UDC 621.382

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RECEIPT OF MULTI-LAYERED METALLIC COVERAGES ON SURFACES of SILICON, THEIR PROPERTIES AND APPLICATION

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It is researched possibility of receipt of multi-layered metallization for Al-NiTi-Pd on the surface of single-crystal silicon of n-tipe. It is shown that because of distinction for coefficients of thermal expansion, parameters of silicon lattice and material of the presipitable layer of tape can have a different degree of imperfectness. The role of thermoburning is set in forming of border of division Al-NiTi-PdSi/n-Si. On the basis of the got multilayered structures the Shottky diodes are made and their descriptions are studied. Possibility of removal of technological operation on creation of diffusive barrier Ni-Ti, in the case of high-quality contact of PdSi and n-Si is educed.

Keywords: tape of alloy, microstructure, cracks, border of division, Shottky barrier

Contact a «metal-semiconductor» is the inalienable element of structure semiconductor device. Research of border of division (BD) between a metal and semiconductor material is presented large interest for development of physics of solid body, and also for expansion of the practical use of active properties of BD in the construction of electronic devices [1].

Properties of BD depend on the degree of it homogeneity, kinetics of physical processes, what be going on in it vicinity, including, possibility of formation of compounds, character of defects and other. It is possible at the scientifically reasonable choice of materials and control of conditions for forming of tape at metallization, in particular, to get BD with preset stable electrophysics parameter for contacts with the Shottky barrier (SB). For this purpose most perspective are connections of silicon with more electropositive elements. At the last two decades the row of conformities for receipt and properties of contact «silicide of metal-semiconductor» is educed. In particular, most interest, due to the unique properties, silicides of platinum and palladium are present [2-9].

Structural perfection of BD substantially influences on the height of SB. During annealing at a temperature higher 523 K during 30 minutes height of barrier of Φ_B for the Shottky diodes Pd_2Si-Si makes 0.73-0.74 eV. At a temperature below 463 K size of barrier is higher (to 0.78 eV), that specifies on heterogeneity of BD (existence of areas with unreached components). Tape of Pd_2Si save stability at high temperatures: 1173 K on Si(111); 1093 K on Si(110), 1046 K on Si(100) (time of annealing 15 minutes). At more high temperatures Pd_2Si coexist with $PdSi$ and Si. The appearing at annealing small islets of $PdSi$, is surrounded by including of dendritic Si, get to the volume of padding of Si [5].

Usually the thickness of layer of silicide does not exceed 20-40 nm, and a contact can be unsteady after high temperature treatment (~773 K [6]). Heat treatment can result to co-operating of silicide with aluminium, used in the integrated circuits

(VLSI), photo-electric transformers as contact interconnections, with refractory metals.

In work [9] it is shown that at the increase of temperature of annealing and increase of duration of heat treatment (> 573 K, t_{ann} = 4 mines) because of interdiffusion of BD inhomogeneous, and the parameters of contact degrade. In work [10] as a diffusive barrier the alloy *NiTi* is used.

In this work three batches of DS were made with multi-layered metallization and researches of their properties are released. There are used the silicon plates of *n*-type (111) with specific resistance 0.7 Ohm·sm [11].

First two batches after besieging of *Pd* exposed to heat treatment at a temperature 623 K during 30 minutes for formation of *PdSi*. In the second party before putting of *Al* contact interconnections ($d_{Al} = 1.2 \cdot 10^{-4}$ sm) besieged the diffusive barrier layer of *NiTi* ($d_{NiTi} = 2 \cdot 10^{-5}$ sm). The third party of DS had a diffusive barrier also, however differed by more subzero temperature of annealing for formation of silicide (573 K).

For establishment of crystalline for tapes of *Al-NiTi-PdSi* were carried out electronic-microscopic researches of its surface. On the initial stage of besieging looked the complete or truncated pyramids of height with noticeable, at a greater increase, by the layerwide structure. Then, the tops of these pyramidal hillocks became flat and simultaneously united with each other, with formation of continuous tape.

It should be noted that the state of surface of used padding's renders substantial influence on formation of defects of crystalline grate of tape. The form of packing defects is determined by the orientation of surface of paddings. At the sharp cooling from heat treatment (~723 K) to the room temperature tape partly collapse and cracks appear on them.

Volt-ampere descriptions (VAD) of DS are got on the basis of *Al-NiTi-PdSi*/*n-Si* in direct and reverse directions at a room temperature. From direct arms VAD the height of barriers, coefficient of infidelity and tension of breakup, is certain at $I_{form} = 10^{-6}$ A. An analogical method of construction of size dependences was applied in works [12-14]. Application of method is conditioned by that properties peripheral and central parts of contact are different: there are mechanical tensions on periphery of contact, there are losses of current. With the height of relation *P*/*S* influence of periphery on properties of contact increases and observed tendency to decrease of Φ_B, which takes place more fluently in the case of structure without a diffusive barrier, than with the diffusive barrier *TiNi*. Decrease of Φ_B with the increase of *P*/*S* testifies about the increase of role of periphery with decrease of area of diodes. At comparison of results of researches of diode structures, treated at the different temperatures of annealing, there is a high level of instability of parameters in the case T_{ann} = 573 K, when variation of height of barrier arrives at 0.1 eV. It can be explained by structural imperfection of BD, by the caused existence of areas with not fully reacting components (*Pd*, *Si*) because of more subzero temperature of annealing.

Similar dependences can be explained by the heterogeneous model of diode contact «metal-semiconductor», where a diode is examined as a two multiplex diode - central and peripheral.

Conclusions. It is set that in the case of contact of silicide of palladium with silicon introduction of diffusive barrier *NiTi* is a superfluous technological operation, resulting in worsening of diode descriptions - decrease of height of barrier, tensions of breakup and to the increase of coefficient of infidelity. It is discovered that with decrease of area of contact influence of periphery on device descriptions is increase, which must be taken into account in technology of device structures. The qualificatory role of thermo annealing in forming of BD *Al-NiTi-PdSi/n-Si* is set. At the correct choice of parameters of thermo annealing it is possible to create SB with homogeneous BD.

LIST OF LITERATURE

1. Мьюрарка, Ш. Силициды для СБИС [Текст] / Ш. Мьюранка. – М. : Мир, 1986. – 176 с. – Библиогр. : с. 174-175.
2. Пашаев, И. Г. Влияние различных обработок на свойства диодов Шоттки [Текст] / И. Г. Пашаев // Физика и техника полупроводников. – 2012. – Т. 46, Вып. 8. – С. 1108-1110.
3. Pashaev, I. G. // ElektronysikalL Properties of Shottky diodes made on the basis of silikon wtth amorphous and polycrystaline metal alloy at low direct voltage [Text] / I. G. Pashaev // Technical and Physical Problems of Engineering. – 2012. – Iss. 10, Vol. 4, No. 1. – P. 41-44.
4. Elzenberg, M. Formation of shallow Shottky contacts to Si using Pt-Si and Pd-Si alloy films [Text] / M. Elzenberg, H. Foell, K. N. Tu // J. Appl. Phys. – 1981. – Vol. 52, No. 2. – P. 861-868.
5. Hitching, G. A. The grows and transformation of Pd_2Si on (111), (110), (100) Si [Text] / G. A. Hitching, A. Shepela // Thin Solid Films. – 1973 – Vol. 18. – P. 252-256.
6. Tsaur, B. J. Effect interface structure on the electrical characteristics of PtSi-Si Shottky barrier contacts [Text] / B. J. Tsaur, D. J. Silversmith // Thin Solid Films. – 1982 – Vol. 93. – P. 343-363.
7. Проблемы создания высоконадежных многоуровневых соединений СБИС [Текст] / В. А. Валиев, А. А. Орликовский, А. Г. Васильев, В. Ф. Лукичев // Микроэлектроника. –1990. – Т. 19, Вып. 2. – С. 116-131.
8. Solomonson, G. A study of Ti as a diffusion barrier between PtSi or Pd_2Si and Al [Text] / G. Solomonson, E. K. Holm, T. G. Finsted // Phys. SCR. – 1981. – Vol. 24, No. 2. – P. 401-404.
9. Robinson, S. V. CRC crit revs [Text] / S. V. Robinson, D. G. Fertig // Solid State Sci. – 1975. –Vol. 5, No 3. – P. 291-296.
10. Пашаев, И. Г. Изучение электрофизических свойств диодов Шоттки, изготовленных на основе кремния с различными аморфными металлическими слоями [Текст] / IX Междунар. конф. и VIII Школа мол. ученых «Кремний-2012», 9-13 июля 2012, Санкт-Петербург, 2012. – С. 34.
11. Критская, Т. В. Современные тенденции получения кремния для устройств электроники. Монография. [Текст] / Т. В. Критская. – Запорожье : ЗГИА, 2013. – 365 с. – с. 307-347. – ISBN 978-966-8462-87-0.
12. Пашаев, И. Г. Изучение восстановления деградационных свойств контакта кремния, изготовленного на основе аморфного металлического сплава [Текст] / И. Г. Пашаев // Инженерная физика. – 2012. – № 7. – С. 23-27.
13. Аскеров, Ш. Г. Размерная зависимость плотности тока насыщения диодов с барьером Шоттки [Текст] / Ш. Г. Аскеров // Известия Вузов. Физика. – 1986. – № 1. – С. 97-98.
14. Pashaev, I. G. The inflience of ultrasonic treatment on the properties of Schottky Diodes [Text] / I. G. Rashaev // Open Journal of Acoustics. – 2013. – Vol. 3. – P. 9-12.