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**Comparison of Trophet-A and Evanohm-R
Alloys for Producing Thin Film Nichrome
Resistors**

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Comparison of Tophet-A and Evanohm-R Alloys For Producing Thin Film Nichrome Resistors

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1. Introduction

Vamistor Corp, a small business located in Sevierville, TN, produces discrete, precision resistors for defense and commercial applications. These resistors are made by depositing a thin film of a nickel/chromium alloy onto the inside surface of a glazed ceramic tubes. This filming process, which actually produces the current carrying component of the resistor, is perhaps the most crucial and sensitive of the manufacturing processes used to produce these resistors. The present manufacturing process uses a commercially available nichrome alloy, Tophet-A, with a nominal composition of 80% Ni, 20% Cr. The thin resistive film is applied by sublimation caused by passing current through the wire. Vamistor Corp. would like to replace this wire with a more electrically stable alloy, Evanohm-R, with a nominal composition of 73% Ni, 20% Cr, 2.5% Al, and smaller amounts of Cu, Si, and Mn. This alloy has been shown to have a lower temperature coefficient of resistance than the Tophet wire and to be more stable following heat treatments. The purpose of this study was to evaluate the resistance stability of thin films produced using Evanohm-R wire compared to those produced by Tophet-A. If greater stability was demonstrated further steps would then be taken to develop resistor manufacturing processes using this Evanohm alloy.

2. Experimental Plan

A set of thin film deposition runs were performed using both Evanohm and Tophet-A wire types by the procedure outlined below:

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1. Select three Nichrome resistor values for the experiment: one low resistance value and one high resistance value. All rated for 1/4 watt power.
2. Prepare two coating rigs with new wire and two with old wire. The new wire diameter should be ~11% larger than the old wire diameter in order to maintain an approximately constant resistance per unit length during deposition.
3. Load each rig with 30 resistors, label each resistor with a unique identification number.
4. Perform thin film coating run per existing procedure.
5. Measure resistance and temperature coefficient of resistance (TCR) for each resistor. Record values on an experiment run sheet with the part identification number.
6. Perform stabilization heat treatment per existing procedure.
7. Repeat resistance and TCR measurements. Record values on the run sheet.

3. Experimental Results

The distributions of resistance values obtained immediately following deposition, but prior to stabilization heat treatment are plotted in Figs. 1 through 4. The resistance distributions for both the high and low resistance thin films prepared using the new, Evanohm wire showed a much greater variation in resistance than did the films produced from old, Tophet wire. The average value and standard deviation for the Evanohm films was 419 ± 338 ohms, compared to 303 ± 30 ohms for the films produced using Tophet alloy. The greater average value obtained for the Evanohm alloy can be explained in part by the greater inherent resistivity of the Evanohm alloy (800 ohms/cm) compared to the Tophet alloy resistivity (650 ohms/cm). For the low value resistors there was greater difference in the average values, but less variation in the distribution of resistances measured. The resistors produced using the Tophet alloy had average and standard deviations of 10.2 ± 1.5 ohms, compared to those films produced with Evanohm alloy with values of 30.4 ± 4.2 ohms, respectively.

It is also interesting to compare the effect of post deposition, stabilization heat treatment on the resistance distributions for thin films produced using the two wires. These distributions, for low

resistance values, are shown in Figs. 5 and 6. Average and standard deviations after heat treatment for the Tophet alloy resistors was 11.2 ± 1.5 ohms; and for the Evanohm alloy resistors was 24.9 ± 3.3 ohms. Heat treatment after deposition resulted in a small increase in average resistance for the Tophet wire and a moderate decrease for the Evanohm wire. The spread of the resistance distribution was unchanged after heat treatment for the Tophet alloy resistors and decreased slightly for the Evanohm alloy resistors.

4. Discussion and Recommendations

The purported advantages of the Evanohm alloy were not observed in this preliminary study. This experiment showed that under the deposition conditions used the Evanohm alloy produced a significantly greater variation in resistance of the as deposited thin films than the Tophet alloy currently in use for producing resistors. There are several potential reasons for the observed variation. Most likely was the deposition parameters (i.e. the current and time used in the sublimation process) used to produce the Evanohm films. The parameters used to produce these films were essentially the same as those used in production for the Tophet alloy films. However, the resistivity and composition of the two alloys differ considerably and as a result the optimum deposition parameters for the two alloys also differ considerably. A first order attempt was made to account for the resistivity differences in the experimental plan, but this still did not result in optimum deposition conditions for the Evanohm alloy. Therefore, it is recommended that a broader screening experiment designed to determine the optimum operating conditions for the Evanohm wire be preformed prior to continuing with the comparison between treatments originally envisioned here.

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Fig. 1 Resistance distribution for low resistance, Tophet-A alloy before stabilization heat treatment.

Fig. 2 Resistance distribution for low resistance, Evanohm alloy before stabilization heat treatment.

Fig. 3 Resistance distribution for high resistance, Tophet-A alloy before stabilization heat treatment.

Fig. 4 Resistance distribution for high resistance, Evanohm alloy before stabilization heat treatment.

Fig. 5 Resistance distribution for low resistance, Tophet-A alloy after stabilization heat treatment.

Fig. 6 Resistance distribution for low resistance, Evanohm alloy after stabilization heat treatment.

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