ishlab chiqilishi kerak bo‘lgan tashxislash dasturiy ta’minoti uchun asos hisoblanadi. Bunday tizim bemorlarni tashxislash va boshqarishni sezilarli darajada yaxshilaydi. Sog‘liqni saqlashning yanada shaxsiylashtirilgan va kasalliklarni erta aniqlashga doir muammolariga yechimlar topishda yordam beradi.

Adabiyotlar

1. Esteva A., Kuprel B., Novoa R. A., Ko, J., Swetter S. M., Blau, H. M., & Thrun S. Dermatologist-level classification of skin cancer with deep neural networks. *Nature*, 542(7639), 2017. –P. 115–118.
2. Rajpurkar P., Irvin, J., Zhu, K., Yang, B., Mehta, H., Duan, T., ... & Lungren M.P. 2017. CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning**.** *arXiv preprint arXiv:1711.05225*.
3. Aytmuratov B.Sh., Nurimov P.B., Yesbergenov H.S., Analysis of X-Ray images using artificial intelligence algorithms for medical diagnostics, Science and Education in Karakalpakstan. 2024 № 2/2 ISSN 2181-9203.
4. Nurimov P.B, Yesbergenov H.S, Tibbiyotda sun’iy intellekt texnologiyalarini qo‘llash, Raqamli texnologiyalarning iqtisodiyot va ta’limdagi o‘rni mavzusidagi xalqaro ilmiy-amaliy anjumani ma’ruzalar to‘plami I tom, Muhammad al-Xorazmiy nomidagi Toshkent axborot texnologiyalari universiteti Samarqand filiali, 316-324-b. 2024.
5. Rivera S.C, Guidelines for clinical trial protocols for interventions involving artificial intelligence: the SPIRIT-AI extension, Nature Medicine, Vol. 26, -P. 1351-1363. 2020.
6. Litjens G., Kooi, T., Bejnordi, B. E., Setio, A. A.,. A survey on deep learning in medical image analysis. *Medical Image Analysis*, 2017. –P. 42, 60-88.
7. Topol E.J. High-performance medicine: the convergence of human and artificial intelligence. *Nature Medicine*, 25(1), 2019.

REZYUME. Sun’iy intellekt tizimlari kasalliklarni erta aniqlash va davolashda yuqori aniqlik va samaradorlikni ta’minlaydi. Sog‘liqni saqlash sohasida tashxislash jarayonini sezilarli darajada yaxshilaydi. Ushbu maqolada sun’iy intellektga asoslangan tashxislash tizimini tuzilishi ko‘rib chiqilgan.

РЕЗЮМЕ. Системы искусственного интеллекта обеспечивают высокую точность и эффективность раннего выявления и лечения заболеваний. Значительно улучшает диагностический процесс в сфере здравоохранения. В данной статье рассматривается структура системы диагностики на основе искусственного интеллекта.

SUMMARY. Artificial intelligence systems provide high accuracy and efficiency in early detection and treatment of diseases. Significantly improves the diagnostic process in the healthcare sector. This article examines the structure of the diagnosis system based on artificial intelligence.

DEVELOPMENT OF NANOMATERIALS TO INCREASE THE PERFORMANCE OF SILICON ELECTRONICS

D.J.Asanov – *assistant teacher*

S.U.Ashirbekova – *candidate of physical and mathematical sciences*

Nukus state pedagogical institute named after Ajiniyaz

Tayanch so‘zlar: silisidlar, elemenlar tarkibi, VLSI (o‘ta keng ko‘lamli integral mikrosxemalar), faza tarkibi, elektron diffraktsiya sxemasi.

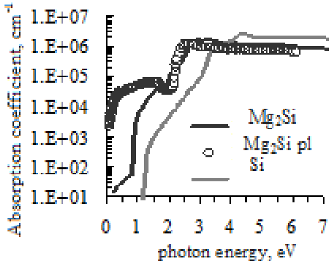
Ключевые слова: силициды, элементный состав, СБИС (сверхбольшие интегральные схемы), фазовый состав, электронограмма.

Key words: silicides, elemental composition, VLSIC (very large-scale integrated circuits), phase composition, electronogram.

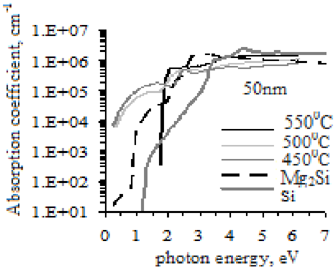
Advances in solid state and semiconductor physics have contributed to the emergence of nanoelectronics, which focuses on the creation of new materials and semiconductor devices. Silicon remains a key material for integrated circuits, but further development is needed for submicron technologies. New silicide-based heterostructures can expand the horizons of nanoelectronics. An important task is the development of silicon-compatible photodetectors for visible and ultraviolet spectra, which is relevant for ecology, biotechnology and medicine.

The compound Mg_2Si is a well-known promising material for the conversion of thermoelectric energy in the temperature range from 500 to 800 K. The fundamental electronic properties of Mg_2Si single crystals have been widely studied both theoretically and experimentally. The formation of epitaxial Mg_2Si films on silicon is complicated by the low sticking coefficient of magnesium to silicon at elevated substrate temperatures. The most interest has been shown in the works on the formation of thin films of stoichiometric Mg_2Si on silicon by molecular beam epitaxy. However, the substrate temperature during growth cannot exceed 200°C, which ensures the formation of only polycrystalline Mg_2Si films with a sufficiently developed surface relief. To create silicide-silicon heterojunctions and construct new semiconductor devices, this is not a sufficient condition. The works present the results of studies on the reflection and transmission spectra for Mg_2Si films grown by multiple and single annealing processes [1]. For the polycrystalline Mg_2Si film obtained by multiple annealing, the absorption spectrum is presented in Figure 1.a. For comparison, the spectra of Mg_2Si and Si single crystals are also shown in this figure. In the Mg_2Si single crystal, intrinsic absorption due to indirect transitions begins at photon energies of 0.67-0.75 eV, and the absorption coefficient α has small values (10-100 cm^{-1}) (Figure 1.a). Starting from energies of 1.8-2.8 eV, direct interband transitions occur, and the absorption coefficient α sharply increases (up to $\approx 10^6$ cm^{-1}) (Figure 1.a). The Mg_2Si film exhibits a higher value of the absorption coefficient α near the absorption edge (Figure 1.a) compared to the single crystal, which is associated with contributions from structural defects and stoichiometry disruption.

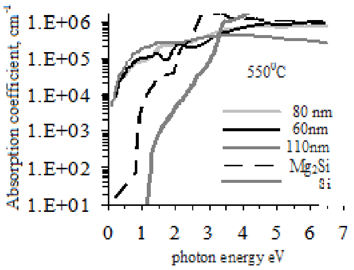
The maximum value of the absorption coefficient for the film ($\approx 1.1\cdot 10^6$ cm^{-1}) is slightly less than that of the single crystal ($\approx 1.5\cdot 10^6$ cm^{-1}) (Figure 1.a), which corresponds to a small loss of valence electrons at broken bonds in the Mg2Si lattice and at the grain boundaries. From the spectral dependence of the absorption coefficient α (Figure 1.a), the energy of the first direct transition is determined to be 0.7±0.05 eV and the second, strongest transition - 2.2±0.05 eV. Figure 1.b presents the spectra for the first series of films grown by single annealing, and Figure 1.c - for the second series. For both series of samples, a decrease in the absorption coefficient α and a shift of the maximum value of α to the region of higher photon energies are observed compared to the single crystal. For the film with epitaxially oriented grains (550°C), the minimum coefficient α is observed in the energy range up to 2 eV (Figure 1.b), which corresponds to minimal absorption at defects. It is evident that with a decrease in the temperature of single annealing, there is an increase in α in this energy range (Figure 1.b), which is associated with an increase in the number of defects. A sharp increase in the absorption coefficient α in the films, associated with direct transitions, is observed at lower photon energy values (1.1-1.7 eV) compared to the single crystal (1.9 and 2.3 eV): for the film with epitaxial grains (550°C) at energy hν≈1.7 eV, for the film at 500°C hν≈1.8 eV, for the film at 450°C hν≈2.0 eV (Figure 1.b). The shift of the energies of direct transitions to the low-energy region for the films (Figure 1.b) occurs due to an increase in the contribution of silicon atoms and a decrease in the contribution of magnesium atoms. This is possible in the case of substitution of magnesium atoms by silicon atoms in the Mg_2Si lattice. With a decrease in the annealing temperature, the concentration of silicon in the Mg_2Si lattice decreases, but the proportion of silicon defects increases (Figure 1.b) [2-4].



a



b



c

Figure 1. - Absorption spectrum for a thin polycrystalline Mg_2Si film grown by repeated annealing (a). For Mg_2Si films grown by single annealing: the first series (b) and the second series of samples (c). For comparison, the absorption spectra of Mg_2Si and Si single crystals are presented (a, b, c).

The studies suggest that the acceleration of the kinetics of silicide formation under RTP conditions is mainly due to the lesser influence of gaseous impurities from the environment. The works investigated the effects associated with the thermal action of radiation on the formation of silicides. Energy is transferred to the lattice depending on the optical characteristics of the substance and the structure of the surface. In semiconductors and metals, the absorption of electromagnetic energy occurs through the excitation of electrons and the subsequent transfer of energy to the lattice. This leads to localized heating of the material on the irradiated surface. There is a diffusion of heat with very large temperature gradients within the irradiated material.

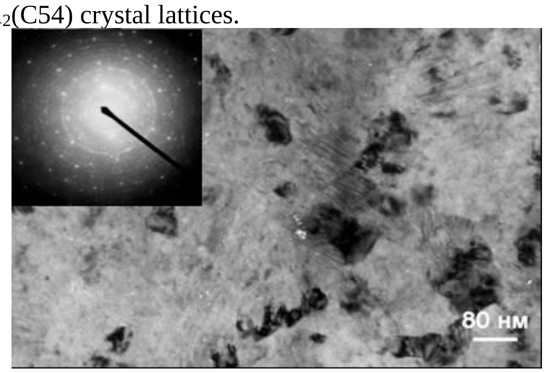
Table 1 - Methods of Metal Silicide Formation

Method	Characteristic of the Method
1. Deposition of metal on a Si substrate and silicide formation by methods: - Stationary or rapid thermal processing; - Laser irradiation; - Mixing by ion bombardment	Sensitive to the purity of the metal-silicon interface and high concentrations of impurities. Capability for selective silicide formation on the surface of silicon areas. Most commonly used for silicides of Pt, Pd, Co, Ti
2. Co-evaporation of metal and silicon or co-sputtering of metal and silicon from two targets.	Difficulties in process control. Low coefficient of relief dusting. Convenient for use in research purposes, rarely used in industrial production.
3. Physical sputtering from composite targets.	The complexity of manufacturing pure composite targets, possible contamination with impurities such as C, O, Ar, Na. Low coefficient of relief dusting.
4. Reactive cathodic sputtering of metal targets in a silane-argon atmosphere.	There is no consumption of silicon from the substrate.
5. Condensation of metals on substrates at the temperature required to initiate the solid-phase reaction.	The deposition process is complicated, relative to methods 1, 2, 3 (issues with silane disposal).
6. Ion-stimulated solid-phase synthesis.	The process is in the research stage. Possibility of epitaxial growth of silicide.
7. CVD - Pyrolytic deposition.	Poor compatibility with the standard CMOS IC fabrication process.

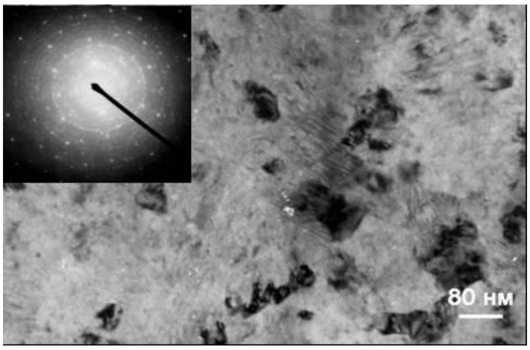
Currently, due to its simplicity, universality, and compatibility with basic IC manufacturing technologies, only the method of diffusion synthesis of silicide layers, which occurs due to reaction diffusion between the silicon substrate and the metal film during their thermal treatment, has become widely used. Other methods of forming thin-film silicide layers have not found wide application due to their complexity and low productivity. The RTP process can be described under the assumptions : - the radiation pulse has a rectangular shape; - before irradiation, the temperature of the heterostructure is constant throughout the volume; - there is no heat exchange between the plate and the substrate holder; - there are no temperature gradients along any coordinates. The heating process of the structure under study can be described by the heat balance equation [6-7].

$$\rho c h \frac{dT}{dt} = (1-R)E - 2\varepsilon\sigma(T^4 - T_0^4)$$

where: ρ – is the density of silicon, c – is the specific heat capacity of silicon, h – is the thickness of the structure, E-- is the power density of the light flux falling on the structure, R- is the reflectivity, T_0 – is the ambient temperature, t – is the time, ε – is the emissivity, σ – is the Stefan-Boltzmann constant, T - is the temperature. As can be seen from Figure 2, the substructure of the $TiSi_2$ (C54) films is characterized by large grains of anisotropic shape. The average grain size ranges from 150 to 200 nm. It should be noted that under these synthesis conditions, it was possible to form epitaxial areas of $TiSi_2$(C54), as evidenced by the presence of moiré stripes with a period of 2.6 nm, resulting from double diffraction on the (200) $TiSi_2$ and (220) Si planes (see Figure 2(b)). This is explained by the significant dimensional and structural mismatch of the Si and $TiSi_2$(C54) crystal lattices.



a



b

Figure 2 - Microphotographs and microelectronograms of $TiSi_2$(C49) (a) and $TiSi_2$(C54) (b) films, obtained from the BTO heterostructure TiN/Ti/Si.

The analysis of experimental data shows that rapid thermal processing using halogen lamps allows for the formation of a titanium disilicide layer in the C49 modification, which has a high specific electrical resistivity (see Figures 3, 4).

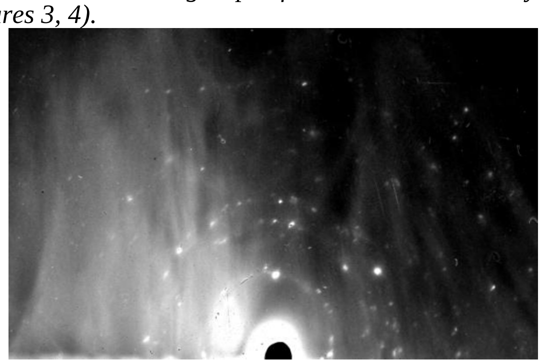


Fig.3

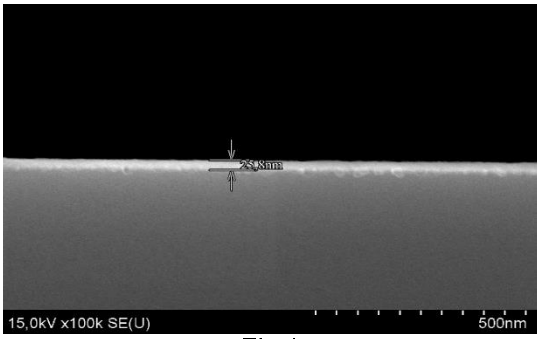


Fig.4

The analysis of experimental data indicates that rapid thermal processing allows for the formation of a titanium disilicide layer in the C49 modification, which has a high specific electrical resistivity of approximately 2000 μΩ·cm. Titanium disilicide in the C49 modification was formed by rapid thermal processing of the TiN/Ti/Si heterostructure at temperatures of 580°C to 620°C and a processing time of 30 seconds. During this thermal treatment, a columnar structure of the film is formed (grain height ~26 nm, grain diameter ~300 nm. (Fig.4). Upon excitation in the range of 360 - 390 nm, all samples exhibit an asymmetric band from 400 to 750 nm. The shape of the luminescence spectrum is related to the varizone structure of the nanosized grains of the titanium disilicide film in the C49 modification. These new research findings on the properties and methods of forming $TiSi_2$ in the C49 modification are recommended for the development of new types of optoelectronic devices as an optional extension of the standard technological process for manufacturing MOS integrated circuits [3-10].

The research results on the formation of metal silicide films that expand the limits of silicon nanoelectronics are presented. The focus is on studying rapid thermal annealing (RTA) technologies and analyzing the structures of thin films during RTA. All types of nanoscale structures obtained can be used for the optional expansion of the standard technological process of manufacturing MOS integrated circuits and other technologies in various fields. The data presented in this work can be used to optimize RTA modes.

References

1. Borisenko V.E. [and etc.]. 2019 Atomic structure, fundamental electronic, optical and magnetic properties of low-dimensional structures made of semiconductors BSUIR (Belarus). 2, 120
2. Galkin N.G. 2023 Jpn J Appl Phys 62, 0803
3. Zaitsev K. Vladimir [et. al]. 2016 In book: Thermoelectrics for Power Generation - A Look at Trends in the Technology 264284
4. Polyakov A.V., Fomin D.V., Novgorodtsev N.S. 2023 Advances in Applied Physics 1, 52-60.
5. Markevich M.I. 2012 Electronics INFO. 7, 112-114.
6. Burkov A.T., Novikov S.V., Schumann J. 2012 AIP Conference Proceedings, 9th European Conferenceon Thermoelectrics. 1449, 219-222.
7. Markevich M.I., Kamalov A.B., Asanov D.J., Esbergenov D.M. & Kazakbaeva M.A. 2024. Specific Features of Carbon Nanoparticle Formation Under the Influence of a Laser Operating in a Double-Pulse Generation Mode. East European Journal of Physics, (2), 394-397.
8. Solomkin F.Yu., Zaitsev V.K., Novikov S.V., Samunin Yu.A., Isachenko G.N. 2013 JTF. 83. 141-145.
9. Markevich M.I., Kamalov A.B., Asanov D.J., Nazhepova S.R. 2023 Science and world. 6(118), 8-10.
10. Asanov D.J., Markevich M.I., Kamalov A.B. 2023 Scientific and methodological journal. Science and society. 2, 3-6.

REZYUME. Yuqori samarali va tezkor yarimo'tkazgich komponentlarini, shuningdek o'ta katta integral mikrosxemalarni (VLSI) ishlab chiqish ishlab chiqarish jarayonlarida yangi materiallardan foydalanishni talab qiladi. Zamonaviy mikroelektronika uchun eng istiqbolli materiallardan biri metall silikidlardir. Ushbu birikmalar qattiq elektronikada, xususan, to'g'rilash va omik kontaktlarni, shuningdek integral mikrosxemalarda o'tkazuvchi elementlarni yaratish uchun keng qo'llanilgan. Bundan tashqari, magnezium silitsid monokristallari mukammal termal samaradorlik ko'rsatkichlarini namoyish etadi, bu esa magniy va kremniyni yuqori termal samaradorlikka ega Mg_2Si kabi yupqa plyonkali yarimo'tkazgichli birikmalarni yaratish uchun jozibali materiallarga aylantiradi.

РЕЗЮМЕ. Разработка высокоэффективных и быстрых полупроводниковых компонентов, а также сверхбольших интегральных схем (СБИС) требует применения новых материалов в производственных процессах. Одними из наиболее многообещающих материалов для современной микроэлектроники являются силициды металлов. Эти соединения нашли широкое применение в твердотельной электронике, в частности, для создания выпрямительных и омических контактов, а также проводящих элементов в интегральных схемах. Вдобавок, монокристаллы силицида магния демонстрируют отличные характеристики термического КПД, что делает магний и кремний привлекательными материалами для создания тонкопленочных полупроводниковых соединений, таких как Mg_2Si, которые обладают высоким термическим КПД.

SUMMARY. The development of highly efficient and fast semiconductor components, as well as ultra-large integrated circuits (VLSI), requires the use of new materials in production processes. One of the most promising materials for modern microelectronics are metal silicides. These connections are widely used in solid-state electronics, in particular, to create rectifier and ohmic contacts, as well as conductive elements in integrated circuits. In addition, magnesium silicide single crystals exhibit excellent thermal efficiency characteristics, which makes magnesium and silicon attractive materials for creating thin-film semiconductor compounds such as MgSi, which have high thermal efficiency.