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Thermal Sensitive Parameter Of The Field Transistor In Current Limit Mode

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Abstract: *In the article, a field-effect transistor with a p-n junction observed in the forward current limiting mode has a temperature sensitivity determined by the process of current formation and, to a certain extent, by the level of carrier injection.*

Keywords— field-effect transistor, bipolar transistor, thickness, p-n-junction, channel-region, current transfer, bipolar transistor.

1. Introduction

The studies known to date have been carried out on rectifying diodes and bipolar transistors. Based on the study of semiconductor diodes of the KD503A and KD102A types, it was found that the temperature coefficient of the conversion slope in them is 0.6 ÷ 0.7 mV / ° C and they can be used as a temperature converter for an electric motor. In another work, it is proposed to use p-n-junctions of industrial diodes such as D220, KD522A and GD507A as a temperature sensor. However, these diodes have large dimensions and capacitance, which limits the possibility of their use in automation devices, in devices of modern measuring technology. The best indicators of the temperature coefficient based on semiconductor diodes and a discrete bipolar transistor are 2.3 ÷ 2.6 mV / ° C.

2. Materials and methods

However, there is still no information about studies carried out on the basis of a field-effect transistor and mechanisms for controlling the temperature coefficient of their parameters. Also, the possibilities of using a field-effect transistor for a new purpose in unconventional switching modes remain poorly studied. The change in the forward bias value that falls at the gate-source junction is taken as a temperature-sensitive parameter, as shown in the diagram in Figure.1.

3. Main part

The operating voltage is regulated by a resistor R_1, and the current through the rectifying junction is limited by a resistor R_2. The difference between a field-effect transistor and diode and bipolar transistor structures is that the thickness of the base region (channel) has a fixed value, and the carrier concentration in the gate region ($1 \cdot 10^{19} sm^{-3}$) is two to three orders of magnitude higher than in the channel region ($2 \cdot 10^{15} sm^{-3}$), which guarantees the sharpness of the p-n transition.

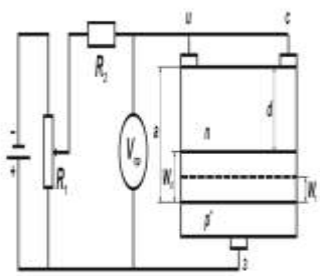
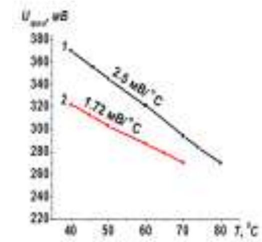


Figure: 1. Scheme for measuring the temperature-sensitive parameter gate-source transition.



1 - cut-off voltage 1.2 V and supply voltage 4.9 V; 2 - cut-off voltage 1.2 V and supply voltage 2.3 V;

Figure: 2. Dependences of the forward voltage drop of a diode-connected field-effect transistor on temperature.

Figure 2. the dependences of the falling voltage at different supply voltages of the diode through the resistance R_2 - current limiter are given. Curve 1 was obtained for a sample with a cut-off voltage of 1.2 V at a supply voltage of 4.9 V, and curve 2 at a supply voltage of 2.3 V.

As can be seen from Fig. 2. at the same supply voltages (4.9 V), the temperature coefficients of the falling voltage (curves 1 and 2) have the same values = 2.5 mV / ° C, and a decrease in the supply voltage leads to a decrease in temperature sensitivity. In this case, the value of the incident voltage is higher in the sample with a lower cutoff voltage (curve 1).

The difference between a field-effect transistor and a diode lies in the fixed value of the thickness of the base region-channel, which contributes to the coverage of the base region by a space charge layer in the blocking mode. That is, in the forward bias mode, we also have processes due to the recombination of carriers in a specific base region. In a conventional diode, the base thickness is not limited and creates a series resistance with respect to the pn junction, which, due to an additional voltage drop across it with a change in recombination currents, weakens the sensitivity of the structure with respect to the contact potential difference. With regard to a field-effect transistor, in the case of the base region thickness determined by the contact potential difference, it would allow achieving maximum temperature sensitivity. Accordingly, when using a material with a larger (band gap) contact potential difference, the measurement accuracy will increase and at the same time the temperature coefficient will increase.

Due to the fact that the forward current through the pn junction is set limited, an increase in temperature leads to a decrease in the falling voltage. In this case, a change in the ratio of the forward current to the saturation current provides a controlled change in the temperature coefficient. In this case, it becomes possible to identify temperature coefficients from a set of samples.

Thus, in the forward current limiting mode, a pn junction field effect transistor has a temperature sensitivity determined by the current transport mechanism and a controlled level of carrier injection. The obtained value of the temperature sensitivity of the forward falling voltage (2.5 mV / ° C) is not inferior to the values that occur in diode and transistor structures, and the miniature design of the field-effect transistor allows it to be used to determine the temperature in narrow gaps of various devices and equipment. Comparison of the temperature coefficients of the cutoff voltage with the temperature coefficient of the drop voltage indicates that in both cases they are related to the magnitude of the cutoff voltage. In forward bias mode, the temperature coefficient is determined by the ratio of forward current to reverse current, that is, its value is controlled. In this case, in samples with a lower cut-off voltage, the drop voltage has a greater value, which increases the measurement accuracy.

4. Conclusion

Thus, the temperature coefficients of the FET are inversely related to the thickness of the base region and are physically controllable. In the forward current limiting mode, a pn junction field effect transistor has temperature sensitivity determined by the current formation process and, to a certain extent, by the carrier injection level.

5. References

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