,” *Spectrochim. Acta - Part A Mol. Biomol. Spectrosc.*, vol. 311, no. November 2023, p. 123985, 2024, doi: 10.1016/j.saa.2024.123985.
- [19] M. B. Hossain, I. M. Mehedi, M. Moznuzzaman, L. F. Abdulrazak, and M. A. Hossain, “High performance refractive index SPR sensor modeling employing graphene tri sheets,” *Results Phys.*, vol. 15, no. September, p. 102719, 2019, doi: 10.1016/j.rinp.2019.102719.
- [20] A. Pal, Y. Trabelsi, P. Sarkar, M. Sharma, M. Kumar, and A. Uniyal, “Tuning sensitivity of surface plasmon resonance sensor based on ZnO layer and CaF<sub>2</sub> prism for the recognition of SARS-CoV-2,” *J. Mater. Sci. Mater. Electron.*, vol. 35, no. 22, pp. 1–11, 2024, doi: 10.1007/s10854-024-13287-9.
- [21] A. Yadav, S. Kumar, A. Kumar, and P. Sharan, “Effect of 2-D nanomaterials on sensitivity of plasmonic biosensor for efficient urine glucose detection,” *Front. Mater.*, vol. 9, no. January, pp. 1–12, 2023, doi: 10.3389/fmats.2022.1106251.
- [22] T. Tene *et al.*, “Advanced SPR-Based Biosensors for Potential Use in Cancer Detection: A Theoretical Approach,” *Sensors*, vol. 25, no. 9, 2025, doi: 10.3390/s25092685.
- [23] S. A. Rafi *et al.*, “Innovative TiO<sub>2</sub>/Ag/TiO<sub>2</sub> Sandwiched SPR Sensor with WSe<sub>2</sub> Layer for Efficient Dengue Virus Detection via TMM and FEM,” *Plasmonics*, vol. 20, no. 7, pp. 5345–5361, 2025, doi: 10.1007/s11468-024-02730-6.
- [24] M. M. Rahman *et al.*, “2D Nanomaterial-Based Hybrid Structured (Au-WSe<sub>2</sub>-PtSe<sub>2</sub>-BP) Surface Plasmon Resonance (SPR) Sensor With Improved Performance,” *IEEE Access*, vol. 10, pp. 689–698, 2022, doi: 10.1109/ACCESS.2021.3137420.
- [25] C. Basak, M. S. Islam, M. K. Hosain, and A. Z. Kouzani, “An ultra-sensitive surface plasmon resonance biosensor with PtSe<sub>2</sub> and BlueP/WS<sub>2</sub> heterostructure,” *Heliyon*, vol. 10, no. 19, p. e38499, 2024, doi: 10.1016/j.heliyon.2024.e38499.
- [26] A. Sánchez-Álvarez, D. Luna-Moreno, O. Silva-Hernández, and M. M. Rodríguez-Delgado, “Application of SPR Method as an Approach to Gas Phase Sensing of Volatile Compound Profile in Mezcal Spirits Conferred by Agave Species,” *Chemosensors*, vol. 11, no. 1, 2023, doi: 10.3390/chemosensors11010070.
- [27] M. El-assar, T. E. Taha, F. E. A. El-Samie, H. A. Fayed, and M. H. Aly, “Zinc selenide based dual-channel SPR optical biosensor for HIV genome DNA hybridization detection,” *Optical and Quantum Electronics*, vol. 55, no. 13, 2023, doi: 10.1007/s11082-023-05296-5.
- [28] S. Singh, A. K. Sharma, P. Lohia, D. K. Dwivedi, and P. K. Singh, “Design and Modelling of High-Performance Surface Plasmon Resonance Refractive Index Sensor Using BaTiO<sub>3</sub>, MXene and Nickel Hybrid Nanostructure,” *Plasmonics*, vol. 17, no. 5, pp. 2049–2062, 2022, doi: 10.1007/s11468-022-01692-x.
- [29] M. B. Hossain, M. M. Rana, L. F. Abdulrazak, S. Mitra, and M. Rahman, “Graphene-MoS<sub>2</sub> with TiO<sub>2</sub>-SiO<sub>2</sub> layers based surface plasmon resonance biosensor: Numerical development for formalin detection,” *Biochem. Biophys. Reports*, vol. 18, no. October 2018, 2019, doi: 10.1016/j.bbrep.2019.100639.
- [30] A. K. Sahu, M. Mishra, K. C. Nayak, and S. K. Tripathy, “An investigation on effect of various mono and Di-sulphide coatings on the performance of an Au–Ag bimetallic SPR sensor: an attempt towards noninvasive urine-glucose detection,” *Opt. Quantum Electron.*, vol. 56, no. 1, pp. 1–21, 2024, doi: 10.1007/s11082-023-05620-z.
- [31] H. Cai, M. Wang, Z. Wu, J. Liu, and X. Wang, “Performance Enhancement of SPR Biosensor Using Graphene–MoS<sub>2</sub> Hybrid Structure,” *Nanomaterials*, vol. 12, no. 13, 2022, doi: 10.3390/nano12132219.
- [32] Z. Zhang *et al.*, “Plasmonic refractive index sensor with high figure of merit based on concentric-rings resonator,” *Sensors (Switzerland)*, vol. 18, no. 1, 2018, doi: 10.3390/s18010116.
- [33] B. Karki, A. Jha, A. Pal, and V. Srivastava, “Sensitivity enhancement of refractive index-based surface plasmon resonance sensor for glucose detection,” *Opt. Quantum Electron.*, vol. 54, no. 9, 2022, doi: 10.1007/s11082-022-04004-z.
- [34] B. Karki, A. Pal, P. Sarkar, R. B. Yadav, A. Muduli, and Y. Trabelsi, “ZnO-Silicon Enhanced Surface Plasmon Resonance Sensor for Chemical Sensing,” *Silicon*, vol. 16, no. 9, pp. 3861–3872, 2024, doi: 10.1007/s12633-024-02973-2.
- [35] H. Y. Wu *et al.*, “High Sensitivity SERS Substrate of a Few Nanometers Single-Layer Silver

Thickness Fabricated by DC Magnetron Sputtering Technology," *Nanomaterials*, vol. 12, no. 16, pp. 1–17, 2022, doi: 10.3390/nano12162742.

- [36] H. A. Abbas, A. J. Rahma, and H. F. Olewi, "Fabrication and characterization of NiO nanoparticles deposited via reactive DC magnetron sputtering technique," *Dig. J. Nanomater. Biostructures*, vol. 19, no. 3, pp. 1309–1318, 2024, doi: 10.15251/DJNB.2024.193.1309.
- [37] V. Matkivskiy *et al.*, "Atomic Layer Deposition of Titanium Oxide-Based Films for Semiconductor Applications—Effects of Precursor and Operating Conditions," *Materials (Basel)*, vol. 16, no. 16, 2023, doi: 10.3390/ma16165522.
- [38] D. Hiller *et al.*, "Comparison of three titanium-precursors for atomic-layer-deposited TiO<sub>2</sub> for passivating contacts on silicon," *J. Vac. Sci. Technol. A*, vol. 42, no. 3, 2024, doi: 10.1116/6.0003309.
- [39] Y. Tiandho, N. L. W. Septiani, G. Gumilar, R. Jonuarti, Suprijadi, and B. Yulianto, "High Performance Refractive Index-Based Sensor Using Ellipsoid Ag@Au Nanoparticles," *IEEE Sens. J.*, vol. 23, no. 9, pp. 9390–9401, 2023, doi: 10.1109/JSEN.2022.3233905.
- [40] S. Mostufa, T. B. A. Akib, M. M. Rana, and M. R. Islam, "Highly Sensitive TiO<sub>2</sub>/Au/Graphene Layer-Based Surface Plasmon Resonance Biosensor for Cancer Detection," *Biosensors*, vol. 12, no. 8, 2022, doi: 10.3390/bios12080603.
- [41] A. Jawad *et al.*, "Modeling and Performance Analysis of an Advanced Hybrid Surface Plasmon Resonance (SPR) Sensor Employing Indium Tin Oxide-Phosphorene Hetero Structure," *Plasmonics*, vol. 18, no. 4, pp. 1391–1401, 2023, doi: 10.1007/s11468-023-01861-6.

### Author Biography



**Yuant Tiandho** received the B.Sc. degree in Physics from Universitas Lampung, Indonesia, in 2012, followed by the M.Sc. and Ph.D. degrees in Physics from Institut Teknologi Bandung, Indonesia, in 2015 and 2025, respectively. Since 2016, he has been a faculty member in the Department of Physics at Universitas Bangka Belitung, Indonesia, where he is actively involved in teaching and research. He is also a member of the Indonesian Optical Society. His research interests encompass computational physics, biosensor development, nanotechnology, and the modeling and simulation of optical materials and devices. In addition, his recent work focuses on plasmonic-based sensing systems and on the

integration of advanced materials to improve sensor performance in biomedical and environmental applications.



**Erna Julianti** received her Bachelor of Nursing (S.Kep) degree from Universitas Sriwijaya in 2011 and completed her Professional Ners program at the same institution in 2012. She obtained her Master's degree in Pediatric Nursing from Universitas Indonesia in 2016, followed by a Specialist Ners degree in Pediatric Nursing in 2017. She is currently a lecturer in the Department of Nursing at Universitas Bangka Belitung, Indonesia, where she actively engages in teaching, research, and community service. Her research interests primarily focus on child health, particularly the prevention and management of stunting, as well as neonatal and pediatric care. In addition, she is involved in applied research addressing maternal and child health issues in community-based settings, aiming to improve healthcare outcomes and support evidence-based nursing practices.



**Zamziri** is a faculty member in the Department of Nursing at Universitas Bangka Belitung, Indonesia, where he is actively involved in teaching, research, and community engagement activities. He received his Bachelor of Nursing (S.Kep) from Universitas Sumatera Utara in 2005 and later earned his Master of Health Sciences (M.Kes) from Universitas Padjadjaran in Bandung in 2016. With a strong academic and professional background in nursing, he has contributed to the development of nursing education and practice, particularly in community and clinical settings. His research interests focus on health education, patient awareness, and nursing care practices, with an emphasis on improving healthcare quality and promoting preventive health strategies in diverse populations.



**Putri Cahyani** has been pursuing her Bachelor of Science (S.Si) degree in Physics at Universitas Bangka Belitung, Indonesia, since 2022. She is an undergraduate student in the Department of Physics, where she is actively involved in academic and research activities related to optical sensing and computational modeling. Her research interests focus on the computational design and simulation of optical sensors, particularly those based on surface plasmon resonance (SPR) for detecting biological targets. She is especially interested in exploring the interaction between light and

nanostructured materials to enhance sensor sensitivity and performance. Through her ongoing studies, she aims to contribute to the development of innovative and efficient sensing technologies for biomedical and environmental applications.



**Fitri Afriani** earned her Bachelor of Science (B.Sc.) degree in Physics from the University of Lampung in 2013 and her Master of Science (M.Sc.) degree in Biophysics from Bogor Agricultural University in 2015, with a research focus on biomaterial development. She completed her Ph.D. degree in Physics at Institut Teknologi Bandung in 2025. She is currently a lecturer in the Department of Physics at Universitas Bangka Belitung, Indonesia, where she actively teaches and conducts research. Her research interests include biomaterials, environmentally friendly and sustainable materials, nanomaterials, and advanced materials for smart and active packaging applications. In addition, her work emphasizes developing functional materials derived from natural resources to support environmentally sustainable technology.