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STUDY OF THE STRUCTURAL STRUCTURE OF IMPURITY MICROINCLUSIONS IN N-SI< NI,CU > SAMPLES

Annotation. The paper presents the results of studies of the electrical properties of Si samples doped with Ni and Cu. It was revealed that a decrease in the mobility of charge carriers in the temperature range of 120÷320 K is of particular importance in increasing the resistivity of the samples.

Keywords: silicon, nickel, copper, impurity, Hall effect.

Currently, the study of semiconductor materials with multicomponent accumulations of impurity atoms that have unique structural properties is of particular importance. In this regard, special attention is paid to the development of new technologies for producing semiconductor materials with impurity micro- and nanoinclusions [1-7]. In this work, the temperature dependences of the concentration and mobility of charge carriers, as well as the resistivity of n-Si<Ni> and n-Si<Cu> samples were studied using the Hall effect method on an Ecopia HMS-7000 device.

Si of the KEF brand with a resistivity of 0.3 Ohm·cm, grown by the Czochralski method, was used as the initial sample. Ni diffusion and Cu in Si were carried out in the SUOL-4M furnace at a temperature of T=1473 K for t=2 hours. The diffusion temperature was controlled using a platinum-platinum-rhodium thermocouple. After diffusion annealing, the samples were cooled at a rate of $\upsilon_{cooling}$

=200 K/s. The samples had the shape of a parallelepiped with corresponding dimensions of 5x5x2 mm. When measuring the electrical parameters of the prepared initial samples, as well as n-Si<Ni> and n-Si<Cu> samples, the temperature increased from 100 K to 320 K.

The graph of the temperature dependence of the resistivity of the original sample, as well as n-Si<Ni> and n-Si<Cu> samples shown in Fig. 1 shows that for the original sample and n-Si<Ni> samples these dependences have almost the same character. At a temperature of 100 K in the original sample the value of ρ is 0.135 Ohm·cm, and in n-Si<Ni> samples ρ=0.139 Ohm·cm. Then, with an increase in temperature to 120 K, these indicators decrease slightly (Fig.1, curves 1 and 3). With a further increase in temperature, they begin to gradually increase and upon reaching T=320 K, the value of ρ in the original samples increases almost 3 times and amounts to 0.37 Ohm·cm. In n-Si<Ni> samples at T=320 K, the value of ρ increases to 0.368 Ohm·cm.

The temperature dependence of the resistivity of n-Si<Cu> samples, in contrast to n-Si<Ni> samples, in the temperature range T=100÷320 K has a different form. At temperature T=100 K, the ρ value of these samples is 0.249 Ohm·cm. With a subsequent increase in temperature to T=120 K, it sharply decreases and amounts to 0.157 Ohm·cm. With a further increase in temperature, the value of ρ of n-Si<Cu> samples begins to gradually increase and at T=320 K it reaches 0.335 Ohm·cm (Fig.1, curve 2).

According to the results obtained, the concentration of charge carriers in the original samples at a temperature of 100 K is $n=6.27\cdot10^{15}$ cm^{-3}. When the temperature rises to 140 K, it increases almost 2.5 times. With a subsequent increase in temperature to 320 K, it remains practically unchanged. A typical picture is also observed in n-Si<Ni> samples. The n value of these samples at a temperature of 100 K is $6.24\cdot10^{15}$ cm^{-3} . When the temperature increases to 320 K, it reaches $1.7\cdot10^{16}$ cm^{-3}. In n-Si<Cu> samples, the value of n at a temperature of 100 K is $1.18\cdot10^{16}$ cm^{-3} . And when the temperature rises to 320 K, it increases almost 8 times.

The results of the temperature dependence of charge carrier mobility – μ in the original sample showed that at a temperature of 100 K it is 6228 cm^2 /V·s. at the same temperature for n-Si<Ni> samples the value of μ is 6890 cm^2 /V·s, and for n-Si<Cu> samples it is 2130 cm^2 /V·s. When the temperature increases to 120 K, the value of μ in the original sample increases and amounts to 6900 cm^2 /V·s, and in n-Si<Ni> samples it reaches 8100 cm^2/V·s. And with a subsequent increase in temperature to 140 K, the value of μ in these samples decreases sharply, and at a temperature of 320 K it is 1030 cm^2 /V·s and 1020 cm^2 /V·s, respectively. In contrast, for n-Si<Cu> samples at a temperature of 120 K, the value of μ increases sharply and amounts to 4660 cm^2 /V·s. A further increase in the temperature value to 320 K leads to a decrease in this value to 211 cm^2 /V·s.

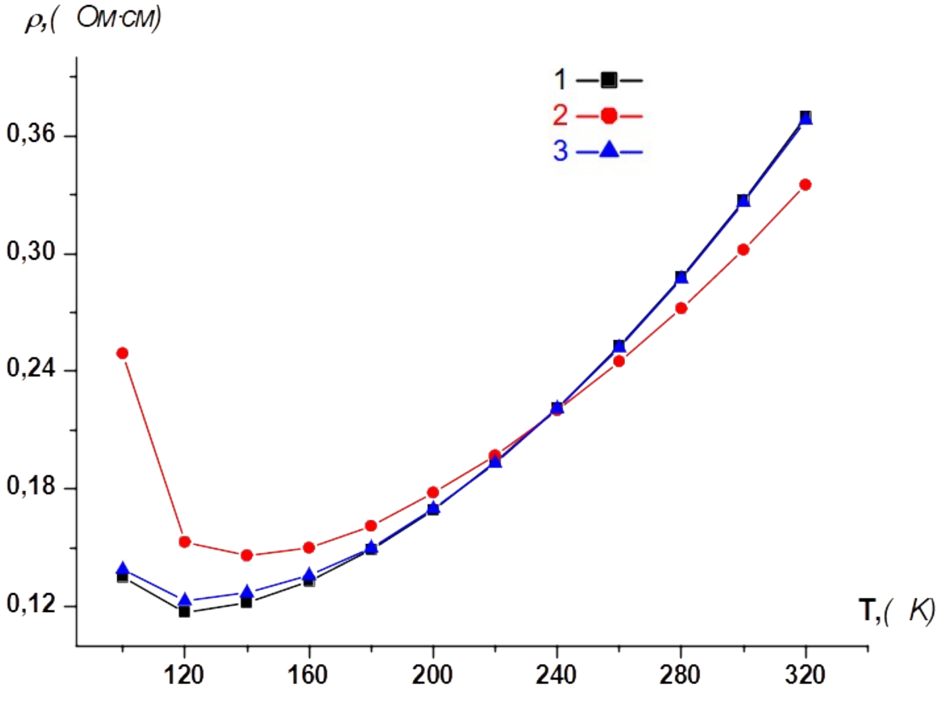

__Fig.1.__ Temperature dependence of resistivity: 1 - initial sample; 2 - n-Si<Cu> samples; 3 - n-Si<Ni> samples.

Thus, it was revealed that the electrical properties of n-Si<Ni> samples in the considered temperature range compared to n-Si<Cu> samples have distinctive characters. The resistivity of n-Si<Cu> samples in the temperature range 120÷320 K increases by ~2 times, while this figure for n-Si<Ni> samples increases by more than 3 times. In this temperature range, the concentration of charge carriers in n-Si<Cu> samples increases almost 8 times, and in n-Si<Ni> samples this value increases almost 2.5 times. In this case, the mobility of charge carriers in n-Si<Ni> samples decreases by 7–8 times, and in n-Si<Cu> samples it decreases by more than an order of magnitude. Consequently, it turns out that the increase in the resistivity of n-Si<Cu> and n-Si<Ni> samples in the temperature range 120÷320 K mainly depends on the decrease in the mobility of charge carriers.

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