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CAPACITANCE-VOLTAGE CHARACTERISTICS OF THE PDSI-SI CONTACT

Afsana E. MAMMADOVA

Baku Engineering University

efsanememmed92@gmail.com

ARTICLE INFO	ABSTRACT
Article history: Received: 2024-05-24 Received in revised form: 2024-10-15 Accepted: 2024-10-25 Available online	*In the work the volt-amper and volt-farad characteristics of PdSi-Si contact have been studied. The possibility for definition of series of important parameters for Pd, Si and PdSi by means of these characteristics has been considered. The linearity of the experimental dependence of 1/C^2 on a voltage and equability of distribution for impurities in the near surface area of a semiconductor have been established.*
Keywords: palladium, silicides, Schottky barrier, diode, volt-farad, palladium silicide	*The value of the acceptor concentration determined from the slope of the current-voltage characteristic coincides with the value calculated from the resistivity of silicon* *Conducted studies of the dependence of capacitance on voltage showed that in the range of 300 -106 Hz the capacitance practically does not depend on frequency* *During the measurement process, R < R was carried out, that is, the measurement limit of the electrometric amplifier was selected*

ВОЛЬТ-ЕМКОСТНЫЕ ХАРАКТЕРИСТИКИ КОНТАКТА PDSI-SI

РЕЗЮМЕ

В работе исследованы вольт-фарадные характеристики контакта PdSi-Si. Рассмотрена возможность определения ряда важных параметров для Pd, Si и PdSi с помощью этих характеристик. Установлены линейность экспериментальной зависимости 1/C^2 от напряжения и равномерность распределения примесей в приповерхностной области полупроводника

Значение концентрации акцепторов, определенное по наклону вольт-амперной характеристики, совпадает со значением, рассчитанным по удельному сопротивлению кремния.

Проведенные исследования зависимости емкости от напряжения показали, что в диапазоне 300-106 Гц емкость практически не зависит от частоты.

В процессе измерения осуществлялось R < R, то есть выбирался предел измерения электрометрического усилителя.

Ключевые слова: палладий, силициды, барьер Шоттки, диод, вольт-фарад, силицид палладия.

PDSİ-Sİ KONTAKTIN VOLT-FARAD XARAKTERİSTİKALARI

XÜLASƏ

İşdə PdSi-Si kontaktın volt-farad xarakteristikaları öyrənilmiş, həmin xarakteristikaların köməyi ilə Pd, Si və PdSi üçün bir sıra vacib fiziki parametrlərin təyin edilməsi imkanlarına baxılmışdır. 1/C^2 – nın gərginlikdən eksperimental asılılığının xətti xarakter daşıması və yarımkeçiricinin səthə yaxın oblastında ionlaşmış aşqarların bərabər paylanması müəyyən edilmişdir.

Cari gərginlik xarakteristikasının oblastında müəyyən edilən qəbuledici konsentrasiyanın dəyəri silisiumun müqavimətindən hesablanan dəyərlə üst-üstə düşür.

Kapasitansın gərginlikdən asılılığına dair aparılan tədqiqatlar göstərdi ki, 300-106 Hz diapazonunda tutum praktiki olaraq tezlikdən asılı deyil.Ölçmə prosesi zamanı R < R həyata keçirildi, yəni elektrometrik gücləndiricinin ölçmə həddi seçildi.

Açar sözlər: *palladium, silisidlər, Şotki barieri, diod, volt-farad, palladium silisid*

Introduction

More information about the mechanism of charge transfer is provided by studying the temperature dependence of the current-voltage characteristics. To measure the temperature dependences, the samples were placed in a thermostat, the power of which was supplied from an autotransformer. The sample temperature was controlled by a chromel aluminum thermocouple mounted directly on the plate. Before taking the temperature characteristics, the effect of heat treatment on the electrical properties of the devices was studied. It turned out that heat treatment of the structure up to 200 C does not cause irreversible changes in the electrical properties of PdSi

In order to prevent premature breakdown caused by an increase in the electric field at the periphery of the contact, diffusion guard rings with a depth of 0.5 μm were used. Although the breakdown voltage was increased from 12 to 30 V, there was no saturation when the palladium-silicon silicide barber reversed current.

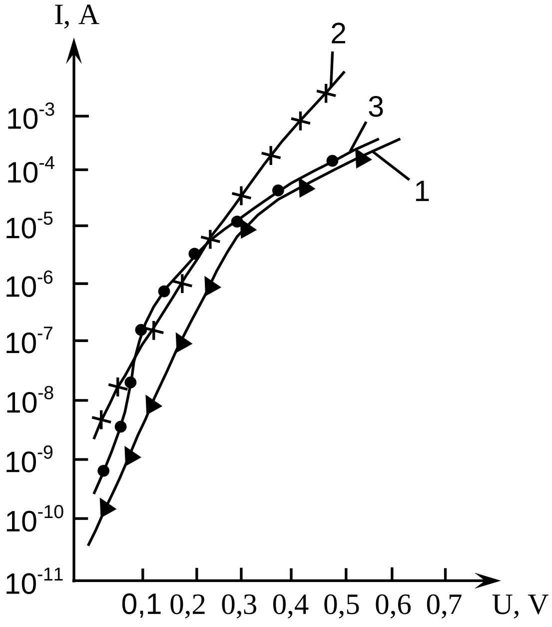
Physicochemical processes occurring at the palladium silicide-silicon interface greatly affect the uniformity of the contact. When PdSi is formed, the volume decreases by 13% compared to the volume of palladium and silicon reacting. Such differences in crystal chemical properties can create favorable conditions for the introduction of both palladium atoms and impurity atoms in the surface layer of silicon. We assume that the introduction of impurity atoms into the surface layer of silicon leads to inhomogeneity at the PdSi-Si interface.

The Schottky barrier height of PdSi-Si ideal diodes lies in the range of 0.70-0.79 eV. At the same time, the results of our measurements showed that the barrier height for PdSi-Si obtained by magnetron sputtering is 0.79 eV. It is for this reason that the breakdown voltage does not depend on the thickness of the palladium silicide obtained by magnetron sputtering, which indicates the homogeneity of the PdSi-Si contact.

The work investigated the electrical properties of PdSi-Si structures obtained both by thermal evaporation and by magnetron evaporation. The current flowing through the Schottky diode was measured by the voltage drop across the output resistance of the electrometric amplifier connected in series with the diode under study and the power source. The amplifier's input impedances were pre-calibrated by comparing their nominal values with the reference impedances.The main difficulty in measuring high-resistance samples is the inability to directly measure the voltage on the sample, since connecting a voltmeter with a low input resistance to the sample leads to a significant current leakage through the voltmeter.In this work, a TR-1657 digital voltmeter was used for measurements, which has an input resistance less than the resistance of the sample being measured. The voltmeter was connected in parallel to a chain consisting of two series-connected resistances of the amplifier input resistance R_g and the sample resistance R_n.

During the measurement process, R < R was carried out, that is, the measurement limit of the electrometric amplifier was selected at which its input resistance turned out to be significantly less than the resistance turned out to be significantly less than the resistance of the sample and the voltmeter essentially recorded the voltage on the sample.

Figure 1 shows the current-voltage characteristic of the PdSi-Si contact obtained by thermal evaporation.



Fiq.VAX struktur 300⁰C, 2-350⁰C, 3-400⁰C

Measurements of capacitance-voltage characteristics (CVC) are among the most common methods for studying semiconductor devices [1]. Using these characteristics, a number of important physical parameters inherent in both structures and the materials from which they are made are determined. Of particular interest is the study of CV characteristics filmed in dynamic mode. The main advantage of this method is the possibility of direct measurement of C(U), ∂C(U)/∂U and other characteristics, which can significantly increase accuracy.

The device is assembled according to the block diagram proposed in [2]. The structure under study (Fig. 2) is included in a bridge circuit to which a sinusoidal test signal UT =U0Sinωt with amplitude UT ≤ kT/q and sawtooth voltage U = αt + const is supplied.

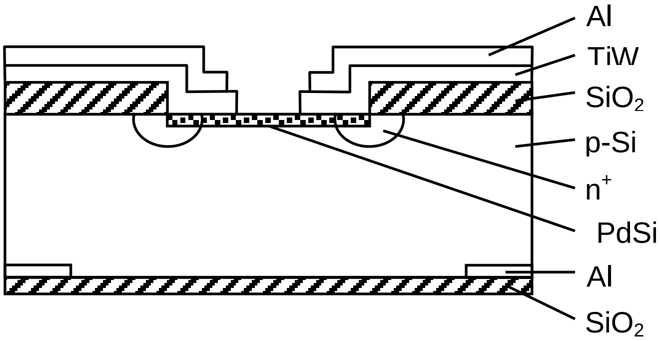


Fig.2 Cross section of a PdSi-p-Si based Schottky diode

The load resistance value was selected from the condition RH > > (ωck)-1 for the test signal and the reverse for the sawtooth voltage. The signal taken from the load RH1, equal to UH = const (Y + jωC), after preliminary amplification, is fed to the detector to isolate the impedance components. The signal from the second arm of the measuring circuit, consisting of the reference capacitance SET and load resistance KN2, is supplied to the input of amplifier U2, amplified and rectified by the detector. The detected signals are fed to the inputs of the comparator and compared. The output of the comparator is connected through differentiating RC chains to the input of the oscilloscope. In this case, the output voltage of the comparator remains constant as long as SET ≠ Cx, and the signal at the oscilloscope input is equal to 0. At some voltage offset, the reference capacitance SET = Cx(U) and a signal appears at the output of the comparator that unlocks the grids of the cathode ray tube of the oscilloscope.

Figure 3 shows an oscillogram of the capacitance-voltage characteristics of PdSi-p-Si structures at a frequency of 1 MHz.

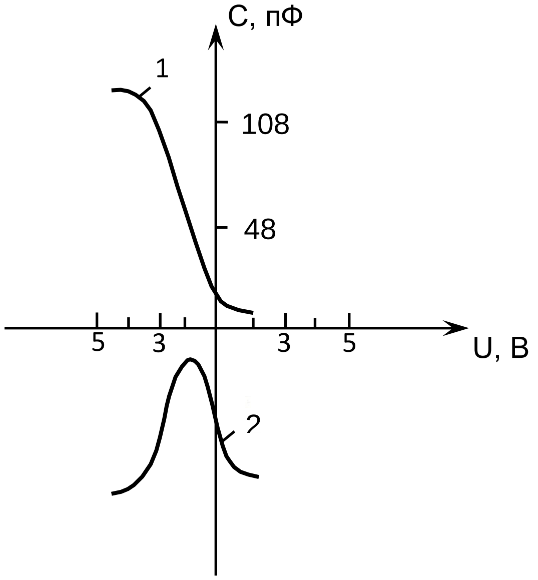


Fig. 3 Current-voltage characteristics of PdSi–n–Si structures

Conducted studies of the dependence of capacitance on voltage showed that in the range of 300 -106 Hz the capacitance practically does not depend on frequency and varies according to the law:

$$C = (q\varepsilon_n N_A / 2)^{1/2} \, (V_{d0} + V_{obr} - kT/q)^{1/2}$$

The position of the Fermi level ξ, as well as the barrier height, can be calculated from the value of NA obtained from the slope of the dependence of S/c2 on U.

Because the:

$$\xi = (kT/q)\ln(N_v/N_A)$$

In the absence of bias voltage, the action of mirror image forces reduces the height of the barrier by:

$$\Delta \varphi_{Bi} = [q^3 \varepsilon_n / 2\pi^2(\varepsilon'_n)^2 \, (\varphi_B - \varepsilon_f - kT/q)]^{1/4}$$

And the superposition of the mirror image forces acting on the carriers and the electric field of the depletion layer leads to a shift of the barrier maximum by:

$$x_M = 1/4 \, [q \, \varepsilon'_n \, (\varphi_B - \varepsilon_f - kT/q) / 2\pi^2(\varepsilon'_n)^2 N_A]^{1/4}$$

The dependence of the I/C2 ratio on the applied voltage for the same diodes is shown in Fig. 18. As can be seen from the figure, the experimental dependence of I/C2 on is linear, which indicates a uniform distribution of ionized impurities in the near-surface region of the semiconductor. The value of the acceptor concentration NA=IOI5 cm-3/ determined from the slope of the current-voltage characteristic coincides with the value calculated from the resistivity of silicon /ϱ=IO Ohm*cm corresponds to NA=I.5.IOI5 cm-3/, which indicates the absence of doping and the formation of electrically active defects in the near-surface region of silicon during the formation of silicide

Conclusion: the results of our measurements showed that the barrier height for PdSi-Si obtained by magnetron sputtering is 0.79 eV. It is for this reason that the breakdown voltage does not depend on the thickness of the palladium silicide obtained by magnetron sputtering, which indicates the homogeneity of the PdSi-Si contact. The work investigated the electrical properties of PdSi-Si structures obtained both by thermal evaporation and by magnetron evaporation

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