THE RESISTIVITY CHANGES AFTER HIGH VOLTAGE PULSE TREATMENT

Pavlik Rahnev Rahnev

Bourgas Free University - Department for Informatics, Engineering and Natural Science
Bourgas - 8000, "Aleksandrovska" 101,BULGARIA
rahnev@bfu.bg

Abstract

In this work the variation of parameters in resistive materials under high voltage transients are described. The subject of the study are thin, thick and bulk resistors and the characteristics being studied are the resistance and temperature coefficient. Possible mechanisms of changes - structural, chemical are also discussed.

1. INTRODUCTION

A main problem in power resistors is the reliability of their parameters. Resistors should operate under extreme electrical stresses – high voltage, high current density, and finally – high power (high temperature). Although some of these external factors could act for very short time(pulses), the changes in the resistors could be irreversible. That is why the homogeneity of the resistive materials is one of the more important factor determining the resistor stability.

A common way to adjust the resistor values is by cutting (removing) part of the materials. It is Known that this procedure has several drawbacks. An alternative method for the trimming of resistor values is to use electrical pulse treatment leading to structural changes in the materials.

In this context it is interesting to study the influence of the electric fields applied simultaneously and their effect on resistors adjustment.

2. SAMPLES PREPARATION

2.1 Bulk resistors

The bulk ceramic resistors from boron carbide are prepared using conventional hot pressing process. The temperature and pressure are in the range of 2200°C and 20 ATM. The duration of the sintering process is approximately about 15 min. After the preparation the samples are carefully cleaned from graphite and then the external contacts are made.

2.2 Film resistors

To prepare the film resistors commonly used techniques are the thin and thick film technologies (thin film deposition and screen printing respectively). As a material for

thin films technique the nichrom (Ni : Cr = 80 : 20) is preferred, because of its low temperature coefficient(less than 1ppn.K^{-1}). The final contacts on NiCr are 1:5 µm Ni and Au. To prepare thick film resistors the classical BiROX pastes are used with sheet resistance of 10 ohm/sq. and Ag/Pd low ohms contacts.

In Figure 1 the typical construction methods of the resistors are shown.

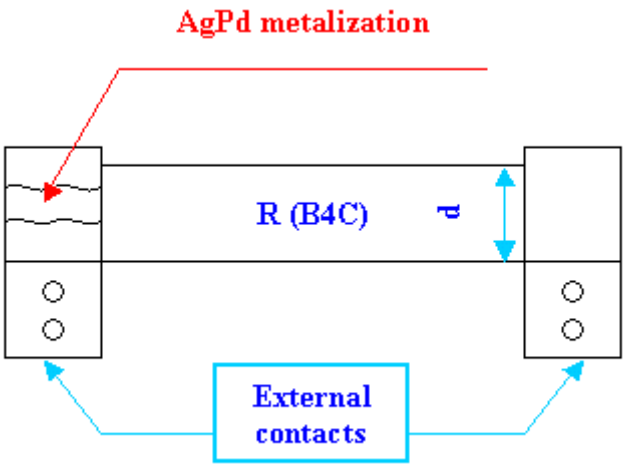


Figure 1a. Bulk ceramic resistor.

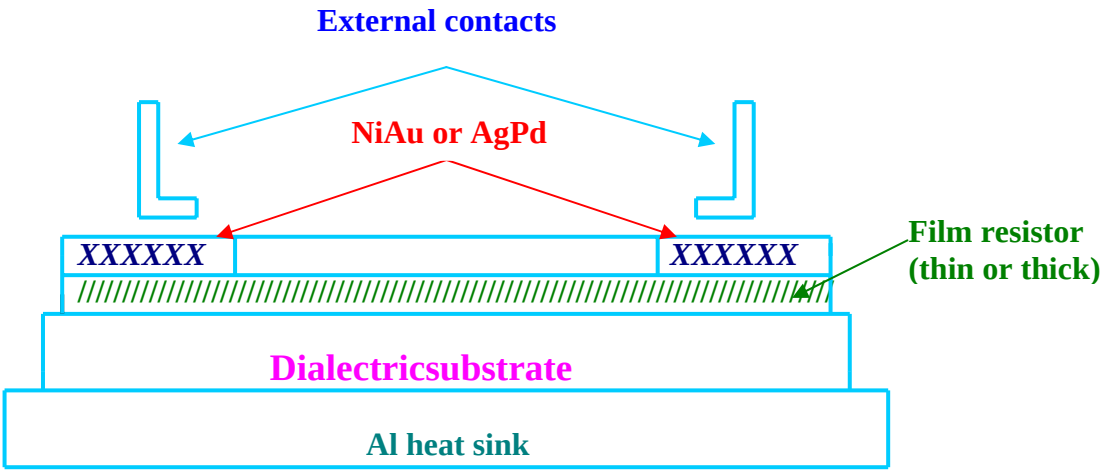


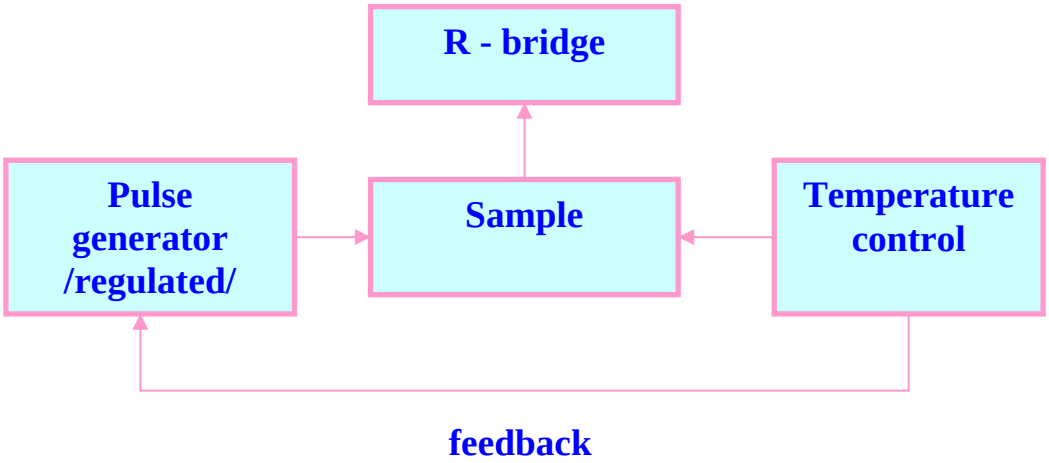
Figure 1b. Film resistors.

Through this process non inductive resistors are produced with the following parameters:

- bulk ceramic - Rn = 2 ÷ 10 ohms, TCR = -1000 ÷ -1200 ppm.K^{-1};
- thin film NiCr – Rn = 10 ÷ 100 ohms, TCR ≤ + 50 ppm.K^{-1};
- thick film BiROX - Rn = 10 ÷ 100 ohms, TCR ≤ 100 ÷ 150 ppm.K^{-1}.

3. EXPERIMENTS

The main characteristics of the experiments is to apply high voltage pulses for very short time preventing the heating of the resistive materials. This means that only electric field will act on the properties of the resistors. The block diagram of the experiment is shown on the Figure 2.



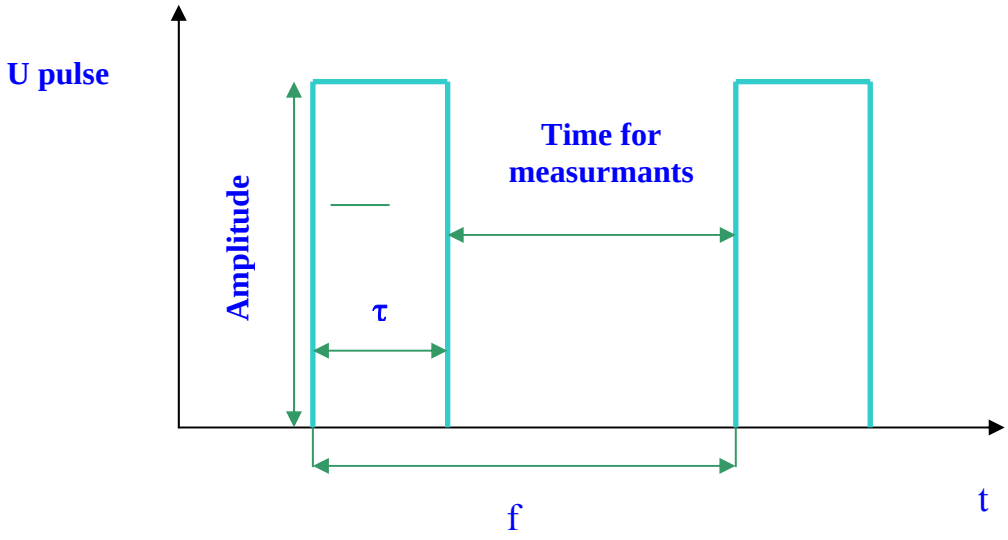


Figure 2.

In practice rectangular pulses are used with amplitude between 100 ÷ 150 V, frequency 100 ÷ 1000 kHz and duration τ = 1 μs. Essential features of the equipment is the temperature control unit where the total heating of the resistors can be measured and the process of pulse treatment can be stopped.

4. RESULTS

After treatment of the samples for a time duration between 10 min and 60 min the changes of the resistance and TCR are observed. The typical curves are presented on Figure 3.

Examining these curves three zones could be determined:

- Zone I showing significant change of the resistance (decrease of the nominal value)
- Zone II showing small change of the resistance
- Zone III showing continuous increase of the resistance. It could be mentioned that the behavior of the samples is not identical, but the changes are common for three groups of materials.

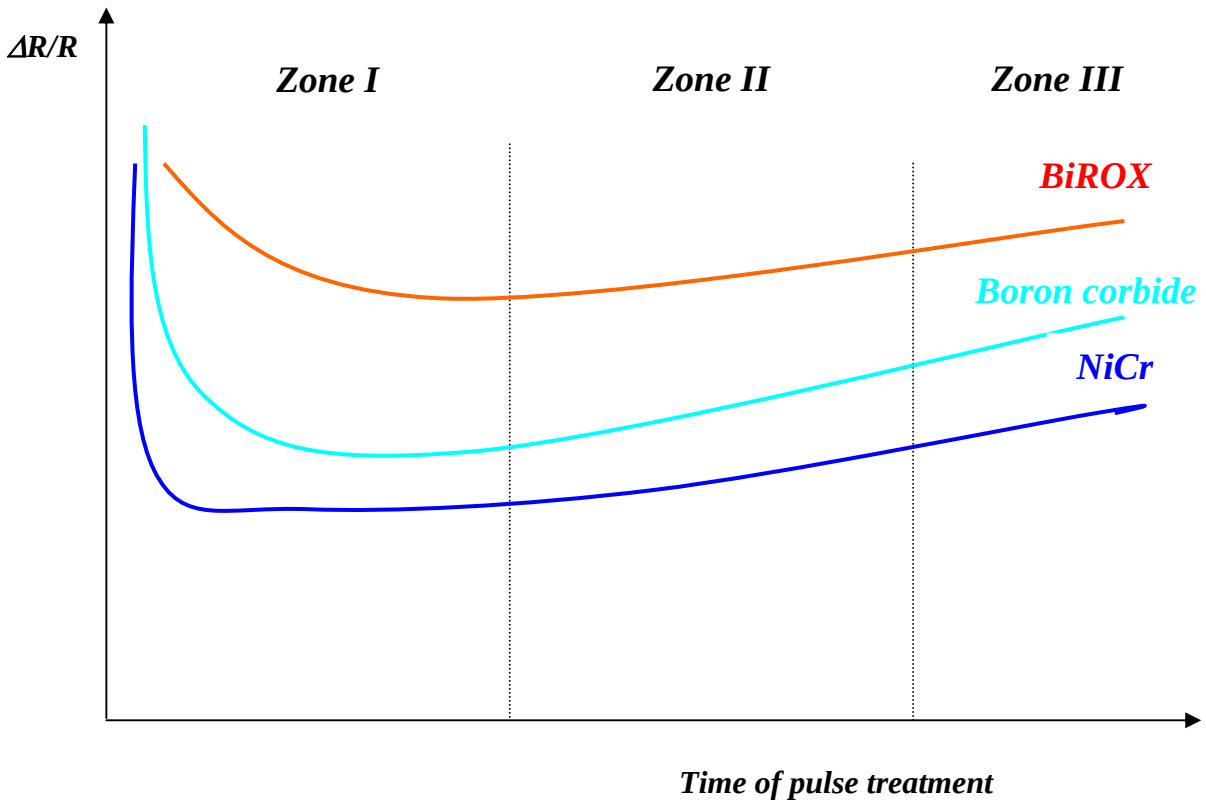


Figure 3.

5. DISCUSSION

The presence of the Zone I could be explained by the homogenization of the structure as a result of the high electric field and local (in very small areas) heating. Next zone (II) of relatively stable work shows that the process is almost finished and other structural changes could not be expected. Zone III is interesting, showing an

increase of the resistance. It should be mentioned that the samples are of low resistance value and contact resistances are not taken into account. The obtained changes with electric pulse treatment are not reversible. The experimental results show that the fact that resistance values can be increased or decreased without using mechanical treatment (i.e. etching)

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