Quantification of the Contact Resistance of Piezoresistive Sensor using the Impedance Spectroscopy

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Abstract: The contact resistance of the wire connected to the piezoresistive structural sensor (PRSS) was investigated using impedance spectroscopy (IS). Equivalent circuit for the PRSS was developed. The test results showed that the contact resistance changed with the applied stress. The contact resistances of cylindrical and circular disk PRSS were determined as 71 Ω and 12 Ω respectively and were very small compared with the bulk resistance of the PRSS.

1. Introduction

PRSS developed in the CIGMAT research laboratory is a self monitoring (smart) structural material with improved structural properties and can be made in any size and shape for various application requirements. The sensitivity of the PRSS sensor is defined as the change in specific resistivity ($\Delta\rho/\rho_o$) corresponding to unit change in applied stress. IS is a useful tool to analyze the electrical properties of materials and their interfaces with electronically conducting electrodes and it is especially good when the composite matrix is moderately conductive and added conductive fillers are highly conductive (Campo et al 2002). Contact resistance is the resistance at the electrode interface with the composite and it is a very important parameter as it can affect the measurements taken using the electrodes.

In this study, contact resistance of PRSS of different shapes and thicknesses were investigated using the IS.

2. Objectives

The overall objective of this study is to quantify the contact resistance of the PRSS of different shapes and sizes

3. Impedance spectroscopy

Impedance spectroscopy (IS) is a useful tool for characterizing the electrical properties of composites. IS analysis were performed by varying the frequency of the applied AC signal from 0.1 Hz to 1 MHz and measuring the corresponding impedances of the PRSS.

4. Analysis and Discussions

Designed equivalent circuit of the PRSS, shown in Figure 1, represents the different elements of the system. In the equivalent circuit R_m represents the bulk resistance of the composite and R_c and C_c represent the resistance and capacitance of the electrode contacts respectively. The total impedance of the equivalent circuit model is given as

$$Z = R_m + \frac{2R_c}{1+\omega^2 R_c^2 C_c^2} - j\,\frac{2\omega R_c^2 C_c}{1+\omega^2 R_c^2 C_c^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

From (1), when the frequency is very small, $\omega \to 0$, $Z = R_m + 2R_c$ and when the frequency is very high, $\omega \to \infty$, $Z = R_m$.

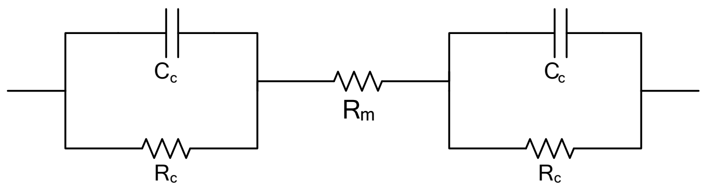

Figure 1. Equivalent circuit model of the PRSS

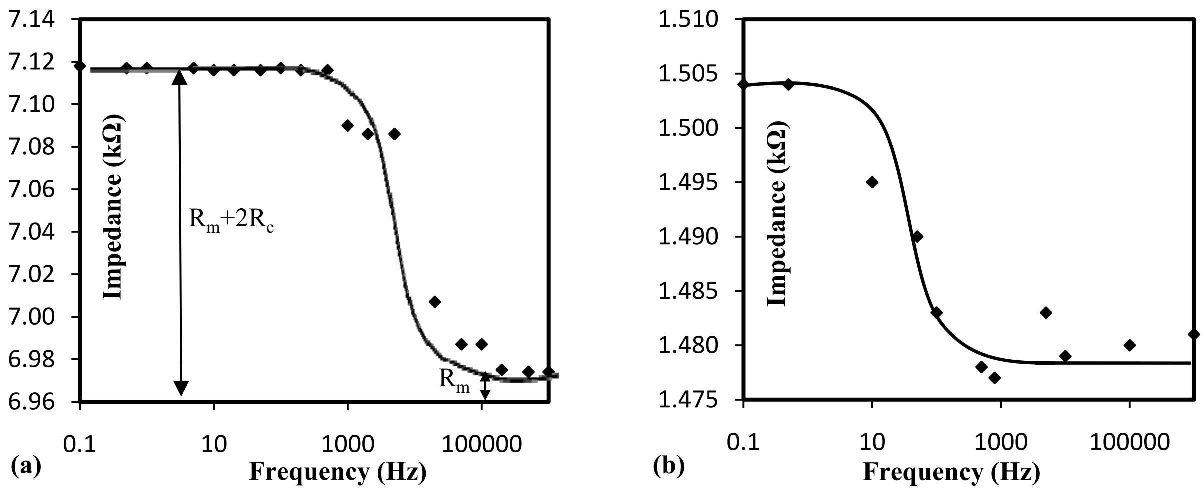

Figure 2.(a) Bode plot of the cylindrical PRSS (b) Bode plot of the circular disk PRSS

The contact resistances of the cylindrical and circular disk PRSS specimens were obtained as 71 Ω and 12 Ω respectively. The bulk resistances of the cylindrical and circular disk PRSS specimens were 7.12 kΩ and 1.5 kΩ respectively. The contact resistance is 0.1% and 0.8% of the bulk resistance for the cylindrical and circular disk PRSS respectively. IS results also showed that there is a small variation in contact resistance with the applied stress. This could be due to changes occurring in the composite side of the interface under the stress.

5. Conclusions

Contact resistances were very small compared with the bulk resistances of the PRSS. The change in resistance using DC resistance measurement is used as the sensing parameter of the PRSS, so the contact resistance's effect on the sensitivity of the PRSS is negligible.

6. Acknowledgement

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7. References

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