ISSN NO: 2770-4491
Date of Publication:24-06-2022

Possibilities of Creating Multifunction Sensors Based on Auto-Oscillating Current in Silicon

Kh.U. Kamalov[1], G.S. Nurimbetova[1], T.U. Kamalov[2], R.M.Asetullaeva[*], D.G.Bekchanov[*].
[1]Karakalpak State University named after Berdakh, Uzbekistan, Republic of Karakalpakstan,
[2]Teacher of information technology and mathematics at secondary state school specialized in mathematics, Uzbekistan, Republic of Karakalpakstan,
[*] Master of Physics, [1]Karakalpak State University named after Berdakh, Uzbekistan, Republic of Karakalpakstan,

Annotation: This paper demonstrates the possibility of manufacturing multifunction sensors based on the influence of external factors on the auto-oscillating current parameters in a nanocluster silicon material consisting of a margens atom.

Key words: nanocluster, silicon, multi-charged center, current self-oscillations, multifunctional sensor.

Today, the electronics industry is developing very rapidly around the world. This is due to the development of new properties of semiconductor materials and the development of new types of sensors. This is also due to the further improvement of existing sensors.

One such sensor is a multifunction sensor [1, 2]. The following is the principle of operation of multifunction sensors. We know that multifunction sensors can perform multiple tasks at the same time. Let's take a closer look at how these tasks can be accomplished.

The first sample was KDB single crystal silicon. The dimensions of the samples were machined to 0.1x0.3x0.8 cm. The samples were placed in a special quartz ampoule together with the introductory element and prepared for diffusion by creating a vacuum in the order of 10^{-4} mmHg.

Depending on the specific resistance of the sample, the diffusion temperature was selected in the range of 1000 ÷ 1200K. The diffusion process was carried out in a step-by-step low-temperature method [3,4]. Manganese atoms were selected as the introductory element to improve the photoelectric properties of silicon. This is because manganese atoms diffuse at low temperatures to form highly charged clusters. The main focus was on the charge state of the manganese atoms after diffusion [5,6].

The results show that manganese in silicon is a donor, and they are located near the B atom in the form of Mn^0, Mn^+ in n-type samples. in p-type specimens, Mn^+, Mn^{++} are located near the B atom. The position of the manganese atoms in this sample was determined by EPR and ASM methods.

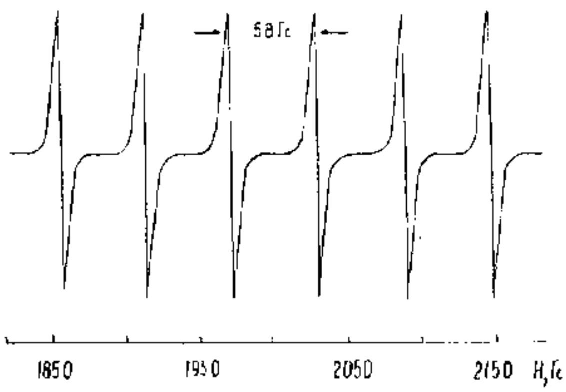


Figure 1. EPR spectrum depending on the individual margens atom.

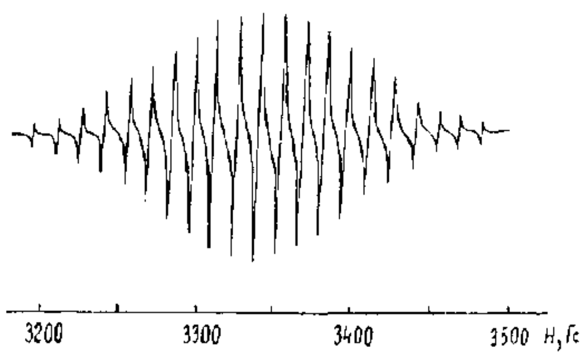


Figure 2. EPR spectral characteristics for a cluster of quaternary manganese

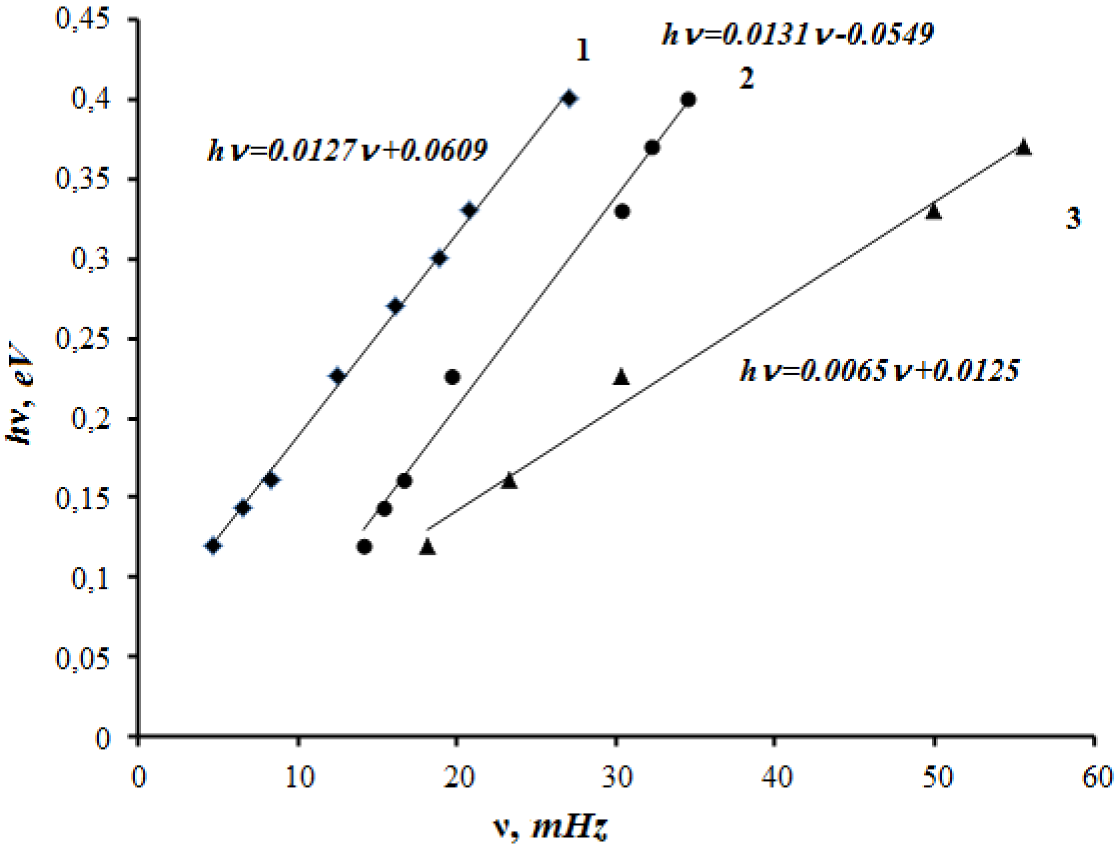
It was found that the parameters and shape of current oscillations generated in nanocluster silicon samples change depending on external factors. External factors include temperature, electric field, IR radiation energy, and radiation intensities. However, the current auto-vibration parameters changed depending on the initial electrophysical parameters of the observed samples and the specific resistances of the sample after diffusion.

In the studied samples, the auto-oscillation of the current occurs only when illuminated by IR light, and the frequency and amplitude of the oscillation depend on the light parameters.

The idea is to further develop multifunction sensors. Their main functions are to measure temperature, electric field strength, light energy and power.

In nanocluster samples consisting of manganese atoms, current autotranslations were observed in the range of 0.12 ÷ 0.43 eV of IR radiation energy, and the corresponding frequency (period) of current oscillations was determined due to changes in IR radiation energy [7]. This connection can be used to determine the energy of the incident light. However, the relationship between the IR radiation energy and the oscillation frequency differs in samples with different specific resistances. This means that the function of multifunction sensors is the same as that of photodetectors.

Figure 3 shows the relationship between the oscillation of the current and the incident energy in the samples with different specific resistances, and shows the equation of their relationship. If our sample has a specific resistance of $5 \cdot 10^{+3}$ Ohm · cm, then the relationship between frequency and energy is based on the law ***hν(ν)= aν+b =0,0127ν+0,0609***



1. $\rho=5 \cdot 10^3$ Ohm ·cm, 2. $\rho=2{,}2 \cdot 10^4$ Ohm·cm, 3. $\rho=8 \cdot 10^4$ Ohm·cm.

Figure 3. Dependence of spectral sensitivity of photoreceptors with different specific resistance on current auto-vibration frequency

The current-oscillating parameters observed in the nanocluster samples were found to change with temperature. Current self-oscillation was observed at the exact temperature range T = 100 K ÷ 150 K, and the presence of current auto-oscillation frequency corresponding to each temperature value was determined. The current dependence of the auto-oscillation frequency of the current generated in a sample with a specific resistance of $5 \cdot 10^{+3}$ Ohm · cm is shown in Figure 4 below.

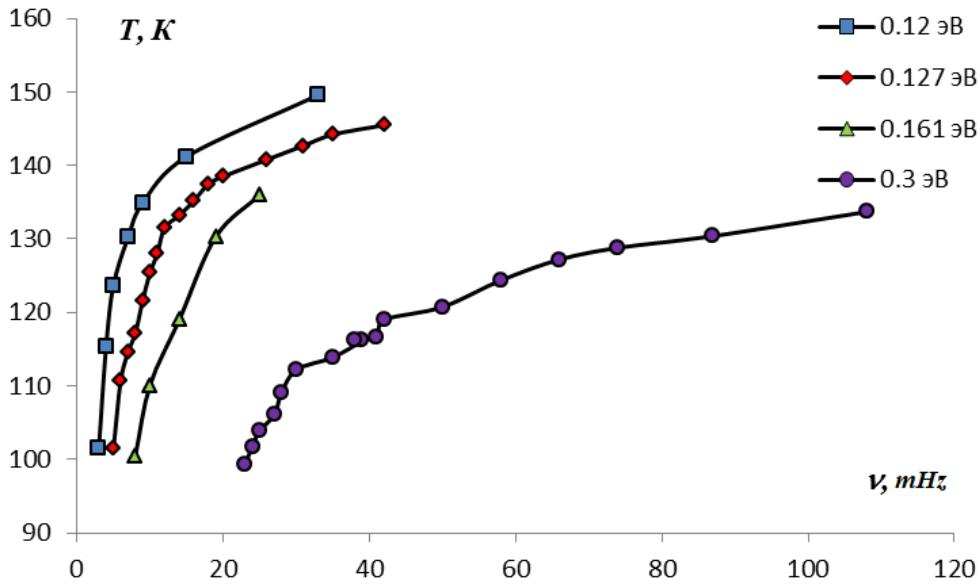


Figure 4. Temperature dependence of current oscillation frequency

As can be seen from Figure 4, the change in the frequency of the auto-oscillation due to changes in the temperature of the sample is subject to a certain law, and we can use this as a gradient for multifunction sensors. Different specific resistance samples can also be used to measure temperature. The difference is that the measurement limits for sensors with different specific resistances are defined.

Another feature of multifunction sensors is the detection of light intensity. This is because the parameters of the current auto-oscillations generated in nanocluster silicon samples also depend on the intensity of the light incident on it.

Figure 5 shows the dependence of the light intensity incident on the surface of multifunction sensors with different specific resistances on the frequency of the current auto-oscillation. In this case, the dependence of the luminous intensity of the sample with a specific resistance of $2.2 \cdot 10^4$ Ohm · cm on the frequency of the current auto-oscillation

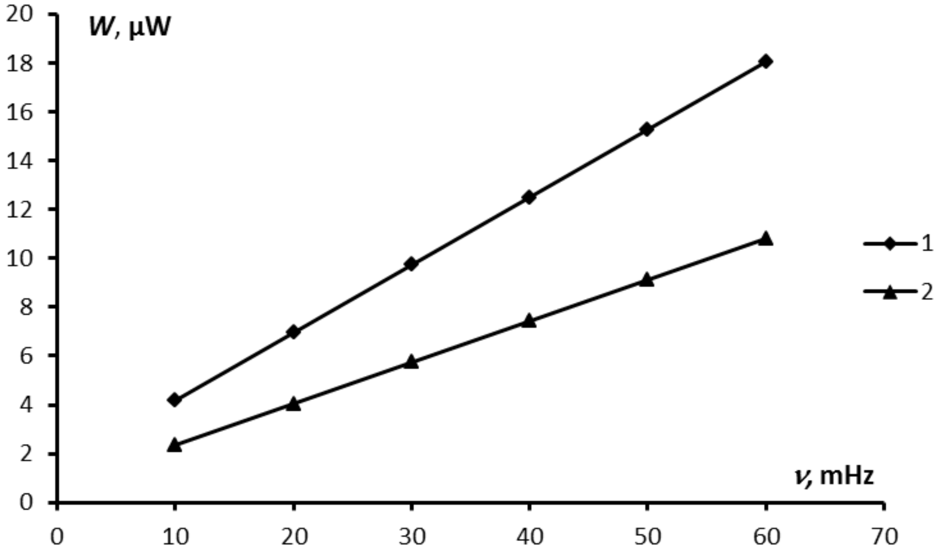
$$W(\nu)=a\nu+b=0{,}2773\nu+1{,}4076 \qquad (1)$$

varies according to the law, while the dependence of the sample on the specific resistance of $8 \cdot 10^4$Ohm · cm

$$W(\nu)=a\nu+b=0{,}169\nu+0{,}6693 \qquad (2)$$

subject to the law. It can be seen that the principle of operation of the sensor depends on the specific resistance of the sample. This is because the diffusion temperature varies when manganese atoms are introduced into the samples by low-temperature diffusion, resulting in a difference in the concentration of nanoclusters formed in the sample volume. Using formulas (1) and (2), the unit for measuring the light intensity of multifunction sensors was derived, and it is shown in Figure 5.

ISSN NO: 2770-4491
Date of Publication:24-06-2022



1. ρ=2,2·10^4 Ohm·cm, 2. ρ=8·10^4 Ohm·cm.

Figure 5 Temperature dependence of current auto oscillation frequency

The results of the study suggest that the value of the electric field applied to silicon nanocluster samples can be determined using the change in current depending on the electric field. Basically, the oscillations were observed between voltages E = 100 ÷ 300 V / cm. E <100 V / cm. no current oscillations were observed in [8].

The current observed in the samples varied with the change in field strength, and this relationship is shown in Figure 6, and the relationship between the field strength of the current oscillation frequency in the sample is shown in Figure 6.

$$U(\nu)=8082{,}6\nu+92{,}567V \qquad (3)$$

The change in the regularity of formula 3 was determined. This means that the relationship between voltage and vibration is linear. Figure 6 shows the change in the frequency of the auto-oscillation current generated in nanocluster silicon samples relative to the applied voltage. If you look at this formula 3; it was found that the frequency of the oscillation was 1.24 $\cdot 10^{-4}$ Gs when the voltage applied to the sample changed by 1 V.

ISSN NO: 2770-4491
Date of Publication:24-06-2022

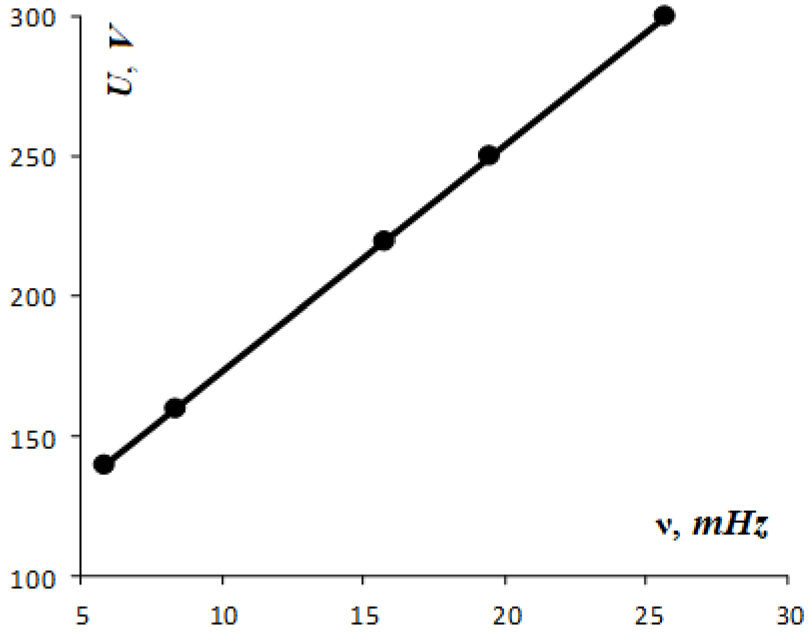


Figure 6. The voltage dependence of the current in nanocluster samples depends on the frequency of the auto-oscillation.

Conclusion:

1. Thus, it was found that in nanocluster silicon samples consisting of manganese atoms, it is possible to generate a stable and sufficiently high amplitude photocurrent. It is possible to use these solid-state generators in the form of quality sensors.
2. Knowing the parameters of the photodetector, it was found that the IR radiation energy acting on the current can be determined from the value of the auto-oscillation frequency.
3. Nanocluster samples have been shown to improve multifunction sensors. This is because it is possible to determine the change in temperature of the sample, the voltage of the electric field applied to it, the energy and power of the incident light by changing the frequency of the current.

References

1. A.A. Druzhinin, I.P. Ostrovsky, S.N. Matvienko, A.M. Wuyczyk. Multifunctional pressure and temperature sensor based on SiGe solid solutions. Technology and design in electronic equipment. 2005. No. 6. Pp. 24-26
2. A.B. Sadullaev., Highly sensitive magnetic field sensors based on highly compensated silicon, operating in the presence of background illumination. UNIVERSUM technical sciences 2018. No. 4 (49). S.1-4.
3. Bakhadyrkhanov M.K., Mavlonov G.Kh., Isamov S.B., Iliev Kh.M., Ayupov KS, Saparniyazova Z.M., Tachilin S.A. Electrophysical properties of silicon doped with manganese by low-temperature diffusion. Inorganic materials. 2011.T. 47.V. 5.P. 545-550.
4. Paul Shewmon. Diffusion in Solids Second Edition 2016. pp.246
5. Bakhadirkhanov MK, Zikrillaev NF, Isamov SB, Koveshnikov SV, // Photoelectric phenomena in silicon with multiply charged nanoclusters Monograph, TSTU. 2017. - S. 279.
6. Bakhadyrkhanov M.K., Ayupov K.S., Iliev H.M., Mavlonov G.Kh., Sattarov O.E. Influence of the electric field, illumination and temperature on the negative magnetoresistance of silicon doped according to the "low-temperature diffusion" method. Letters to ZhTF. 2010. T. 36. No. 16. S. 11-18.

ISSN NO: 2770-4491
Date of Publication:24-06-2022

7. Bakhadyrkhanov MK, Zikrillaev NF, Isamov SB, Kamalov Kh.U., Koveshnikov SV, Silicon-based photodetectors for the spectral region 3÷10 μm with frequency output with nanoclusters of manganese atoms ... // Devices. 2017. No. 6 (204). P. 12-15.
8. Bakhadyrkhanov M.K., Zikrillaev N.F., Isamov S.B., Kamalov Kh.U., Koveshnikov S.V., Khodzhanepesov K.A. Solid-state infra-low frequency generator with controlled parameters. // Devices. 2018. No. 3 (213). P. 1-5.
9. 9.Назирова Р. М. и др. Интенсивная технология NPK-удобрений на основе мытого сушёного концентрата центральных Кызылкумов //Проблемы современной науки и образования. – 2019. – №. 2 (135). – С. 6-11.
10. 10.Назирова Р. М. и др. Комплексные удобрения на основе местного сырья //Проблемы науки. – 2019. – №. 11 (47). – С. 25-28.
11. 11.Назирова Р. и др. Интенсификация процесса получения сложных удобрений из местного сырья. – 2019.
12. 12.Назирова Р. М. и др. Изучение физико-химических свойств добавок при производстве новых видов сложных стабилизированных удобрений //Universum: технические науки. – 2020. – №. 5-2 (74). – С. 69-73.
13. 13.Nazirova, R. M., et al. "Investigation of solubility kinetics and interaction of stabilizing additive in production of complex fertilizers based on granular nitrate and stabilizing additives." Academicia an international multidisciplionary research journal 10.5 (2020): 657-664.