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ELECTROPHYSICAL PROPERTIES OF HIGHER MANGANESE SILICIDE FILMS TO SILICON

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ABSTRACT

Investigation of the injection phenomenon in compensated semiconductors , in particular , silicon doped with different lines Impurity atoms, which create deep energy levels in the band gap, provide valuable and useful information about the nature of these levels, as well as for determining the mechanism of so far passage in such materials . This work is devoted to obtaining injecting contacts based on silicon doped with impurity manganese atoms. To receive engineering contacts$p^+ - p - p^-$ and $n^+ - n - n^-$a plate of industrial silicon KDB-2, KDB-7.5 and KDB-10 with a diameter of 76 mm was used in part of the original material. Diffusion of boron or phosphorus into silicon was carried out from a solid source of nigridboron BN and phosphorus P_2O_3pentoxide . Controls the temperature of diffusion, the structures were found to be based on both hole and electronic conductivity with a number of different values of resistivity. The obtained results of the study allow creating injection contacts, the technology of which approaches the setting conditions, which makes it possible to create various semiconductor devices based on silicon doped with impurity manganese atoms.

The current stage of development of electronics and microelectronics cannot be changed without improving the contact properties semiconductor devices. This requires the ability to formulate conditions for optimizing technological processes for obtaining good optical and injection contacts, reducing the cost warm up when receiving contacts. For this chain , a replacement for expensive materials such as gold, silver and other cheaper ones is being developed. new materials. In this regard, bringing the laboratory technology of obtaining semiconductor devices closer to the setting of conditions has a certain prospect. This is due to the fact that many physical effects and phenomena have not yet found their practical application due to the impossibility of using existing technological regimes in the production of semiconductor devices. Structures based on compensated silicon are of interest to researchers , since a number of interesting physical phenomena have been discovered that are widely used in semiconductors. electronics[1-4].

Keywords: manganese, silicide, silicon, impurity atom, thermobatteries , single-crystal silicon, structure, semiconductor devices, hardening, diffusion technology.

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A study of the electrical and photoelectric properties of diffusely doped silicon with elements of groups I , II , VI and the iron subgroup is given in [1-10].

The process of diffusion of most impurities into silicon was carried out at temperatures $T = 900 \div 1250^{0}C$from the gas phase of diffusants or a chemically deposited metal layer in vacuum. In this case, the diffuse doping time from was several tens of minutes to several hours, depending on the value of the coefficient diffusion of the selected impurity element into silicon [1, 2].

The mechanism of manganese diffusion and electrochemical parameters into silicon was studied using radioactive isotopes by the method from the gas phase of the subsequent removal of layers by a step [3,4]. The concentration distributions of impurities were studied by four probes and by neutron activation analysis [5]. These research results showed . What's concentrated distribution crfc is a function . This distribution of impurities in the near-surface area in silicon is explained in different ways: relatively slow diffusion of impurity atoms between the nodes of the crystal lattice, volumetric dissociative diffusion, the essence of which is that the properties of the near-surface region are due to the interaction of rapidly diffusing between the site atoms of manganese with vacancies in the crystal lattice .

The next version of the explanation of the mechanism of diffusion of impurity manganese atoms into silicon of the near-surface layer, caused by the processing of the sample [6]. The sharp increase in the concentration near the surface in the works of silicon by the authors [7, 8] is explained by the deposition of the impurity on the defects .

It was shown in [9] that, upon diffusion doping of silicon with manganese atoms, there is a near-surface region of the concentration distributions of manganese, which are several orders of magnitude greater than in the volume of silicon. The results of the study obtained by the method of layering by removing the surface are shown in Fig. 1

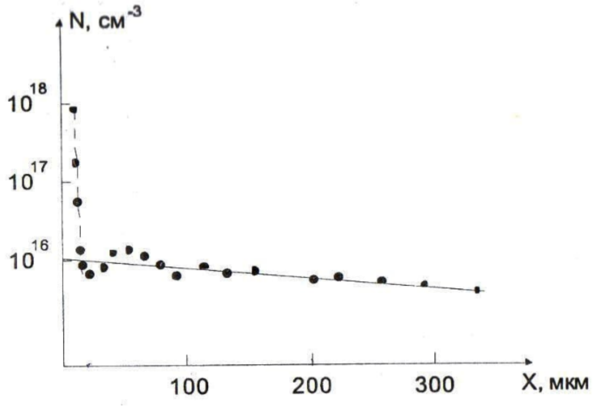

Fig.1. The distribution of manganese concentration in silicon as a result of diffusion at a temperature $1250^{0}C$for 15 min according to [14].

It can be seen from the figure that the concentration distribution of manganese in silicon consists of two sections. The first section is near-surface with depth $15 \div 20$ мкм, characterized by a sharp decrease in the concentration of impurity manganese atoms by an $3 \div 4$order of magnitude. The second section in the volume of the sample shows a more linear distribution of impurity manganese atoms. Interesting results of a study on the diffusion of impurity manganese atoms in silicon were obtained by the authors in [9]. The diffusion of manganese into silicon was studied in the temperature range $T = 900^0 C$by the DLTS method. In this case, special attention was paid to taking into account the boundary conditions; it was found that before the surface concentration of impurity manganese atoms is established more uniformly over the volume , it is formed in equilibrium with manganese atoms diffused into silicon.

We have studied the electrical and kinetic properties as the proportion of impurity atoms of manganese and silicon increases in binary compounds. Literature review and analysis of existing data on the compounds of manganese atoms with silicon found that the most well-studied silicides Mn_3Si with a small silicon content. From the results of the study, it was found that the electrical conductivity of the formed compound changes with an increase in temperature according to an exponential law, reaching a minimum in the temperature range of $T = 500 \div 600^0 C$Fig.2.

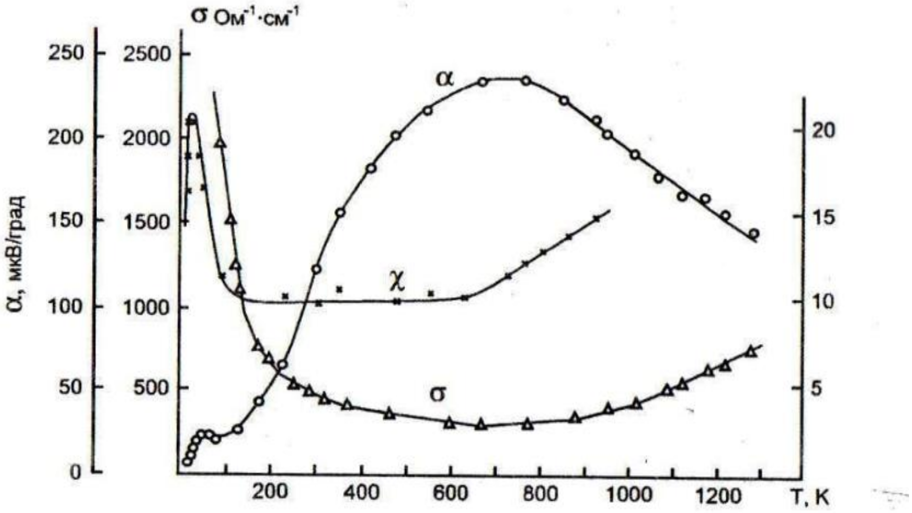

Fig.2. Temperature dependence of the electrical conductivity σthermo -E.D.S. α and thermal conductivity χ of higher manganese silicide.

Such a course of the characteristic (T) is explained by the phase transformation of the structures Mn_3Si. From the analysis of the obtained experimental data, it was found that the formed silicide Mn_3Sihas a metallic character. The conductivity and electrical properties of such films depend on the concentration of impurity manganese atoms involved . the above mentioned manganese silicides. The weak temperature dependences of ρ(T) and α(T) in a wide temperature range indicate that the obtained silicides have semimetallic properties. The ongoing study of electro-physical parameters at room temperature suggests that the manganese-silicon interface contains not only $MnSi$ but one of the higher silicides (HSM) $Mn_xSi_{1-x}$with a semiconductor character.

An analysis of the obtained experimental works showed that higher manganese silicides (Mn_xSi_{1-x}) are the most promising material for creating thermoelectric generators and microelectronic devices in the working area at medium temperatures . It is for this reason that studies on the properties of higher manganese silicide on the silicon surface are a promising direction that are both theoretical and practical in nature.

The kinetic properties of the higher manganese silicide were studied by us in detail and it was established that, in terms of their electrical properties, HSM is self- alloyed. semiconductor p - type with a high concentration of current carriers in a wide temperature range ($T = 80 \div 300\ K, n = 10^{21}\text{см}^{-3}$) and relatively low mobility (μ=10 $\frac{\text{см}^2}{\text{в}} * \text{с}$, $\text{Т} = 300\text{К}$). The band gap, VSM determined from the analysis of the electrical conductivity and the Hall coefficient in the region of intrinsic conductivity is $\text{Е}_{\text{д}} = 0{,}67 \div 0{,}8\text{эВ}$[10-15]. This value of the band gap is close to the energy of direct transitions, determined from the analysis of the Hall coefficient in the region of impurity conduction , and is approximately $\sim 10\ m_0$(m_0- the mass of a free electron) and indicates the narrowness of the valence band. We also found that single-crystal samples have highly anisotropic kinetic properties, which is preserved in the intrinsic conduction region up to $\text{T} = 1000\text{К}$.

Based on the study, this work found that the value of thermo -EMF both perpendicular to the main axis of the rag and parallel to the growth of the main axis of silicon weakly depends on the composition.

HSM films obtained by the described technology have the following characteristic properties:
– have thermo -EMF anisotropy, which persists up to 800^0C,
– have chemical resistance to aggressive environments in a wide temperature range (up to 800^0C) and do not require surface protection,
– have a high adhesiveness of the film itself with the matrix and resistance to various mechanical influences, which is due to the formation of the HSM film in the process of reactant diffusion of the silicon substrate with manganese vapor,
– the evaporation temperature of the manganese silicide film VSm is close to the evaporation temperature of manganese proper 970^0C,
– thermoelectric parameters of VSM films are 1.5 – 2 times greater than the corresponding parameters of a massive HSM crystal, due to the layered structures of the film.

The technical parameters of VSM films are as follows :
– the spectral sensitivity range extends from 0.2 to 200 μm,
is the conversion factor $S = 500 \div 2000$ мкВ/Втat the radiation length $\lambda = 10{,}6$ мкм,
– coefficient of thermo -E.D.S. α ≈300 μV/K,
- time constant (speed) $\tau \leq 10^{-6}$c,
– electrical resistance of the element is not more than 200 Ohm,

Obviously, the described properties of HSM films make it possible to create non-selective thermal radiation receivers under conditions of measuring fast processes when writing information to memory devices, as well as when transmitting data via various communication channels.

REFERENCES

1. Boltaks B.I. diffusion in semiconductors . FM, Moscow 1961. p.462
2. Boltaks B.I., Bakhadyrkhanov M.K., Gorodetsky S.M., Kulikov G.S. Compensated silicon. Ld: Nakka, 1972. p.122.
3. Zainabidanov S. _ Physical basis formation of deep levels in silicon. Tashkent: Fan, 1984. p. 160.
4. Yunusov M.S. Physical phenomena in silicon doped with elements of the platinum group. Tashkent: Fan, 1983. p.80
5. Nistryuk I.V., Seregin P.P., Boltaks B.I. Diffusion distribution and state of cobalt atoms in silicon. //FTT. 1976. Vol. 18. Issue . 3. p. 592 - 595
6. Martin J., Haas L. und Raitel K. Radichemische Untersuchungen zur Diffusion von Gold in Silicum . //Sol. St. Elektr . 1966. V. 9. N. 1. p. 83-85
7. Bakhadyrkhanov M.K., Boltaks B.I., Kulikov G.S. Diffusion, electrotransport and solubility of manganese impurity in silicon. //FTT. 1972. Vol. 14. Issue . 6. p. 1671 - 1675
8. Gilles B., Bergholz W. fnd Schroer W . Difusion of manganese in silicon studied by deep-level transient spectroscopy and tracer measurements. // J.Appl . Phys. 1986. V. 59. N. 10. p. 3590 - 3593
9. Shank.F.A . Structures of double alloys. Deut. add . ed. Moscow: metallurgy, 1973. p. 760.
10. Samsonov G.V. , dvorina L.A., Rud B.M. Silicides M.: Metallurgiya, 1979. p.272.
11. Geld N.Z., Sidorenko F.A. Silicides of transition metals of the fourth period. M. : Metallurgy, 1971. p. 323.
12. Ilchenko V.V., Strikha V.I. Rearrangement of the electronic structure of the metal silicide-silicon interface during low-temperature annealing. // Ukr . Phys. Magazine. 1983. V. 28. No. 2. With. 248-252.
13. Kamilov TS, Sadullaev BL, Ganiev U.Sh. _ and Kamilov BT // Semicond . sci. Technol. 13(1998) 496–499.
14. Kamilov TS, Chirva vP , Kabilov DK // Semicond . sci. Technol. 14(1999) 1012-1017.
15. Adambaev K., Zaitsev V.K., Kamilov T.S., Kulikov G.S., Nazyrov D.E. , Ordin S.V. // Surface, Physics, Chemistry, Mechanics, No. 7, 1988, p.66 - 70.