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Analysis of Current-Voltage Properties of Schottky Diode with TiO_2 Interlayer Prepared by RF Magnetron Sputtering

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Abstract
This study focuses on investigating the electrical behaviour of Metal-Insulator-Semiconductor (MIS) type Schottky barrier diodes based on titanium oxide (TiO_2). An MIS-type Al/TiO_2/p-Si Schottky diode structure was fabricated by depositing a TiO_2 metal oxide thin film as an interlayer on p-type silicon using the technique of Radio Frequency Magnetron Sputtering at room temperature. The electrical performance of this fabricated structure was evaluated through the measurements of current-voltage (I-V) conducted in a dark environment at ±5 V and room temperature. These measurements enabled the determination of key Schottky diode parameters, including barrier height (Φ_b), saturation current (I_o), and ideality factor (n), using both the Thermionic Emission (TE) method and the Cheung method. Utilizing the TE method, approximate values for Φ_b, n, and Io parameters were calculated as 0.59 eV, 4.07, and 2.78E-06 A, respectively. Meanwhile, employing Cheung's method yielded approximate values of Φ_b and n parameters as 0.39 eV (H(I) vs I) and 4.39 (dV/dln(I) vs I), respectively. The analysis indicates that the developed Schottky diode functions as a rectifier diode, demonstrating typical diode characteristics. Furthermore, a comparison of numerous devices reported in the literature was conducted based on TiO_2 preparation methods against the parameters of the TiO_2/p-Si host device.

1. Introduction

Conventional diodes use p-type and n-type semiconductors to form a p-n structure. In Schottky diodes, a metal and a metal-semiconductor are combined to form a Schottky barrier at the junction [1], as shown in Figure 1. Looking at the characteristics of Schottky diodes, it can be seen that they have many good properties, such as fast switching and low voltage drop. Fast switching is described as the transition between the on-state and the off-state, where the conduction is stopped when the voltage is applied forward. In fact, this speed is related to the fact that the memory load of Schottky diodes is much less than that of other diodes. When compared to conventional diodes, Schottky diodes are more resistant to the low voltage drops known as forward voltage drops, thus reducing power losses and increasing energy efficiency. Schottky diodes have both advantages and disadvantages; examples of disadvantages include the fact that they produce a lot of heat in an operating system and are resistant to low voltage when it's fed backwards. The fact that they produce a lot of heat in the operating system is a situation that should be taken into consideration in systems that need to operate at high power. Examples of its advantages include being preferred in situations where efficiency, power, high switching speed, and high-frequency operation are important [2]. Given these characteristics, they are used in power supplies,

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power rectifier circuits [3], radio frequency sensitive detectors [4], and circuits requiring high switching speeds [5].

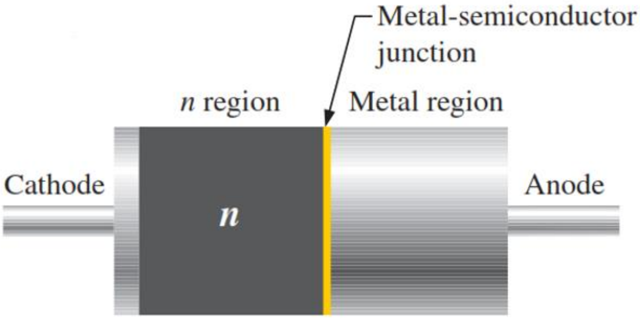

Figure 1. Schematic of a typical Schottky diode.

Depending on the thickness of the interlayer between the n-region and the metal region, Schottky diode structures are referred to as Metal/Semiconductor (MS), Metal/Insulator/Semiconductor (MIS) or Metal/Oxide/Semiconductor (MOS) structures. They consist of metals corresponding to the chosen p- or n-semiconductors. Literature suggests that metals such as gold (Au), silver (Ag), and aluminium (Al) are used for the metallic area because of their high purity. The preferred choice of p-type or n-type semiconductor material is silicon (Si). This is because it is more economical and stable [6].

When semiconductor components are manufactured, charge transfer between structural metals and semiconductors plays a major role. The control of this transfer is the key to the performance of the solid-state device. Therefore, insulating layers such as silicon dioxide (SiO_2), tin dioxide (SnO_2), silicon nitride (Si_3N_4) and TiO_2 are commonly used as interlayers. For this reason, a TiO_2 interlayer was used in the present study. The interlayers in question do not have to be exclusively inorganic. Organic interfacial layers such as polyindole, polyaniline, and polyvinyl alcohol (PVA) are known to form. The interfacial layers between the metal and the semiconductor are chosen according to a certain logic. They are chosen to provide surface passivation, minimum leakage current, a controllable current transfer mechanism, and high dielectric stability close to rectifier properties [7]-[9].

In terms of their electrical characteristics, MIS and MOS structures are very similar. These structures can be electrically distinguished by whether their interface structures are insulating or polymeric and have variable metal-semiconductor interface properties, and the series resistance (R_s) and barrier height of the resultant Schottky diode can be uniform. While the MS structure means that there is no insulator or polymer interface layer, the interface layers in MIS and MOS structures can be insulator and polymer. This situation causes changes in the interface states. This change serves to regulate the interface transitions by isolating the metal-semiconductor structure from each other, as well as altering the electrical properties of the metal-semiconductor combination that forms the Schottky diode structure. Consequently, current transfer in MIS and MOS structures differs from that in MS structures [10].

When the thickness of the insulating interface layer between the metal and the semiconductor is less than 100Å, Schottky diodes are called MIS, and if it is more than 100Å, they are called MOS. For a fabricated MIS structure to be ideal, two situations must occur. The first is the absence of any intermediate charge and interface state in the insulator between the metal and the semiconductor. The second is that this situation does not occur at the insulator-semiconductor interface. In reality, MIS structures differ from the ideal [11], [12] because of the interactions between the insulating layer within the MIS structure and the charges at the interface between the insulator and the semiconductor. Another deviation from the ideal is that the dielectric properties of the isolation layer at the interface are similar to those of a parallel plate capacitor [12]-[14].

The insulating semiconductor metal, titanium dioxide (TiO_2), is used as the interface in this paper and has high transmittance and permittivity over a wide range of wavelengths in the visible region of the electromagnetic spectrum. TiO_2 has three different natural polymorphs: anatase (tetragon), rutile (tetragon), and brookite (orthorhombic). The most thermodynamically stable phase is rutile TiO_2. However, metastable anatase and brookite TiO_2 phases can be converted to rutile phases after calcination at a certain temperature. Rutile and anatase TiO_2 are generally tetragonal in structure [15], whereas brookite TiO_2 is orthorhombic. The phases of TiO_2 are shown in Figure 2. TiO_2's dielectric constant differs between these phase conditions, and its transparency and electrical conductivity vary as its bandgap alters. For example, widening the bandgap improves their transparency but reduces their electrical conductance. If the electrical conductivity is to be increased in parallel with the increase in transparency, metals are added to the TiO_2 structure to increase the defect density of the structure, and it is observed that the overall conductivity increases. The ability to use TiO_2 as a coating material is another important aspect. Its high refractive index and high melting temperature are related to this coating ability. As a result, it has been widely used as a coating material in optical circuits and optical applications. For the semiconductor metal TiO_2 grown as an insulating interfacial layer in the present study, there are many growth processes. They are spraying, evaporation, chemical deposition, and sol-gel methods.

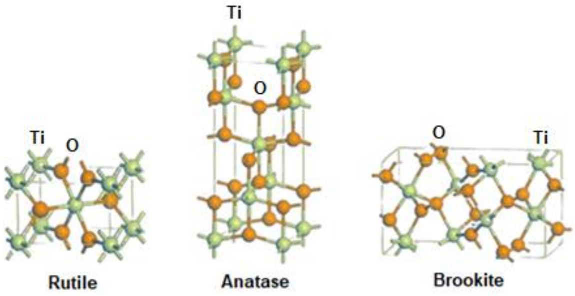

Figure 2. Crystal configurations of titanium dioxide in different phases [15].

In the present study, RF magnetron sputtering was used to grow rutile TiO_2 as an interfacial insulating layer. This method relies on creating a plasma on the surface of the object, and the atoms or molecules in the plasma form a thin layer on the surface for deposition [16]. It has been widely used in the literature for the fabrication of Schottky diode and photodiode structures. Using the RF magnetron sputtering method, Ali fabricated Ag/ZnO/Al Schottky photodiodes with rectifying properties [17]. Using RF magnetron sputtering, Ferhati et al. fabricated metal/TCO/p-Si structures. They mentioned that the Al /ZnO /p-Si Schottky structure can be a reliable and cost-effective solar cell [18]. Using the same method, Raj et al. have developed a p-type CdTe/V_2O_5/Ag Schottky diode structure. Purpose the V_2O_5 interface layer was a contributor to the electrical behaviour of the fabricated Schottky diode. It was shown to be useful in the fabrication of multi-structure solar cells such as TCO/CdS/CdTe/V_2O_5/Ag [19], with positive results from this contribution.

In order to understand the current response of the structure to voltage, many studies have been carried out to investigate the interface states at the insulator/semiconductor junctions that form Schottky structures [20]. As can be seen from these studies, many theories have been developed for the determination of the I-V of the Schottky structure [21]. Examples of these theories are the TE method and the Cheung method. The most common of these methods is the traditional I-V method [22], and in this method, the diode parameters are found using the slope of the linear region of the ln I versus V curve. Another method, the Cheung method, is applied to the data in the downward curved region of the forward bias Ln. I-V curve or to the linear region, and the diode parameters can be found with the Cheung functions [23].

How close to ideal the I-V characteristics of a Schottky structure determines whether it can be described as an ideal diode. It is therefore necessary to examine the I-V characteristics of the structure to determine how close it is to the ideal. This is done by examining the junction states of the structure. By understanding and controlling the interfacial behaviour, it is possible to make diodes which come close to the ideal Schottky diodes. It extends the life of the construction and makes it possible to change the construction more quickly.

It is the release of electrons and holes from the surface due to the heating of any surface and the generation of a TE. In Schottky diode structures, the metal part of the Schottky structure is allowed to pass through the junction between the semiconductor and the bulk, or vice versa, if the charge carriers do not have enough energy to overcome the potential barrier due to the temperature rise of the surface caused by heat, and this situation is called TE. In the case of n-type semiconductors, electrons are emitted. In the case of p-type semiconductors, holes are used to create Schottky structures [24].

In this study, the RF magnetron sputtering technique was used to fabricate the Al/TiO_2/p-Si Schottky diode structure. From the I-V measurements in the dark and at 300 K of the fabricated diode, the electrical parameters of the structure, such as series resistance (Rs), barrier height (Φ_b), and ideality factor (n) were examined using TE and Cheung methods.

2. Material and Method

The present study used a p-Si crystal as a substrate with two different structures (one matte, one shiny). The surface orientation of the crystal is 100, its thickness is 380 μm, and its resistivity is in the range 1-10 Ω-cm. The fabrication of the Schottky structure started with the chemical cleaning of the p-type Si substrate. It was first submerged in acetone for 10 minutes at 50 °C, followed by a deionized water wash and a two-minute release into methanol. Once more, the wafer was immersed in a $NH_4OH:H_2O_2:H_2O$ solution for 15 minutes at 70 °C after being cleaned with deionized water. To get rid of the solution on the wafer surface, it was dipped into deionized water. The wafer was washed in a 2% Hydrogen Fluoride (HF) solution for two minutes to eliminate any free oxygen from the surface. Lastly, the cleaning process was finished with deionized water [25]. A high-purity Al contact with 124 nm thickness was deposited on the matte surface of the silicon after the cleaning process. The purpose of this contact is to provide an ohmic contact. On the whole of the bright side of the p-type Si crystal, a 17 nm thick TiO_2 insulating interface layer was deposited and grown. RF magnetron sputtering was used for deposition, and the deposition parameters are given in Table 1. The final technique used to create the Schottky diode structure was physical vapour deposition (PVD). This technique is used for the fabrication of the rectifier contacts. Approximately 128 nm of Al metal is deposited on TiO_2 as the rectifier contacts. Figure 3 shows the resulting Schottky diode structure (TiO_2/p-Si Schottky barrier diode). Clearly, the TiO_2/p-Si diode has a rectifying function and was constructed using mathematical approaches.

Table 1. Parameters used in RF magnetron sputtering process for TiO2 thin-film fabrication.

Process parameters	Values
Power	150 Watt
Coating pressure	4.2×10^{-3} mbar
Base pressure inside the chamber	3.3×10^{-7}mbar
Target-to-substrate distance	50 mm
Sputtering gas	Argon
O_2 flow rate	1.3 sccm
Argon flow rate	12 sccm
Ar/O_2 ratio	9/1
Deposition rate	0.1 Å/s

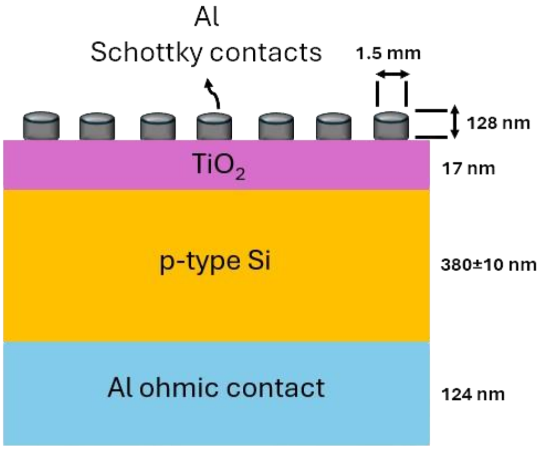

Figure 3. Schematic layout of Schottky structure.

3. Results and Discussion

The electrical parameters of the Al/TiO_2/p-Si Schottky structure, including barrier height (Φ_b), ideality factor (n), and series resistance (R_s), were examined in the present study by utilizing current-voltage (I-V) characteristics. All electrical characterization measurements were taken in a dark room and under room temperature, and the I-V graph obtained from the data is shown in Figure 4.

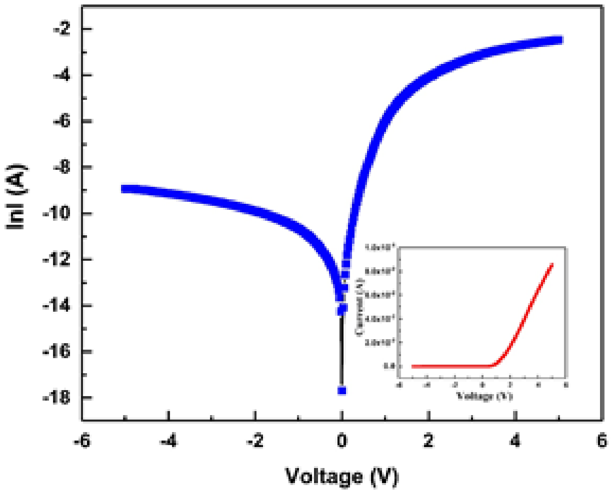

Figure 4. ln (I)-V characteristics of Al (124 nm) / TiO_2 (17 nm) / p-Si (380±10 nm) Schottky diode structure.

The presence of TiO_2 in the Schottky structure as an interlayer shows the behaviour of a high rectifying, low leakage diode, as shown in Figure 4. As higher currents are achieved, the current side of the ln(I)-V curve becomes progressively curved. This is the forward polarised region, and the bend is related to the mass resistance of the R_s or MIS structures of the contact wires used to measure the I-V curve. In the forward bias region, the current increases exponentially with the voltage, while in the reverse bias region, the current is seen to have a weak dependence on the voltage. At higher bias voltages, the ln I-V plot has a significant deviation from the linear case due to the effects of series resistance. The R_s effect and the existence of interfacial states cause the I-V curves to bend downward at sufficiently high supply voltages.

It is also possible to insert an artificial insulating layer between the metal and the semiconductor. The presence of this insulating layer transforms the structure into a metal-insulator-semiconductor shape and completely modifies the I-V characteristics of the layer. Therefore, a single current conduction mechanism may not be sufficient to study the electrical characterisation of the

Schottky diode structure at a desired temperature and voltage.

In the presented study, the TE method was used to make this characterization. If MIS structures have an insulating interface layer and V>3kT/q, there is a relationship between forward bias voltage and current as in equation (1) [1].

$$I = I_0\, exp\left(\frac{qV}{nkT}\right)\left[1 - exp\left(-\frac{qV}{kT}\right)\right] \qquad (1)$$

To perform the electrical characterization of an ideal Schottky diode structure using the TE method, it is expected that the applied voltage should not be too high. In this way, the current transmission model will be suitable for TE. Considering the case V>3kT/q, equation (1) can be arranged as equation (2);

$$I = I_0\, exp\left(\frac{qV}{nkT}\right) \qquad (2)$$

where n represents the ideality factor of the Schottky diode structure, q is the amount of charge of the electron, T represents temperature in K, kB is the Boltzmann constant, V is the voltage applied to the structure, and Io is reverse saturation current (equations (1) and (2)). I_o is obtained from the straight-line intersection of the ln(I)-V graph shown in Figure 4. The mathematical approach is expressed by equation (3);

$$I_0 = AA^{*}T^{2}\, exp\left(-\frac{q\varphi_b}{kT}\right) \qquad (3)$$

where A*, A, and Φ_b in equation (3) denote the Richardson constant of p-type Si taken as 32 A/cm^{2}K^2, the surface area of the Schottky diode, and the effective barrier height of the structure, respectively.

The graph of ln(I) versus V should be linear for the ideal Schottky diode structure. It is the high value of n that causes the curve to deviate from linearity. This will depend on how far the diode is from being in its ideal state. Ideally, the Schottky diode is expected to work in harmony with the TE technique in low-current transmissions. However, there can be various deviations in practical applications. This far-from-ideal behaviour is explained by the presence of the parameter n. This parameter is explained by the equation (2). In fact, to determine the compatibility of Schottky diodes with the TE technique, this parameter is often used. This can be readily reached using the slope of the linear part of the graph in Figure 4. Equation (2) is rearranged, and the mathematical approach for the parameter n is rearranged as equation (4);

$$n = \frac{q}{kT}\frac{dV}{d(ln\, I)} \qquad (4)$$

The parameter n can be found by the slope of the ln(I)-V graph. The slope in question is that it can be determined by finding the nonlinear region in the graph and extrapolating that region. The barrier height Φ_b of the Schottky diode structure is expressed by equation (5);

$$\varphi_b = \frac{kT}{q}\, ln\left(\frac{AA^{*}T^{2}}{I_0}\right) \qquad (5)$$

The values of Φ_b and n can be calculated from the intersections of the ln(I)-V curve, which shows a forward trend due to the room temperature experimental study. In an ideal diode, n equals one. However, n usually has a value larger than unity. The reasons why this parameter moves away from 1 are the presence of an insulating layer between the metal and the semiconductor, Rs, and the interface density of states (Nss) in the forbidden energy band [26, 27]. The voltage applied to diode structures during electrical characterisation affects the barrier height within the structure, and this effect is related to the naturally occurring insulating oxide interfacial layer (~5-20Å thick) even in ideal diode structures.

The effect of the TiO_2 layer on the series resistance (Rs) of the device was also observed using Cheung functions [23]. The current flowing through a component is not linear at high forward bias. It is the use of this non-linear region by the R_s and Cheung functions that causes the potential drop in this region. The value of R_s can be attained using the following equations for the Al/TiO_2/ p-Si heterojunction [23]:

$$\frac{dV}{d(\ln I)} = n\frac{kT}{q} + IR_s \qquad (6)$$

$$H(I) = V - \frac{nkT}{q}\ln\left(\frac{I}{AA^{*}T^{2}}\right) \qquad (7)$$

$$H(I) = n\phi_b + IR_s \qquad (8)$$

where Rs in equations (6) and (8) denote the series resistance.

When the parameters of Cheng’s functions are examined, the barrier height is influenced by the n. A higher n (greater than 1) often indicates increased recombination in the depletion region, which can lead to a lower effective Φ_b. The Φ_b can change with temperature due to the intrinsic properties of the materials involved. Higher temperatures can increase the thermal energy available, potentially reducing Φ_b [28]. If there is significant Rs, it can distort the I-V characteristics, leading to an increased n. A lower Rs generally indicates better diode performance and can result in an n closer to 1 [29]. The n can also vary with temperature, as changes in thermal energy affect charge carrier dynamics and recombination rates. The Io is exponentially related to the Φ_b. A higher Φ_b typically results in a lower Io, as fewer carriers can overcome the barrier. Io increases with temperature, as higher thermal energy helps more charge carriers to overcome the barrier, which can also affect the Φ_b determination. The Rs can obscure the true behaviour of the diode. High Rs can cause a nonlinear I-V response, leading to inaccurate determinations of Φ_b and n. Ideally, a Schottky diode should have a minimal Rs. Increased Rs leads to higher voltage drops at higher currents, making the diode appear less ideal and affecting the extracted parameters [30]. By considering these interactions, Cheung's functions provide a more comprehensive understanding of the diode's performance characteristics.

The plots of dV/d(lnI) and H(I) vs. I will both be linear, as per the last two equations, and they will be utilized to find the experimental n, Φ_b, and R_s. On the other hand, two R_s values are determined, one from Equation (6) and the other from Equation (8). The Φ_b was attained from the linear part in the forward bias for I–V characteristics. Figure 5 displays the graphs of dV/d(lnI) vs. I and H(I) vs. I for the Al/TiO$_2$/p-Si diode at 300 K, respectively.

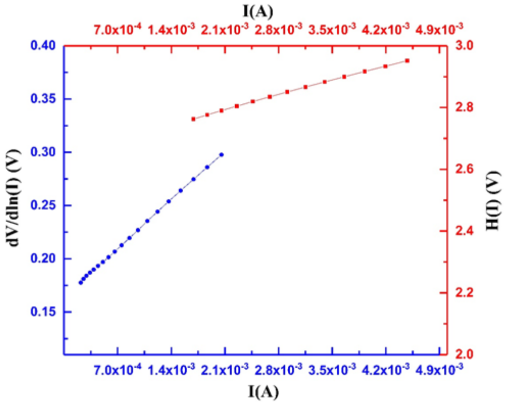

Figure 5. Cheung plots of Al (124 nm) / TiO$_2$ (17 nm) / p-Si (380±10 nm) Schottky diode structure.

Rs and n values are calculated from the slope and intersection of the straight line on the curve of dV/dln(I) vs. I. The values of Φ_b are acquired from the intersection of the curve in Eq. (8), and R_s is determined from the slope of the H(I) vs. I curve using the n value in Eq. (6). Table 2 displays the computed values of n, Φ_b, and R_s for the Schottky diode. Table 2 provides the diode characteristics for the Al/*RF magnetron method-grown* TiO$_2$/p-type Si.

The n, Φ_b and I_o values attained from the I-V measurements of the Al/TiO$_2$/p-Si Schottky diode structure created specifically for the presented study are given in Table 2.

Table 2. The crucial parameters attained from I-V measurements.

Method		**n**	**Φ_b (eV)**	**R_s (kΩ)**
Standard (TE)		4.07	0.59	-
Cheung	dV/d(lnI) vs I	4.39	-	0.366
	H(I) vs I	-	0.39	0.125

Table 2 illustrates the near-ideal diode characteristics of the TiO$_2$/p-Si heterojunction diode utilized in our research, featuring a Φ_b value of approximately 0.59 eV. To facilitate comparison with our experimental findings, we also present heterojunction parameters acquired through various techniques documented in the literature in Table 3. The values recorded in Table 2 are within the range of values previously reported for TiO$_2$/p-Si heterojunctions produced using various deposition techniques [31]-[38]. The main advantage of our study is that the technique used is suitable for the deposited film, based on the comparisons in Table 3. It was found that using the TE technique and Cheung functions, the n values for the diode were 4.07 and 4.39, respectively. Using the TE technique and Cheung functions, the Φ_b values were found to be 0.59 eV and 0.39 eV respectively. The non-ideal behaviour of the diode (n>1) confirmed the existence of interface states. The Φ_b values for the diode obtained by both methods are in agreement. The diode properties of various Schottky diodes with TiO$_2$ interlayers of different thicknesses, fabricated at 300 K using different techniques in the literature [31]-[38], are presented in Table 3 to comparison with our research.

Table 3. Comparing diode characteristics across different types of Schottky diodes incorporating a TiO_2 interlayer.

Diodes	**Interlayer Coating Methods**	**n**	**Φ_b (eV)**	**References**
Al (124 nm) / TiO_2 (17 nm) / p-Si (380±10 nm)	RF magnetron sputtering method	4.07 (TE) 4.39 (Cheung)	0.59 0.39	Present work
Al/TiO_2 (4 nm) /p-Si	ALD	12.71 (TE) 12.73 (Cheung)	0.64 0.68	[2]
Al/n-TiO_2/*p*-Si	Spin coating	5.4	0.58	[3]
Al/TiO_2 (760 nm) /p-Si	Drop-casting method	2.39 (first linear region) 8.29 (second linear region)	0.74 eV 0.65 eV	[33]
Au/TiO_2/p-Si	Drop-casting method	17.42	0.654	[34]
Al/TiO_2(55 nm)/p-Si	Pulsed laser deposition	3.73	0.69	[35]
Al/TiO_2/p-Si	Spin coating	8.97 (TE) 9.53 (Cheung)	0.74 0.55	[36]
Al/TiO_2/p-Si	Chemical	1.51	0.72	[37]
Au/TiO_2/p-Si	Electrochemical	2.07	0.84	[38]

Table 3 illustrates how the n and Φ_b values were impacted by the variations in the techniques used to construct the interface layer in the measurements. In this study, when basic diode parameters such as n and Φ_b found using the RF magnetron sputtering method were compared with the values obtained with other methods, lower n and Φ_b values were found than the n and Φ_b values obtained using ALD [31], Spin coating [22], [36] and Drop-casting [33], [34] methods. The basic diode parameters of the Al (124 nm) / TiO_2 (17 nm) / p-Si (380±10 nm) Schottky diode in our study were found to be higher than the values found by chemical [37] and electrochemical [38] methods.

In the presented study, electrical characterization of Schottky diode structures was carried out under forward bias voltage at room temperature. Characterization parameters n and Φ_b were calculated using the TE technique, which allows the determination of forward I-V properties. The Schottky diode structure was fed with flat power, and a structure-specific I-V graph was obtained. With the help of this graph, the n value was calculated as 4.07 and the Φ_b value as 0.59 eV. As illustrated in Figure 6, the diagram of the energy band of the TiO_2/p-Si heterostructure is fabricated under equilibrium at zero bias in the dark.

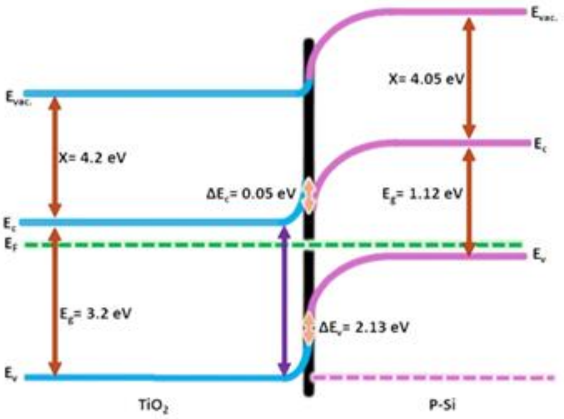

Figure 6. Schematic the diagram of the energy band of TiO_2/p-type Si Schottky structure under dark [32].

4. Conclusion and Suggestions

The electrical characterisation of the Al/TiO_2/p-Si Schottky diode structure has been achieved by keeping it in two different environments, dark and room temperature. Its I-V characteristics have been discussed. Electrical parameters such as n and Φ_b, which change due to the effect of TiO_2, which acts as an insulating interfacial layer in the structure, on the interfacial states, have been calculated using the TE technique. The electrical properties of the Al/TiO_2/p-Si Schottky diode structure are crucial for the evaluation of the interface states. Using the I-V curve generated under flat feeding, the n and Φ_b values were calculated to be 4.07 and 0.59 eV, respectively. In an ideal diode, n equals one. However, in our study, it is seen that the value of n is greater than 1. The reason for this is thought to be the presence of the insulator TiO_2 between the metal and the semiconductor and the distribution of the interface states between the metal and the semiconductor. It can be said that a thin oxide insulator layer of almost 5-20 Å thickness is naturally formed even in the most ideal Schottky diode structures. The deviation from the ideal situation caused by the dependence of the barrier height on the applied voltage is expressed as $1/n=1-(\delta\Phi_b/\delta V)$. Part of the voltage applied to the Schottky diode structure in the electrical characterisation process will fall on Φ_b and the rest on the interface insulating oxide layer, as can be seen from the expression. This makes Φ_b a function of the applied voltage. As part of the applied voltage falls on the oxide layer, the R_s value increases and the n parameter deviates from the ideal value of one, as the amount of voltage falling on the Schottky diode is reduced.

It has been investigated how the values of n and Φ_b are affected by changes in the interfacial layer formation techniques. A remarkable improvement was observed when comparing the experimental results found in our study with the existing literature. In this study, n and Φ_b were found to be lower than those obtained by ALD, spin coating and drop casting when comparing the basic diode parameters such as n and Φ_b obtained by RF magnetron sputtering with those obtained by other methods. In this study, the fundamental diode parameters of the Al/TiO_2/p-Si Schottky diode are higher than those obtained by chemical and electrochemical methods.

Metal-semiconductor interface insulators play a crucial role in various electronic and optoelectronic applications. Studies and models for these layers are developed to understand and optimize several key properties, such as electrical properties, thermal stability, interface states, optical properties, mechanical properties, chemical properties, dielectric properties, and integration with other materials. In our study, it is only interested in the electrical properties of the Schottky diode, and it is preferred TE and Cheung methods for investigating its electrical properties. Both methods have been validated in various studies, and they are generally reliable for assessing Schottky diode performance, provided that the measurements are taken under suitable conditions and the models are applied correctly. Using TE alongside the Cheung method provides a robust framework for analysing Schottky diodes, enabling accurate parameter extraction and deeper insights into device behaviour. For this reason, it’s considered that the methods we followed are reliable for researching diode’s electrical properties.

In summary, a MIS-type Al/TiO_2/p-Si Schottky diode structure was fabricated. Compared to SiO_2 and SnO_2, which are widely used in the microelectronics industry, TiO_2 has many advantages. Some of these advantages are the long service life due to its high adhesion capacity, the achievement of Schottky diode structures capable of fast switching, and the possibility of easy development of transistors and integrated circuits. Considering all these important points, it is predicted that original Schottky diode structures will be obtained far beyond the results presented in the study, which are close to ideal, by studying the changes to be made in the preparation of TiO_2 thin films using the RF magnetron sputtering technique. The results show that the fabricated diode can be used in photodiode, photosensor, and optoelectronic applications.

Contributions of the authors

Barış Polat: Supervision, performed the computations, and verified the analytical methods.
Elanur Dikicioğlu: Supervision, conducted the experiments, performed the computations, and verified the analytical methods.

Conflict of Interest Statement

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The study is complied with research and publication ethics.

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