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Analysis of current–voltage and capacitance–voltage characteristics of perylene-monoimide/n-Si Schottky contacts

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ABSTRACT

The electrical and interface state properties of Au/perylene-monoimide (PMI)/*n*-Si Schottky barrier diode have been investigated by current–voltage (I–V) and capacitance–voltage (C–V) measurements at room temperature. A good rectifying behavior was seen from the I–V characteristics. The series resistance (R_s) values were determined from I–V and C–V characteristics and were found to be 160 Ω and 53 Ω, respectively. The barrier height (Φ_b) of Au/PMI/*n*-Si Schottky diode was found to be 0.694 eV (I–V) and 0.826 eV (C–V). The ideality factor (n) was obtained to be 4.27 from the forward bias I–V characteristics. The energy distribution of interface state density (N_{ss}) of the PMI-based structure was determined, and the energy values of N_{ss} were found in the range from $E_c - 0.508$ eV to $E_c - 0.569$ eV with the exponential growth from midgap toward the bottom of the conduction band. The values of the N_{ss} without R_s are 2.11×10^{12} eV^{-1} cm^{-2} at $E_c - 0.508$ eV and 2.00×10^{12} eV^{-1} cm^{-2} at $E_c - 0.569$ eV. Based on the above results, it is clear that modification of the interfacial potential barrier for metal/*n*-Si structures has been achieved using a thin interlayer of the perylene-monomide.

1. Introduction

The electrical properties of metal–semiconductor (MS) contacts have been extensively investigated due to their technological applications [1–14]. Schottky contacts play an important role in controlling the electrical performance of semiconductor devices. The electrical properties of an MS contact depend mainly on interfacial layer, series resistance (R_s) and the interface states (N_{ss}) between metal and inorganic semiconductor. The electrical properties of MS structures can be modified by organic compounds when an organic layer is deposited between the inorganic semiconductor and metal. Many researchers have studied the electrical properties of organic compound interfacial layer deposited on inorganic semiconductors [15–26].

Recently, organic–inorganic junctions such as Cu(II) complex/*n*-Si [15], PEDOT:PSS/*n*-Si [16], DNA/*n*-Si [17], carmine/*n*-Si [18], analine green/*n*-Si [19], VoPc/*n*-Si [20], and PTCDA/*n*-Si [21] have been fabricated because of their potential use in electronic and optoelectronic devices, lower production cost and easy preparation techniques and then their electrical properties have been determined. Perylene and its derivatives have been considered as a promising candidate in organic electronics such as photovoltaic devices [27,28], light emitting devices [29–31], laser dyes [32,33], fluorescent solar collectors [34], Schottky diodes [21,35] and field effect transistors [36]. Perylene-monoimide (PMI) dyes have been also used for dye sensitized solar cells (DSSCs) with overall conversion efficiency of 1.61% [37] and 2.6% [38].

The performance and reliability of organic based Schottky barrier diodes especially depends on the formation of organic layer at MS interface, the level of N_{ss} at organic layer/Si interface, series resistance of devices, and inhomogeneities of the Schottky barrier formation at MS interface [2–6,15–26]. The existence of such an organic layer can have a strong influence on the diode characteristics as well as the interface state density, ideality factor and barrier height [15–26]. Therefore, it is important to determine the interface properties of such an organic based Schottky diode [15–26].

The aim of the present study is to investigate the electrical and interface state properties of organic on inorganic semiconductor structures by using current–voltage (I–V), capacitance–voltage (C–V) and conductance–voltage (G–V) measurements and report the electrical properties of rectifying contact barriers using perylene-monoimide (PMI) as an interlayer formed on an *n*-Si substrate for the modification of Au/*n*-Si Schottky contacts. For this purpose, PMI organic semiconductor is deposited on an inorganic semiconductor (*n*-Si wafer) by a spin coating technique and then a Schottky barrier diode is fabricated on this structure.

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2. Experimental details

In this study, an n-type P-doped Si semiconductor wafer with (1 0 0) surface orientation, 380 μm thickness and 20 Ω cm resistivity was used. The n-Si wafer is initially degreased with organic solvents like trichloroethylene, acetone and methanol by means of ultrasonic agitation in sequence for 5 min each to remove contaminants and rinsed in deionized water and then dried in N_2 flow. Before making contacts, the n-Si wafer was chemically cleaned using the Radio Corporation of America (RCA) cleaning procedure (i.e. a 10 min boil in $NH_3 + H_2O_2 + 6H_2O$ followed by a 10 min boil in $HCl + H_2O_2 + 6H_2O$) with the final dip in diluted HF for 60 s, and then rinsed in deionized water of resistivity of 18 MΩ cm with ultrasonic vibration and dried by high purity nitrogen. The ohmic contact was made by evaporating the Au on the back of the n-Si substrate, then it was annealed at 450 °C for 3 min in N_2 atmosphere. The native oxide on the front surface of the substrate was removed in $HF + 10H_2O$ solution and then it was rinsed in deionized water for 60 s and was dried in N_2 atmosphere before forming an organic layer on the n-type Si substrate. The PMI was synthesized according to the previously published procedures [39–41]. The PMI organic film to the front surface of the n-Si wafer was formed by a spin coating method at a spinning rate of 1000 rpm with a Laurell Spin Coater. The molecular structure of PMI is given in Fig. 1(a). Then, by evaporating Au metal on the PMI at 10^{-6} Torr, the Au/PMI/n-Si/Au device was fabricated (diode area $= 3.14 \times 10^{-2}$ cm^2). The schematic representation of the device is shown in Fig. 1(b). The PMI layer thickness was estimated to be about 28 nm from measurement of the interfacial layer capacitance in the accumulation region from capacitance–voltage characteristic at 1 MHz. The current–voltage (I–V) measurements by a Keithley 2410 SourceMeter and the capacitance–voltage (C–V) and conductance–voltage (G–V) measurements by using HP 4192A LF impedance analyzer (5 Hz–13 MHz) were performed at room temperature and in dark.

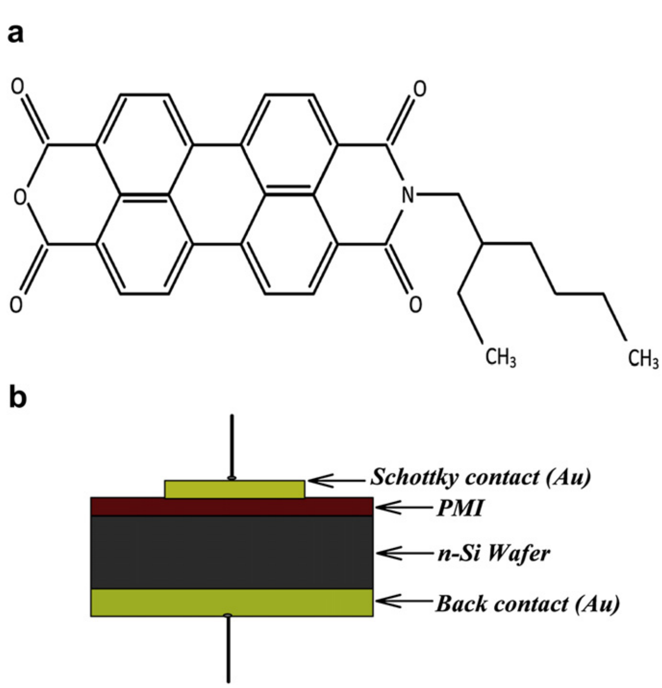

Fig. 1. (a) Molecular structure of a perylene-monoimide organic compound. (b) Cross-sectional view of Au/PMI/n-Si Schottky diode for electrical characterization.

3. Results and discussion

3.1. Current–voltage characteristics

The dark current–voltage characteristics of the Au/PMI/n-Si/Au Schottky barrier diode, for forward- and reverse-bias, are shown in Fig. 2(a). It is seen that the I–V characteristic is nonlinear, asymmetrical, showing rectification behavior. RR, as the ratio of forward to reverse bias current, was 140 at ±1 V at room temperature (300 K). The total current for a Schottky diode is composed of both the thermionic emission and the tunneling components. Assuming that the thermionic emission is the predominant mechanism of Schottky barrier diodes and the I–V characteristics of Schottky contacts in the forward bias are given by the following relations [2]:

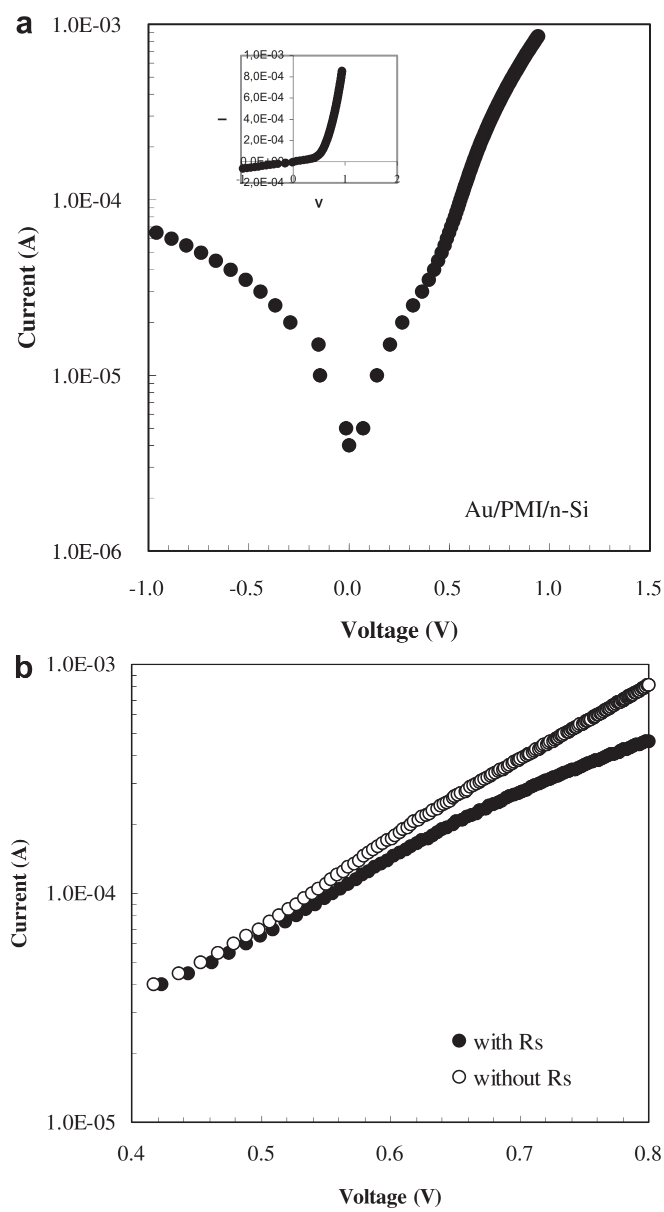

Fig. 2. (a) The forward and reverse bias current–voltage characteristics of the Au/PMI/n-Si Schottky diode at room temperature. (b) The corrected semi-log I–V characteristics of Au/PMI/n-Si Schottky contact.

$$I = I_0\left[\exp\left(\frac{q(V-IR_s)}{nkT}\right)-1\right] \approx I_0\exp\left(\frac{q(V-IR_s)}{nkT}\right), \quad (1)$$

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

where q is the electronic charge, I_0 is the saturation current, n is the diode quality factor, A is the Schottky contact area, A^* is the effective Richardson constant and is equal to 112 A/cm^2 K^2 for n-type Si [2], T is the absolute temperature in Kelvin and Φ_b is the Schottky barrier height.

The parameters I_0 and n can be determined from the intercept on the y-axis and the slope of the linear region of the semi-log I–V plot shown in Fig. 2(a), respectively, together with Eq. (1). The values I_0 and n for Au/PMI/n-Si Schottky diode were calculated as 1.24×10^{-6} A and 4.89, respectively. Φ_b is deduced as 0.679 eV using the I_0 value together with Eq. (2). It should be known that Φ_b is the contact potential barrier that exists at the interface between the organic and inorganic layers, i.e. at the perylene-monoimide/n-Si interface.

Furthermore, it is evaluated that I–V behavior of the diode is affected by parasitic resistances such as series resistance (R_s) and shunt resistance (R_{sh}). R_s and R_{sh} are determined using I–V characteristics by means of diode resistance $R_d = \partial V/\partial I$ relation and the plot of R_d vs. V was shown in Fig. 3. At sufficiently high forward bias, the junction resistance approaches a constant value, which is the R_s. On the other hand, the junction resistance is also constant, at sufficiently high reverse bias, which is equal to the diode R_{sh}. The value of R_s and R_{sh} are 160 Ω and 14.9 kΩ, respectively. It is clear that Au/PMI/n-Si Schottky contact has low series resistance and high shunt resistance and it is necessary for ideal device. When the value of R_s is obtained, it could be used to accurately calculate n and Φ_b. Fig. 2(b) is obtained by subtracting the effect of series resistance from current–voltage characteristics in Eq. (1). It should be noted that the effect of the series resistance in the linear region can be neglected in Fig. 2(b). Fig. 2(b) shows the forward bias semi-log I–V characteristics with and without taking into account R_s of Au/PMI/n-Si Schottky contact, and the corrected I_0, n and Φ_b values of 7.61×10^{-7}, 4.27 and 0.694 eV, respectively, are obtained.

The high ideality factor value ($n = 4.27$) of Au/PMI/n-Si Schottky diode is attributed to the presence of the perylene-monoimide layer on n-type Si, the interface states and series resistance effects. These are important parameters for the diode performance. The high values in the ideality factor can be attributed by various effects such as inhomogeneities of film thickness, interface states, series resistance, tunneling process and non-uniformity distribution of the interfacial charges [14–26]. It is noted that the semi-log I–V curve of Au/PMI/n-Si Schottky barrier diode is linear at low forward bias voltage, but deviate considerably from linearity at large bias voltage. It is evident that the linear portion of the I–V characteristics includes the effect of the interfacial parameters rather than that of the series resistance, and the downward curvature region of the forward I–V plot includes the effects of the interfacial parameters and the series resistance [14–26].

Recently, some authors have experimentally studied the electrical properties of the Schottky structures by using the organic films. For example, Farag et al. [21], Güllü et al. [24] and Yakuphanoğlu [25] reported the values of 5.8, 4.35 and 6.30 for the ideality factor n of PTCDA/n-Si, Orange G/n-Si and FSS/n-Si, respectively. It can be concluded that the ideality factor value of 4.27 that we have obtained for the Au/PMI/n-Si device is naturally acceptable when compared with those of the organic–inorganic devices above.

The barrier height (Φ_b) value of 0.694 eV that we obtained for the Au/PMI/n-Si Schottky diode is higher than the value of 0.64 eV given for Au/n-Si Schottky diode [16,42]. Furthermore, the Φ_b value of 0.694 eV of our Au/PMI/n-Si device is lower than the value of 0.827 eV given for Au/PTCDA/n-Si device in Ref. [21] but is higher than the value of 0.65 eV given for Au/NiPc/n-Si device in Ref [26]. In literature, similar barrier height modifications have been declared experimentally by insertion of organic thin films between the metals and the semiconductors [15–26]. All these results have indicated that the organic layer can be used to vary the effective barrier height of MS diodes. The case may be attributed to an organic interlayer modifying the effective barrier height by influencing the space charge region of the inorganic semiconductor [22,43].

The values of n dependent on voltage have obtained by using Eq. (1). The voltage dependent effective barrier height (Φ_e) values have deduced from Eq. (3) using the calculated Φ_b value and the voltage dependent n values. Fig. 4 depicts the voltage dependence of the ideality factor n and the effective barrier height Φ_e. A strong voltage dependence for both n and Φ_e is observed and can be discussed below. This bias dependence is presumed to be due to the presence

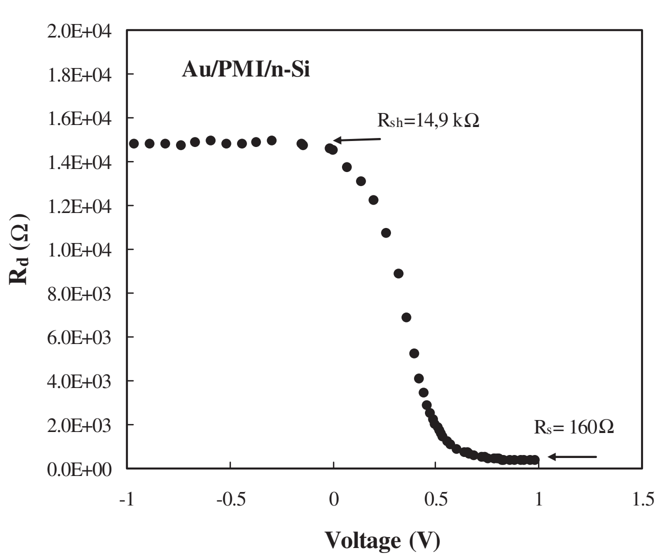

Fig. 3. The diode resistance R_d vs. the applied voltage V of Au/PMI/n-Si Schottky diode at room temperature.

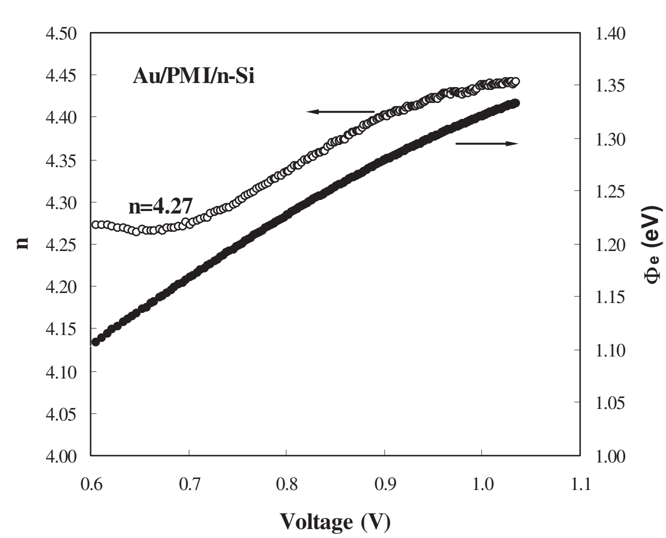

Fig. 4. The voltage dependence of the ideality factor n and the effective barrier height Φ_e of Au/PMI/n-Si Schottky diode.

of an organic interfacial layer and interface states located between interfacial layer and semiconductor interface [18,23]. The high value and the bias dependence of n are attributed to the potential drop in the interfacial layer and recombination through the interface states between the semiconductor and interfacial layer interface [21,24,25,44,45]. It is more important to know how the barrier height varies with the applied voltage. The potential across the interface varies with bias because of the change in the interface states charge as a result of the applied voltage, which modifies the Schottky barrier height. The effective barrier height Φ_e is given by [18,44,45]:

$$\Phi_e = \Phi_b + \beta V = \Phi_b + \left(1 - \frac{1}{n(V)}\right)V, \tag{3}$$

where β is the voltage coefficient of the Φ_e and is a parameter that combines the effects of both the interface states and interfacial layer thickness for the cases in which interface states are in equilibrium with the semiconductor. In this case, the interface states density N_{ss} is given by [18,44,45]:

$$N_{ss} = \frac{1}{q}\left(\frac{\varepsilon_i}{\delta}(n(V) - 1) - \frac{\varepsilon_s}{W_D}\right), \tag{4}$$

where δ is the thickness of the organic interfacial layer ($\delta \cong 28$ nm) (calculated from corrected C–V measurement at 1 MHz frequency using the formula $C_{org} = \varepsilon_i \varepsilon_0 A/\delta$ where C_{org} is the capacitance of the interfacial layer ($C_{org} = 3.192$ nF), W_D is the width of the space charge region ($W_D = \sqrt{2\varepsilon_s V_D / qN_D} = 844.69$ nm) calculated from corrected $1/C^2 - V$ characteristic at 1 MHz, $\varepsilon_i = 3.2\varepsilon_0$ from optical measurements [46] and $\varepsilon_s = 11.8\varepsilon_0$ [1] are the permittivity of perylene-monoimide and silicon semiconductor, respectively.

The energy of the interface states E_{ss} with respect to the bottom of the conduction band at the surface of n-type inorganic semiconductor is introduced by [15,23]:

$$E_c - E_{ss} = q(\Phi_e - V), \tag{5}$$

where E_c is the conduction band edge. The energy distribution or density distribution curves of the interface states can be plotted from experimental data of this region of the forward bias I–V with and without taking into account R_s in Fig. 2(b). Fig. 5 shows the resulting dependence of N_{ss} with and without taking into account R_s as a function of $E_c - E_{ss}$ using Eqs. (4) and (5) at room temperature. It is clear from Fig. 5 and in the inset of Fig. 5 that the exponential growth of N_{ss} toward the bottom of the conduction band is apparent. This case indicates the continuum of the interface states. In the range from $E_c - 0.508$ to $E_c - 0.569$ eV, the values of the N_{ss} with and without taking into account R_s are in the range from 2.96×10^{12} to 2.52×10^{12} eV^{-1} cm^{-2} and from 2.11×10^{12} to 2.00×10^{12} eV^{-1} cm^{-2}, respectively. These values are better than in the literature values where organic compounds were deposited on n-type Si [15,22,23]. The N_{ss} values of our structure obtained without taking into account the R_s values are lower than those calculated considering the R_s. These explanations depict that the R_s value should be taken into account in determining density distribution curves of the N_{ss}.

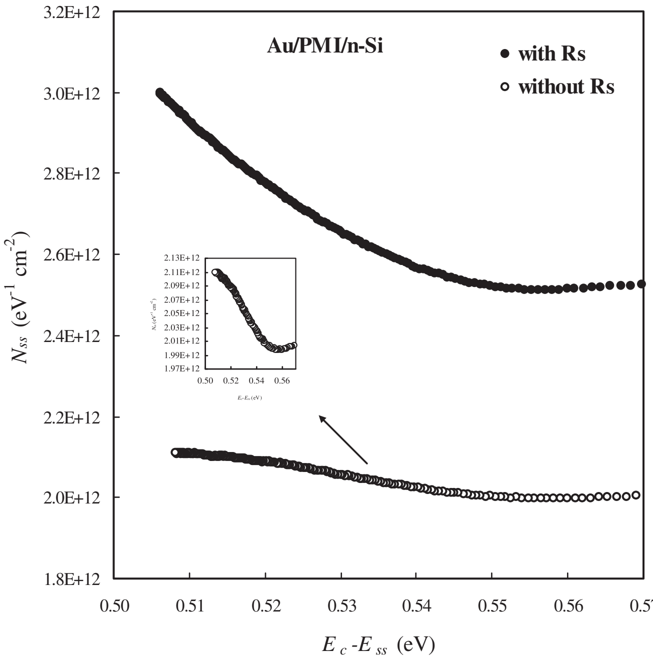

Fig. 5. The variation N_{ss} values with $E_c - E_{ss}$ inferred from the I–V measurement with and without taking into account R_s for the Au/PMI/n-Si Schottky diode.

3.2. Capacitance–voltage characteristics

Fig. 6 represents the measured capacitance–voltage (C_m–V) and conductance–voltage (G_m–V) measurements under forward and reverse-bias voltages at 1 MHz frequency at room temperature for Au/PMI/n-Si Schottky diode in dark. As seen in Fig. 6, the measured capacitance (C_m) and conductance (G_m) are dependent on bias voltage. The shape of the C_m–V curve under 1 MHz indicates n-type behavior. The capacitance increases with increasing positive voltage until accumulation steady state. The values of the capacitance and conductance depend on a number of parameters such as the thickness and formation of the interfacial layer, series resistance and density of interface states. The effect of interface state density can be eliminated when the (C_m–V) and (G_m–V) curves are measured at sufficiently high frequency ($f \geq 500$ kHz), since the charges at the interface states cannot follow an ac signal [47,48]. In this case, the interface states are in equilibrium with the semiconductor. The absence of a peak for G_m–V curve in Fig. 6 means that series resistance produced dominant loss, completely masking the interface trap loss. Because of this, we cannot extract the interface trap properties from the ac response.

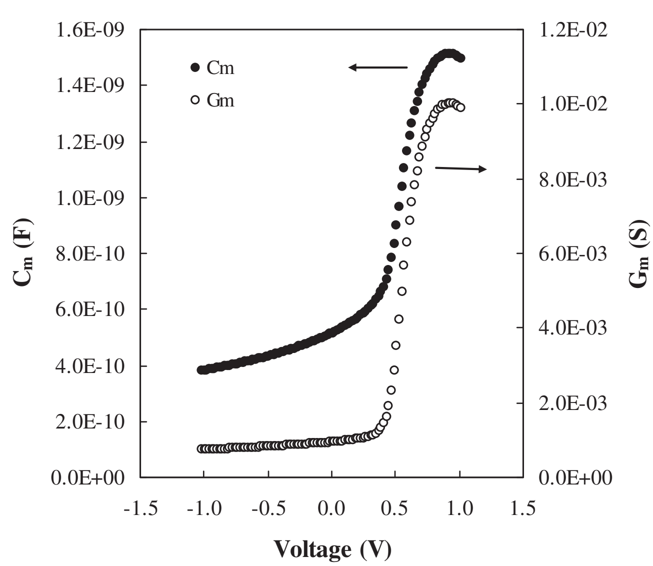

Fig. 6. The measured capacitance–voltage (C_m–V) and conductance–voltage (G_m–V) plots of the Au/perylene-monoimide/n-Si Schottky diode at 1 MHz.

From the above discussion the series resistance (R_s) seems the most important parameter which causes the electrical characteristics of Schottky structures to be non-ideal [47,48]. The existence of such a perylene-monoimide organic layer converts the device to metal–interfacial layer–semiconductor (MIS) diode and may have a strong influence on the diode characteristics as well as a change of the interface state charge with bias which will give rise to an additional field in the interfacial layer [47,48]. The real series resistance of MIS structures can be determined from the measured capacitance (C_m) and conductance (G_m) in accumulation region at high frequency (1 MHz $\leq f$) [47,48]. We have applied the method by Nicollian and Goetzberger [49] to extract the series resistance of our Au/PMI/n-Si Schottky diode subtracted from the measured capacitance (C_m) and conductance (G_m) values. From (C_m–V) and (G_m–V) measurements in accumulation region, the series resistance (R_s) was calculated through relation [47,48]:

$$R_s = \frac{G_{m,acc}}{G_{m,acc}^2 + (\omega C_{m,acc})^2}, \tag{6}$$

where $C_{m,acc}$ and $G_{m,acc}$ are the measured capacitance and conductance in accumulation region. The voltage dependence of the series resistance for PMI/n-Si Schottky diode at the frequency 1 MHz in accumulation region is plotted in Fig. 7. As seen in Fig. 7, the series resistance (R_s) gives a peak about 0.49 V in depletion region. Such behavior of R_s is attributed to the particular distribution of localized interface states at PMI/n-Si interface and the interfacial insulator layer at the Au/n-Si interface. The value of series resistance obtained for Au/PMI/n-Si Schottky contact in accumulation region is 53 Ω. This R_s value is used to correct the measured (C_m) and (G_m) curves.

The corrected capacitance (C_c) and equivalent parallel conductance (G_c) for series resistance were evaluated form the relations:

$$C_c = \frac{\left(G_m^2 + \omega^2 C_m^2\right) C_m}{a^2 + \omega^2 C_m^2}, \quad G_c = \frac{\left(G_m^2 + \omega^2 C_m^2\right) a}{a^2 + \omega^2 C_m^2}, \tag{7}$$
$$a = G_m - \left(G_m^2 + \omega^2 C_m^2\right) R_s.$$

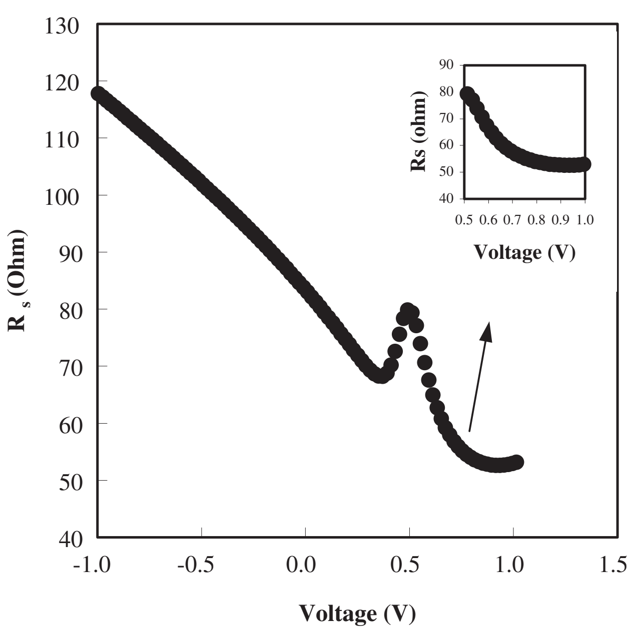

Fig. 7. Variation of the series resistance (R_s) of the Au/perylene-monoimide/n-Si Schottky diode with bias voltage in strong accumulation region.

Fig. 8 depicts the voltage dependence of the corrected capacitance (C_c) and conductance (G_c) characteristics for Au/perylene-monoimide/n-Si Schottky diode at 1 MHz at room temperature and in dark. From C_c–V measurement in accumulation region in Fig. 8, the interfacial layer capacitance (C_{org}) for our sample was found to be 3.192 nF. This capacitance results from the organic interfacial layer between Si and metal. The interfacial layer thickness δ calculated from high frequency (1 MHz) C_c–V data in accumulation region using the equation for corrected interfacial layer capacitance ($C_{org} = \varepsilon_i \varepsilon_0 A/\delta$), where $\varepsilon_i = 3.2\varepsilon_0$ [46] and ε_0 are the permittivities of the interfacial layer and free space, respectively, has been determined to be about 28 nm, for our Au/perylene-monoimide/n-Si Schottky diode.

As can be seen from Fig. 8, it is clearly seen that the G_c–V characteristic of the sample consists of a peak. This peak corresponds to the depletion area of the device and its existence verifies the presence of interface states [48–51]. The value of interface traps density (N_{ss}) is determined from this peak value. The application of a single-frequency approximation method [49] allows estimation of the density of interface states from the G_c–V measurements. A fast and reliable way to determine the density of interface states (N_{ss}) of Schottky structures is the Hill-Coleman method [49] and confirmed by Konofaos [50], Dakhel [51] and Tuğluoğlu [48]. According to this method, N_{ss} was found to be 1.27×10^{12} eV^{-1} cm^{-2}. The value obtained for N_{ss} is of the same order as those reported by Okur et al. [17] for Au/DNA/n-Si Schottky diode.

Fig. 9 depicts the reverse-bias $1/C_c^2$–V plot obtained from C_c–V data of the Au/PMI/n-Si Schottky diode at 1 MHz and in dark. The $1/C_c^2$–V plot of Au/PMI/n-Si Schottky diode is linear, which indicates the formation of a Schottky junction [18,19,26]. This dependence is assigned to the presence of traps acting as donors in the Au/PMI/n-Si Schottky diode, and allows estimation of their trap density.

The C–V characteristics of Au/PMI/n-Si Schottky diode can be analyzed by the following relation [2]:

$$\frac{1}{C^2} = \frac{2(V_d + V)}{A^2 \varepsilon_s \varepsilon_0 q N_d}, \tag{8}$$

where A is the area of the diode, V_d is the diffusion voltage at zero bias which is determined from the intercept of $1/C_c^2$–V plot, N_d is

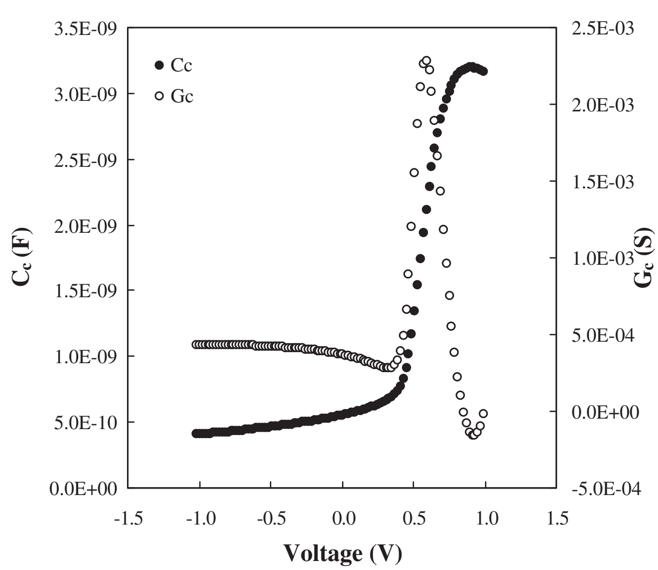

Fig. 8. The voltage dependent plots of the corrected capacitance (C_c) and conductance (G_c) for Au/perylene-monoimide/n-Si Schottky diode at 1 MHz.

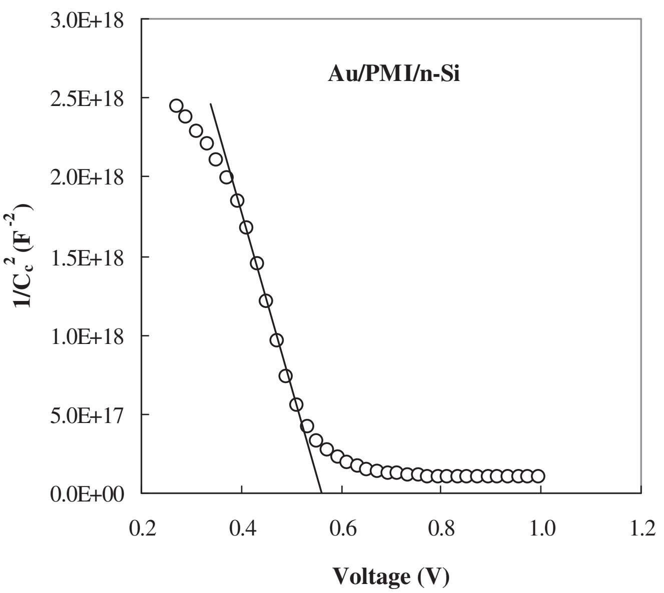

Fig. 9. The $1/C_c^2$–V plot of the Au/perylene-monoimide/n-Si Schottky diode at 1 MHz.

the ionized traps like-donor which is determined from the slope of $1/C_c^2$–V plot, ε_s is the dielectric constant of the semiconductor ($\varepsilon_S = 11.8\varepsilon_0$ for Si) and ε_0 is the dielectric constant of vacuum ($\varepsilon_0 = 8.85 \times 10^{-12}$ F/m). The values of V_d and N_d were obtained to be 0.584 eV and 1.07×10^{15} cm^{-3}, respectively. The obtained value of V_d is considered low as compared to the published data by Aydoğan et al. [18], Aydoğan et al. [19] and El-Nahass et al. [26] for carmine/n-Si, aniline green/n-Si, and NiPc/n-Si devices, respectively.

The value of the Schottky barrier height Φ_b can be calculated using $1/C_c^2$–V plot by the following well-known equation [2]:

$$\Phi_b = V_d + V_n - \Delta\Phi_b, \tag{9}$$

where V_n is equal to the Fermi energy level ($E_F = (kT/q)\ln(N_c/N_d)$), N_c is the effective density of state in the conduction band of n-Si ($N_c = 2.8 \times 10^{19}$ cm^{-3}). $\Delta\Phi_b$ is the image force barrier lowering ($\Delta\Phi_b = (qE_m/4\pi\varepsilon_s\varepsilon_0)^{1/2}$, where E_m is the maximum electric field ($E_m = (2qV_dN_d/\varepsilon_s\varepsilon_0)^{1/2}$)). The values of the Fermi energy level (E_F), image force barrier lowering ($\Delta\Phi_b$) and Schottky barrier height (Φ_b) of Au/PMI/n-Si Schottky diode obtained from the reverse bias $1/C_c^2$–V characteristics at 1 MHz frequency at room temperature have been found as 0.254 eV, 1.298×10^{-2} eV and 0.826 eV, respectively. It can also be observed that the barrier height (Φ_b) obtained from I–V measurements are lower than those obtained from C–V measurements. The difference in barrier heights obtained from I–V and C–V measurements may be due to the formation of an interfacial layer containing defects [18,22,45]. Furthermore, due to the difference in the I–V and C–V measurement methods, barrier heights deduced from them are not always the same. The capacitance C is insensitive to potential fluctuations on a length scale of less than the space charge region and the C–V method averages over the whole area and all measurements to describe Φ_b. The DC current I across the interface depends exponentially on barrier height and thus sensitively on the detailed distribution at the interface [2–5].

4. Conclusions

The forward and reverse bias I–V and C–V characteristics of the Au/PMI/n-Si Schottky diodes produced using the spin coating method were measured at room temperature and in dark. The electronic properties of the Au/perylene-monoimide (PMI)/n-Si Schottky diode were investigated. Experimental results present that both N_{ss} and R_s are important parameters that influence the electrical characteristics of Au/PMI/n-Si Schottky barrier diodes.

The values ideality factor (n) and Schottky barrier height (Φ_b) have been calculated as 4.27 and 0.694 eV, respectively, from I–V characteristics and the value of the Schottky barrier height (Φ_b) obtained from C–V characteristics is 0.826 eV (at 1 MHz frequency). The energy distribution profile of N_{ss} of the Au/PMI/n-Si Schottky diode was obtained from the forward bias current–voltage (I–V) characteristics by taking into account both the bias dependence of the effective barrier height (Φ_e) and R_s. The values of the N_{ss} with and without the R_s at $E_c - 0.508$ and $E_c - 0.569$ ranged from 2.96×10^{12} to 2.52×10^{12} eV^{-1} cm^{-2} and from 2.11×10^{12} to 2.00×10^{12} eV^{-1} cm^{-2}, respectively. Modification of the interfacial potential barrier for metal/n-Si diodes has been achieved using a thin interlayer of the perylene-monomide (PMI). The obtained results indicate that PMI organic layer controls electronic parameters of the Au/n-Si Schottky diode.

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