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World Bulletin of Education and Learning (WBEL)

ISSN (E): 3072-175X | Volume 01, Issue 03, December 2025

https://worldbulletin.org/index.php/1

CONCENTRATION OF SIMULTANEOUSLY DOPED GALLIUM AND ANTIMONTY IMPURITY ATOMS IN SILICON

Rakhmanov U. M.
Teacher of the Department of "Department of Exact Sciences" at the University of Business and Science Tashkent Branch
E-mail: ulugbekraxmanov08@gmail.com
+99899 352 48 25

Abstract

The distribution of Ga and Sb atoms in silicon is observed and compound semiconductors are obtained by used to produce modern electronic elements are solar cells. Silicon is the only element on earth used in the production of electronic elements and solar cells.

Keywords: Diffusion, silicon, modeling, film, semiconductor, solar cell, CO2, atmosphere, temperature, energy.

Introduction

Annotatsiya:

Ga va Sb atomlarini kremniyda taqsimoti ko'riladi va diffuziya usulida birikmali yarimo'tkazgichlar olinib zamonaviy elektronika elementlari va quyosh batareyalari ishlab chiqiladi. Kremniy yer yuzidagi elektronika elementlari va quyosh batareykalarini ishlab chiqarishda ishlatiladigan yagona yarimo'tkazgichdir.

Kalit so'zlar: Diffuziya, kremniy, modellashtirish, plyonka, yarimo'tkazgich, quyosh batareya, CO_2, atmosfera, harorat, energiya.

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Аннотация:
Наблюдается распределение атомов Ga и Sb в кремнии, и методом диффузии получают полупроводниковые соединения, которые используются для производства современных электронных элементов и солнечных батарей. Кремний — единственный полупроводник на Земле, используемый в производстве электронных элементов и солнечных батарей.

Ключевые слова: Диффузия, кремний, моделирование, пленка, полупроводник, солнечная батарея, CO2, атмосфера, температура, энергия.

INTRODUCTION

The main sources of energy for the production of electricity are recognized as unsustainable. For example, the burning of fossil fuels (coal, oil, and natural gas) releases large amounts of CO_2 into the atmosphere, causing serious climate problems such as global warming, rising sea levels, and changes in precipitation. Nuclear power plants are more environmentally friendly (zero CO_2 emissions). However, these plants can become extremely dangerous if they are not operated safely, as in the case of the Chernobyl disaster in 1986, or in the event of natural disasters such as Fukushima. For the reasons mentioned above, it is very important to use more clean and renewable energy sources. The above problems can be solved by converting renewable energy sources, especially solar energy into electricity. Solar energy is directly converted into electricity through the photovoltaic (PV) effect, which was discovered and demonstrated by Nobel laureate Henri Becquerel [1-4].

Solar panels are traditionally divided into three different generations: silicon-based solar panels, thin-film solar panels, and nano-crystalline material-based solar panels. The inability to control the main parameters of silicon, such as its mobility, forbidden field energy, energy zone structure, limits its capabilities. But silicon makes up 26-27% of the earth's composition, besides, the technology of obtaining silicon used in industry is cheaper and more widespread than the technology of obtaining other semiconductor materials [8]. Therefore, silicon is

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still the leading semiconductor material used in electronics and solar panel production. Therefore, scientific research is being conducted both theoretically and practically all over the world to control the main parameters of silicon and to increase the efficiency of silicon solar panels [7].

THEORETICAL CALCULATIONS

In the work of authors Ahmad Mostafa and Mamoun Medraj [Binary Phase Diagrams and Thermodynamic Properties of Silicon and Essential Doping Elements (Al, As, B, Bi, Ga, In, N, P, Sb and Tl)], the diffusion parameters of gallium and antimony elements in silicon 'shown.

$$D_i = A \cdot e^{\left(\frac{B[ev]}{kT}\right)} \left[\frac{cm^2}{s}\right] \quad (1)$$

here, A is a quantity equal to the diffusion coefficient when the temperature is infinite; B-activation energy; D_i-diffusion coefficient.

Table 1.

Elements	***A***	***B***
Al	0.317	3.023
As	8.85	3.97
B	3.79	3.645
Bi	1.08	3.85
Ga	**3.81**	**3.552**
In	3.13	3.668
N	200000	3.24
P	1.03	3.507
Sb	**40.9**	**4.158**
Tl	1.37	3.7

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Table 1 and equation (1) can be used to calculate the diffusion coefficient at a certain temperature.

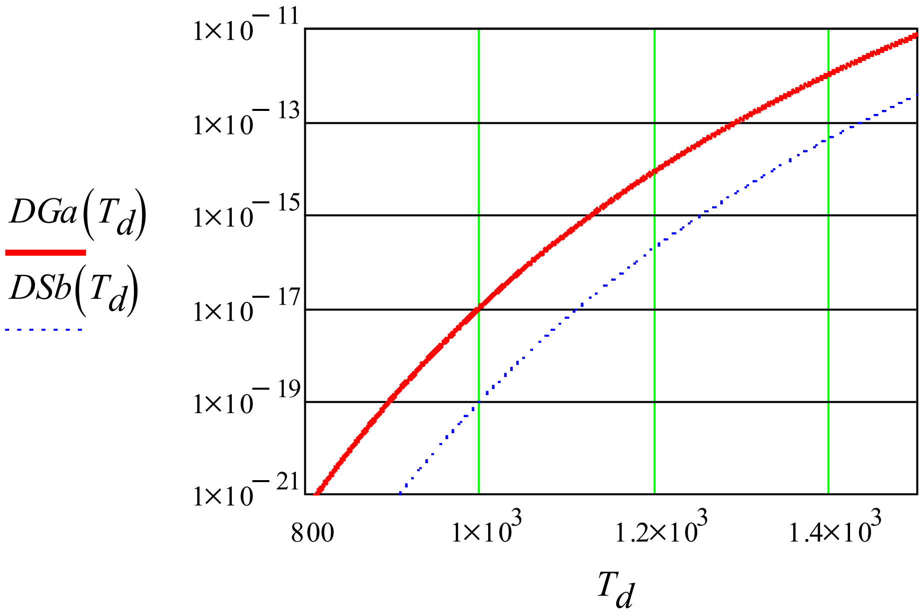

Figure 1. Graph of diffusion coefficients of gallium and antimony elements as a function of temperature.

The graph of the dependence of the concentration of elements on the depth of penetration is determined using the following equation (2):

$$C(x) = C_0 \cdot erfc\left(\frac{x}{2\cdot\sqrt{D(T)\cdot t}}\right) \qquad (2)$$

here is $C(x)$ – the concentration of the element, C_0 – the maximum solubility of the element in silicon, x – is the penetration depth, $D(T)$ – the diffusion coefficient, and t – the diffusion time.

The maximum solubility of gallium and antimony elements in silicon can be determined using the following graph [5-6]:

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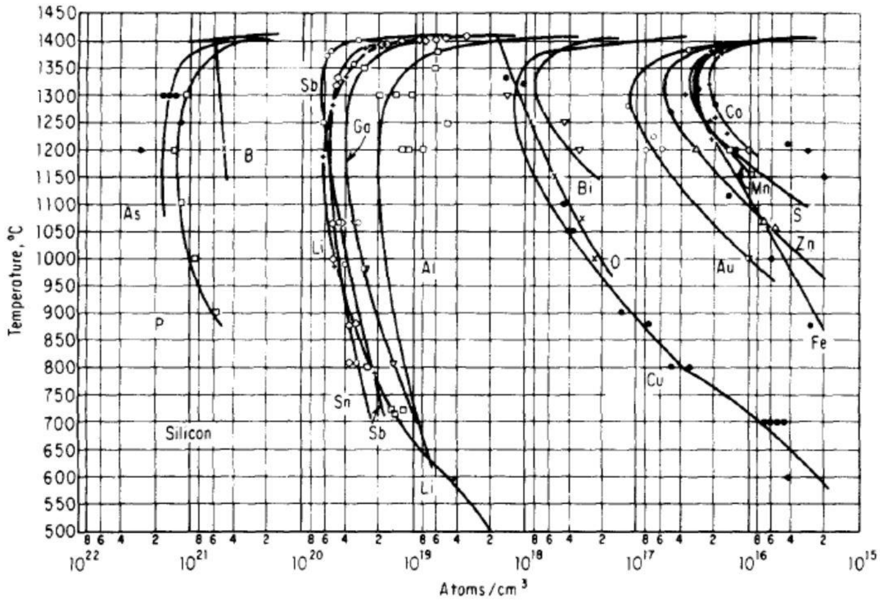

Figure 2. Graph of the temperature dependence of the solubility of some impurity atoms in silicon.

Using Figure 2, we can construct Table 2 below.

Table 2.

T, °C	$C_0\,(x\cdot10^{19}),\ cm^{-3}$	
	Sb	Ga
1000	3.955	2.869
1050	4.4557	3.287
1100	4.935	3.64
1150	5.47	4.03
1200	6.05	4.0366
1250	6.375	3.91
1300	6.7134	3.65

Using equations (1) and (2) and table 2, we can obtain the distribution of the concentrations of gallium and antimony elements at temperatures of 1000÷1300 °C during the same period of time (5 hours).

$C_0(x*10^{19}),cm^{-3}$

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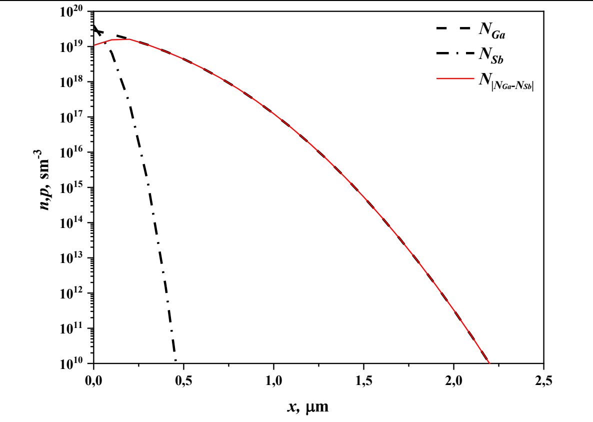
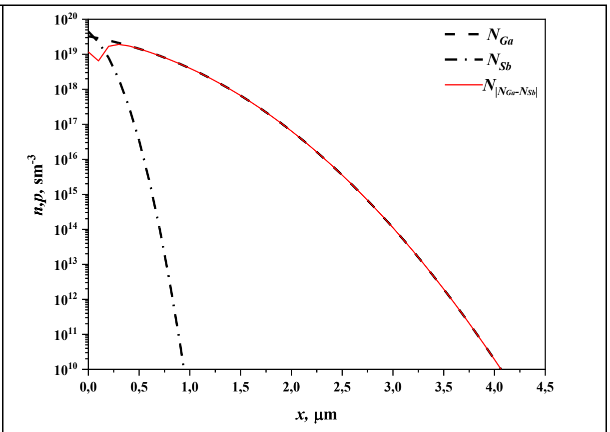


a)



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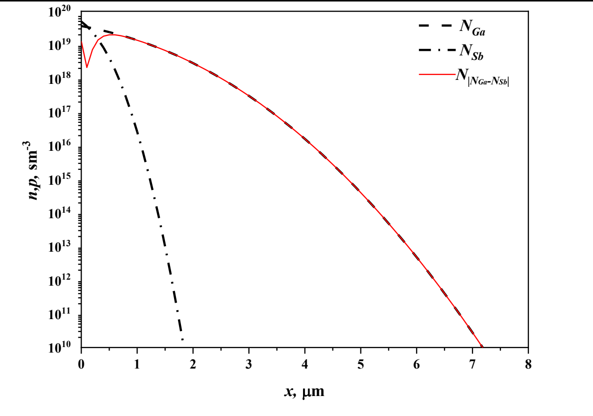

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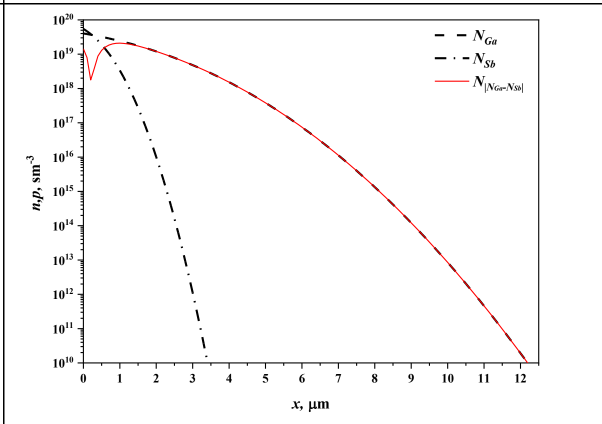

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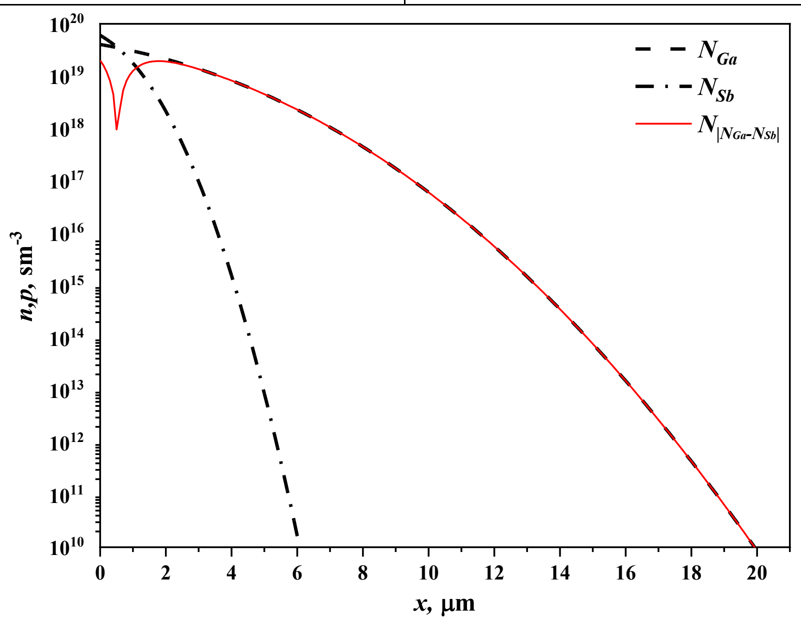

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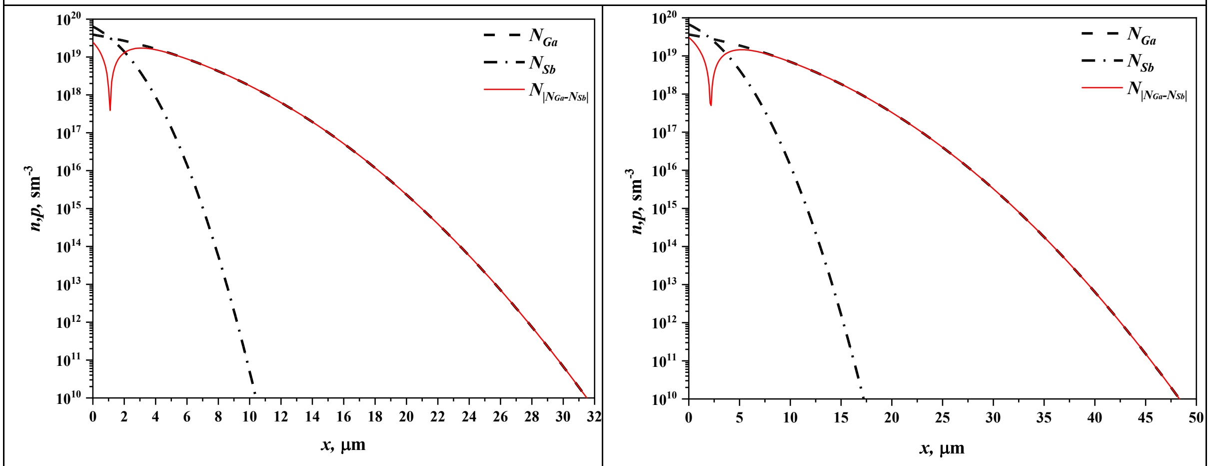
e)



f) *g)*

Figure 3. Depth distribution of concentrations of gallium and antimony atoms entering silicon simultaneously at temperatures of 1000÷1300 °C and during the same time (5 hours).

CONCLUSION

Based on these calculated results, we can design experiments that we can conduct. The essence of theoretical calculations and mathematical modeling of the diffusion process is that it reduces the number of unnecessary experiments, helps us to achieve the result faster and easier, reduces energy consumption and somewhat reduces costs.

In our future work, we will consider how well the experimental results confirm the theoretical calculations.

References

1. Ahmad Mostafa, Mamoun Medraj. Jurnal Materials 2017, 10, 676; doi:10.3390/ma10060676.
2. B.O. Isakov, SCIENCE and SOCIETY, 2, 19-20 (2022).
3. М. К. Бахадырханов, С. Б. Исамов. Журнал технической физики, 2021, том 91, вып. 11.
4. M. K. Bakhadyrkhanov, K. S. Ayupov, G. Kh. Mavlyanov, S.B. Isamov. Semiconductors, 44 (9), 1145 (2010).

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Online Publishing Hub

World Bulletin of Education and Learning (WBEL)

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https://worldbulletin.org/index.php/1

5. Shaghayegh Esfahani. Materials Science and Engineering University of Toronto. Solvent Refining of Metallurgical Grade Silicon Using Iron 2010.
6. M. K. Bakhadyrhanov, U. X. Sodikov, Kh. M. Iliev, S. A. Tachilin, Tuerdi Wumaier. Materials Physics and Chemistry, 1, 89 (2019).
7. Giyosiddin, M., Anvar, U., Islomshokh, Z., & Ulugbek, R. (2023, January). High photoconductivity of silicon with nanoclusters of manganese atoms to create efficient solar cells. In AIP Conference Proceedings (Vol. 2552, No. 1, p. 060009). AIP Publishing LLC.
8. Rustamkhon, M., Alawadi, A. H., Abbas, A. H., Jayashree, J., Santhi, G. B., & Kumar, J. R. R. (2024). Second-Life Applications of Electric Vehicle Batteries in Energy Storage. In E3S Web of Conferences (Vol. 540, p. 02011). EDP Sciences.