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TEMPERATURE DEPENDENCE OF TRANSISTOR CHARACTERISTICS OF ELECTRIC SIGNAL AMPLIFICATION IN OPTOELECTRONIC DEVICES

***Abstract**: The article discusses the results obtained in determining the temperature dependence of the characteristics of a semiconductor transistor designed to amplify electrical signals. In particular, the voltage drops across the currents determined by the temperature increase was determined to be used as a parameter to measure the platform temperature, as well as the unusual nature of the direct current in certain temperature ranges was determined. can be used in the generation and amplification of signal oscillations, as well as in variable circuits.*

***Key words**: optoelectronic devices, signal amplification, semiconductor transistor, temperature, current and voltage, emitter, collector, base, charge carriers, differential resistance, reverse mode, electron-hollow pair.*

***Language**: English*

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Introduction

Optoelectronic systems depend on a platform to obtain, collect and process complete and accurate information about the environment. The platform consists mainly of semiconductor devices, and the reception and processing of the required signals depends on the physical properties of the semiconductors, which are manifested under certain conditions. These features make it very sensitive to external influences, for example, transistors designed to amplify electrical signals can heat up during operation. This leads to a deterioration in the characteristics of the transistor. Special cooling radiators are used to prevent overheating. However, if the signal receiving platform is an integral part of the devices, the signal transmission area is applied externally, for example, in the field of road control. In both cases, the mental transport platform operates in the process of ambient temperature, humidity, and other external influences. For example, in the hot summer environment of Uzbekistan, the temperature is around 50°C. Such thermal conductivity of semiconductor devices, for example, negatively affects the operation of transistors designed to amplify electrical signals. In this regard, in the scientific laboratory of the Andijan Machine-Building Institute studied in practice the temperature dependence of the characteristics of semiconductor transistors designed to amplify electrical signals.

Results and discussion

Figure 1 shows the voltage dependence of the current in the correct direction in the base-emitter (*a*) and base-collector (*b*) fields at different temperatures. In both cases, we can see that the voltage (U) shifts parallel to the left at the p-n junction as the temperature increases. In both cases, $I_{p\text{-}n}$ increases with increasing temperature I_0. In operating mode, the $qU<\Delta W$ indicator is negative and $I_{n\text{-}p}$ increases with increasing temperature. In this case, the input characteristics of the transistor for I_{n-p} shift to the left with a value of ΔU=1÷2 *мВ/℃*. The results we obtained are consistent with these considerations. In this case, the temperature coefficient of voltage for the current in the transistor under study is ε_U~2 *мВ/℃*, as in the case of diode structures. In our case, ε_U decreases linearly from 2,2 *мВ/℃* for the base-emitter field to 1,3 *мВ/℃* for the base-collector field from 1,3 *мВ/℃* to 0,6 *мВ/℃*. In this mode, a current value higher than 10 mA must be selected. In this case, the temperature sensitivity of the voltage drop across both transitions takes constant values. That is, the voltage decreases linearly with increasing temperature, which may allow them to be used as a temperature measurement parameter.

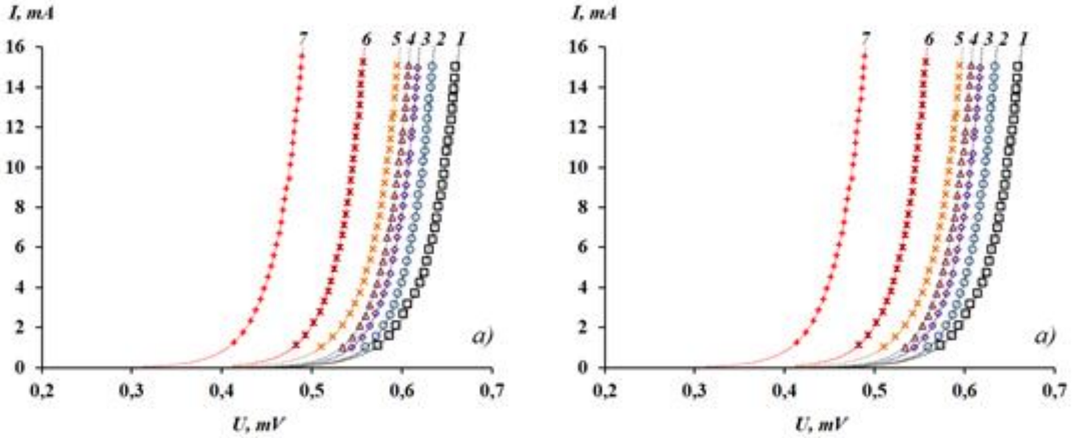

Figure 1. The correct direction of the base-emitter (*a*) and base-collector (*b*) fields at different temperatures depends on the voltage of the current: 1 – 25°C, 2 – 35°C, 3 – 50°C, 4 – 65°C, 5 – 75°C, 6 – 100°C, 7 – 150°C.

[1] found that the formation of electron-cavity pairs with increasing temperature and changes in the energy distribution of charge carriers lead to a decrease or increase in the dark current in silicon-based p-n-structures. However, although the characteristics of a silicon-based transistor have been sufficiently studied, the temperature dependence of the direct current in its base-collector junction has not been fully studied. For example, most of the literature (cited in the literature references [2-5]) suggests that the current and voltage dependence shifts to the left with increasing temperature. In this regard, it is interesting to study in detail the temperature dependence of the correct directional current in the base-collector transition of a silicon-based transistor.

In this study, the temperature dependence of the maximum value of I_{p-n} for the base-emitter and base-collector fields was carefully analyzed. Studies show that their temperature dependence varies. For example, a constant change and a sudden increase were observed for the base-emitter field in the range T~25÷150°C. In the base-collector field, however, abnormalities, such as decrease, sudden increase, and constant change, have been identified. To evaluate such an unusual change in I_{p-n}, the temperature coefficient of the current $\alpha_I=\Delta I/\Delta T$ was determined. For the base-emitter field, α_I decreases exponentially with temperature. For the base-collector field, the change in α_I was found to correspond to the temperature dependence of I_{p-n}.

It should be noted that some properties of the p-n structure or transistors depend on the physical parameters of the transitions [1, 6-11]. In addition to the temperature coefficient of the current transition considered, the physical parameters also include the differential resistance of the transitions. Although it has a small value, it varies according to the temperature. Also, as the temperature increases, the potential barrier height at the base-emitter and base-collector junctions decreases, the formation of electron-cavity pairs increases, and the energy distribution of the charge carriers changes (e.g., electrons occupy relatively higher energy levels in the conduction band). leads to a decrease in resistance. This leads to an increase in current within certain temperature ranges for both cases. It should be noted that despite the increase in electron-cavity pairs formed in the p and n fields, the mobility of charge carriers decreases due to the increase in thermal vibrations of the crystal lattice at certain temperature ranges [1, 7, 8]. This increases the differential resistance, which leads to a steady change of I_{p-n} in the base-emitter and base-collector fields or a decrease in I_{p-n} for the base-collector field.

An unusual change in the current in a certain range of p-n-junctions under consideration may allow it to be used in the generation and amplification of oscillations, as well as in alternating circuits.

When studying the reverse mode characteristics of the base-emitter and base-collector fields, it was observed that at the set temperatures in both cases the current does not change with increasing voltage in the reverse mode of p-n-junctions. It should be noted that in many studies (e.g., [1, 3-5], as well as see the references given there), the temperature sensitivity of the base-collector p-n-pass reverse current was observed. However, in our case, at 25÷150 °C, the base-collector p-n-junction reverse current is partially increased at small (1 V small) values of voltage, then the current increase is almost imperceptible with increasing voltage. That is, the current does not change when the temperature increases from 25°C to 150°C, α_I is found to tend from 0.5 to zero. As mentioned above, this property may depend on the physical parameters of the transistor base-emitter or base-collector p-n-junctions. Base-emitter or base-collector p-n-junctions In the reverse mode, the transitions act as a current limiter, while in the correct connection mode, the current decreases linearly with increasing temperature. Together, these processes form a base-emitter or base-collector p-n - transition volt-ampere characteristic.

Conclusion

Thus, the decrease in voltage at currents determined by the increase in temperature can be used as a parameter to measure the platform temperature, as well as the unusual nature of the direct current current in certain temperature ranges to generate oscillations on the platform to obtain complete and accurate environmental information and can be used in amplification as well as in variable circuits.

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