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Effect of Curing Process on Sensing Performance of Paint Sensors for Temperature Measurement

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1. Introduction

Thermal factors could affect the satellite is mission success potential and thermal interpretation is essential to fulfill the missions[1]. Temperature sensors are installed for satellite thermal control[2]. However, in the case of a commercially available temperature sensor, the shape is limited. Due to the limited shape, it is difficult to measure the curvature and the position must be taken into account in the satellite design phase. The film type temperature sensors have been studied to solve the disadvantages[3]. Thin film type temperature sensors can measure curved surfaces, but it is not easy to use the size and shape desired by the user. Therefore, the possibility of the temperature sensor is confirmed through the advantage of smart paint which is not limited in shape and size[4].

To compensate for the disadvantages of the commercialized temperature sensor, a paint type temperature sensor was fabricated. Experiments were conducted to optimize the manufacturing process of paint. The characteristics of resistance change according to the curing method during the manufacturing process were derived.

2. Experimental details

A polymer solution having an appropriate viscosity was used to prepare the paint used for the test. The solution was prepared by mixing DMF(N-N Dimethylformamide) and PEO(Poly-ethylene oxide). $BaTiO_3$ powder was added to the polymer solution. This material is the main material of PTC thermistors and enables temperature measurement. After $BaTiO_3$ powder was dispersed, Ag was added. The added Ag is for electrical conductivity. This process has completed the manufacture of paint capable of temperature measurement. The prepared paint was applied with a commercially available brush. The substrate was cured in a convection oven. The curing temperature was room temperature, 50 ℃ and 100 ℃, and the curing time was 12 hours, 24 hours and 48 hours respectively. A total of nine test samples were produced.

The chamber was used to create a high temperature environment. The change in resistance with temperature was measured. The experiment proceeded linearly from about 25 ℃ to about 200 ℃. The temperature change inside the chamber was measured with a K-type thermo-couple. The test sample was placed in the center of the chamber and the changing resistance was measured using the electrodes at both ends of the test sample. The temperature measurement and resistance change measurement were experimentally designed to be performed at the same time.

3. Experimental Results

Noise in the resistance measurement affects the accuracy of the sensing. To confirm this, Fig. 1 shows the resistance that changes as the temperature rises. Fig. 1(a) is the result of a rest samples cured at room temperature for 12 hours, 24 hours and 48 hours. The three conditions continued to rise from an initial temperature of about 25 ℃ to a final temperature of about 200 ℃. Also, the measurements were stable. Fig. 1(b) show the results of the test samples cured at 50 ℃ for 12 hours, 24 hours and 48 hours. The resistance of the 50 ℃ environment also increased steadily to about 200 ℃. The most stable measurement is obtained when the curing time is 24 hours, and the most unstable measurement is obtained when the curing time is 48 hours. Also, when compared with the measurement results obtained by curing at room temperature, it can be confirmed that noise is relatively generated in all three measurement results. Fig. 1(c) is the result of a test sample cured at 100 ℃ for 12 hours, 24 hours and 48 hours. When the temperature is increased to about 200 ℃, the resistance is continuously increased. The most stable measurement was obtained when the curing time was 12 hours, and the most unstable measurement was obtained at 48 hours. However, compared with the result of hardening at 50 ℃, it shows comparatively stable measurement results, and a 12 hours, it shows similar results to that of room temperature.

The resistance change affects the sensing resolution. Fig. 2 shows the resistance change of six test samples. The resistance change was the highest in the test sample cured for 12 hours in the environment of 100 ℃. However, in the case of the test samples cured in the environment of 100 ℃, the resistance change rapidly decreased after 24 hours. It is possible to obtain a result that the sensing

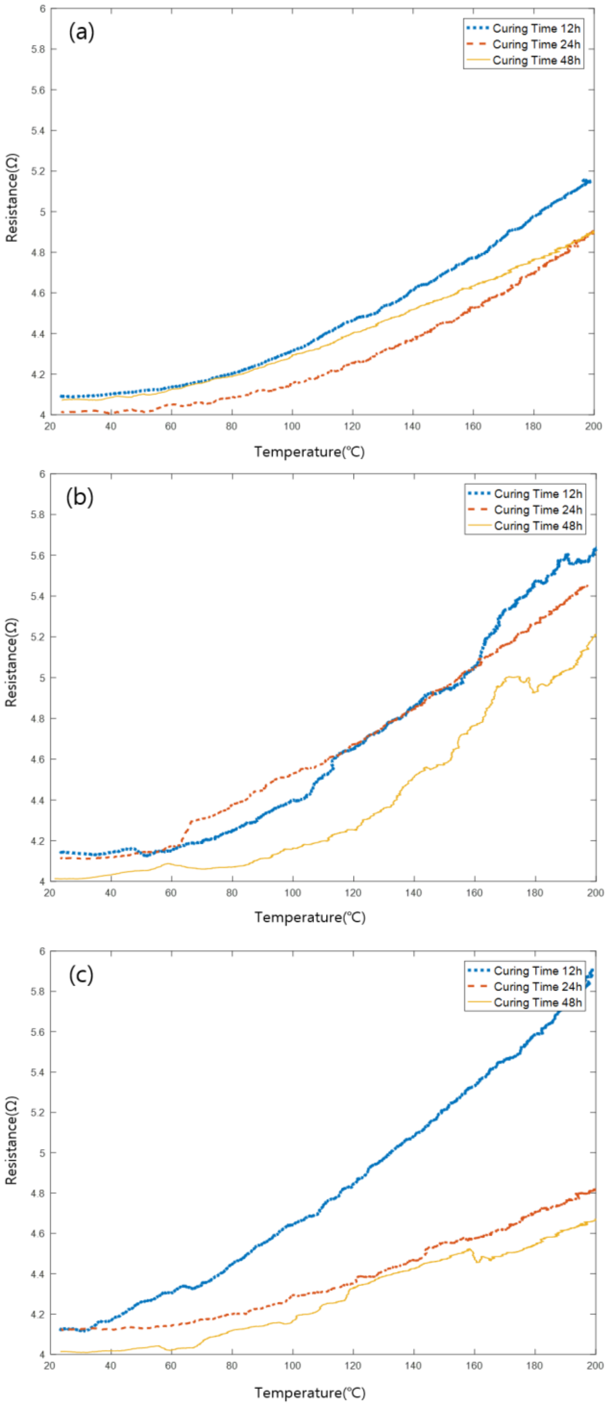

Fig.1 The resistance history of the test samples with increasing the temperature: (a) Room temperature, (b) Curing temperature 50 ℃, (c) Curing temperature 100 ℃.

resolution is lowered when a long time exposure is performed in an environment of 100 ℃ or more. Test samples in a 50 ℃ environment showed a higher resistance change than test samples cured at room temperature. In the case of the test samples cured at room temperature and 50 ℃, the change in the resistance change is small over time. This can lead to the conclusion that long exposures under these conditions have no significant impact on resolution.

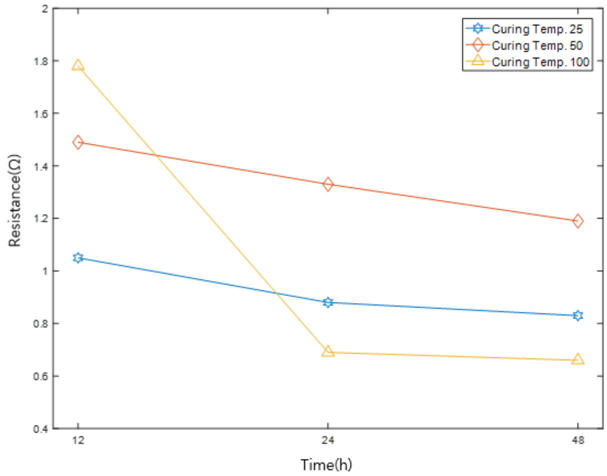

Fig.2 The resistance change of the test samples.

4. Conclusions

In this paper, temperature measurable paint was prepared and conditions for curing temperature and curing time were given during the manufacturing process. The measurement stability and the sensing resolution were confirmed by the experiments conducted through these conditions. Curing at room temperature and curing at 100 ℃ showed relatively high stability. The sensing resolution was the highest at 12 hours at the curing temperature of 100 ℃, but the resolution was drastically decreased afterwards. In the case of test samples that were cured at room temperature and 50 ℃, there was little change in resolution over time. The results show that the initial curing is carried out at 100 ℃ for 12 hours, which is the most efficient paint sensor, and that the manufactured paint sensor can be stored at less than 50 ℃.

References

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