Perfecting technology for producing thermistors at VNIIFTRI

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Abstract. In this work characteristics of the thermistors, created by the method developed in VNIIFTRI were investigated. Parameters of thermistors are studied, dependences of their properties on manufacturing techniques are revealed.

Task this work is debugging of the production technology and also studying properties of thermistor depending on parameters of their manufacture. It will allow to improve characteristics of wattmeter on their basis, processibility production and also to reduce marriage percent.

The objective of this work is to debug production technology, as well as studying the properties of temperature resistors, depending on the parameters of their manufacture. This will improve the performance of power meters based on them, the manufacturability production, as well as reduce the percentage rejects.

Measuring the power electromagnetic waves is one of the main types of measurements in the microwave range. Measurement microwave power using thermistor converters is carried out by replacing the power of high-frequency electromagnetic waves absorbed in a thermistor by direct current power. This ensures the traceability of the microwave power unit to the standards of the basic physical quantities - voltage and DC resistance. Also, a feature thermistor converters is high linearity and stability over time [1].

For this reason, thermistor converters underlie almost all national microwave power standards of leading foreign countries [2].

In the Russian Federation, to date, high-frequency thermistors have not been produced. In the USSR, several types of thermistors were produced for use in power converters, but the upper frequency of commercially available coaxial thermistor converters did not exceed 12 GHz. The production technology of high-frequency thermistors in the Russian Federation has been lost. This circumstance makes it difficult to improve the existing state primary, secondary and working microwave power standards, and hinders the development of new generation working microwave power standards of the through-type (power calibrators). This leads to high relevance of the work.

The properties of a thermistor are affected by many parameters: the content of each of the three components its composition, the type of plasticizer burned, the heating rate the furnace, the annealing temperature, time, aging temperature, and many other parameters. Changing only one of them changes the properties of products.

The manufacturing of the first batches of thermistors was carried out in a short time and by limited forces, and the production cycle of one batch of products takes at least a week. Due to these reasons, it
was not possible to investigate the influence of all technological parameters, and they were not optimized.

In this paper, we studied the influence the following technological parameters:
- manganese content in the working fluid;
- maximum annealing temperature;
- furnace heating rate;
- aging time.

The development of three-component systems is complicated by the fact that much more experiments are required to study their properties. Therefore, due to the complexity and high cost the production process at this stage, it was decided limit ourselves to studying the effect of manganese in the manganese-copper-cobalt system. In the experiment, equal mass parts of copper and cobalt were used, and only the mass concentration of manganese was changed. The result of the experiment can be seen in Figure 1. With a decrease in the mass fraction of manganese, the linear resistance initially decreases, then stabilizes at a certain value.

![Figure 1. Dependence of the linear resistance of the thermistor on the mass fraction of manganese in its composition](image)

The annealing temperature of thermistors dramatically affects their characteristics and appearance. The composition of the working fluid of a thermistor can include 3 phase components - an unreacted mixture of oxides, an oxide melt and the so-called spinel solid solutions - three-component polycrystalline structures that are semiconductors [3]. Spinel formation begins at a temperature unique to each composition. Therefore, when the percentage composition of the components changed, it was necessary to select the sintering temperature again. When the filament overheats by 10 degrees, it melts, and at a temperature below the optimum by 10 degrees, the working fluid still consists of a sintered mixture of oxides, and is practically an insulator. The furnace heating rate does not play a significant role.

![Figure 2. External differences of the working fluid filament when changing the annealing temperature by 30 degrees.](image)
It is also planned to study the dependence of the properties of thermistors on the content of cobalt and copper, to study the possibility of accelerating the aging process. To optimize some other technological processes.

As a result of the work, the influence of the listed parameters on the resistance and microstructure of thermistors was established. Charts are constructed that allow the method of interpolation to optimize technological parameters for future products. Refined data obtained in early experiments. The production flowchart has been simplified.

References.

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