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Humidity sensor characteristics of Woodceramics

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The humidity sensor characteristics of Woodceramics were investigated. The Woodceramics used in this experiment were baked at 650-900℃. The size of specimens with 1×1×10 mm was selected. One was as-cut,the other was polished its sections. Above 700℃,the resistance of the specimen was below 50 Ω and the decrease of resistance with relative humidity increase was little. The specimen baked at 650℃ had about 1k Ω. The resistance of as-cut specimens decreased with increase in relative humidity, but resistance of the polished specimen did not almost change.

An SEM was used for observation of micro-structure . Hollow structure was found on the surface of the as-cut specimen.

1. INTRODUCTION

Porous carbon Woodceramics (WCS) materials are likely to find application in many fields such as self-lubricating and electromagnetic shield materials [1] . The resistance hygroscope utilizes the change of resistance caused by the adsorption of vapor. Various porous materials are used in hygroscopes, but no research on the applications of WSC to humidity sensors has been conducted so far. Carbon materials have been used for resistance hygroscope, but their use has not become widespread due to its low resistance and large hysteresis [2] .

WCS can be used for practical humidity sensor because of the practical manufacturing advantage it offers. One of these is that the specific resistance can be changed by varying the sintering temperature. Another advantage is that WCS can be formed finely either before or after sintering.

We examined the relationship between relative humidity and resistance, and observed the surface of specimens using an SEM and investigated their microscopic structure .

2. TEST METHOD

WCS sintered at 650 to 900℃ were used for specimens. We assumed that specimens should be made as thin as possible to increase the rate of vapor adsorption and desorption, and to lower the hysteresis. We therefore used specimens of approximately 1 mm^2, which is the minimum size that can be made using a diamond cutter, with a length 10 mm.

Figure 1 shows the relationship between the sintering temperature and resistivity. The figure shows that the resistance of specimens sintered at 650℃ was approximately 1k Ω. This resistance is adequate for conversion to electrical signals.

The condition of the specimen surface is likely to greatly affect the sensitivity. To compare the sensitivity, we produced two types of specimens. One was made by cutting WCS with a diamond cutter and applying no other process (hereafter called 'as-cut'), the other type was made by cutting WCS with a diamond cutter, then polishing its surface with #1000 sandpaper to size 1 × 1 × 10 mm (hereafter called 'polished'). To observe the surface of the two types of specimens, we used an SEM.

The condition of the surface of a specimen is also expected to affect the specimen density and volume resistance. We measured the density and resistance of the specimens, which were assumed to be parallelepipeds, and compared them with the bulk values.

Figure 2 shows the structure of the experimental WCS humidity sensor. To prevent the hysteresis from increasing, the vapor had to be adsorbed or desorbed from four sides of a WCS chip; therefore, we did not attach the WCS chip directly to the slide-glass, but separated it from the slide-glass using copper wires of 1 mm diameter. We used silver paste to adhere the WCS to the copper wires.

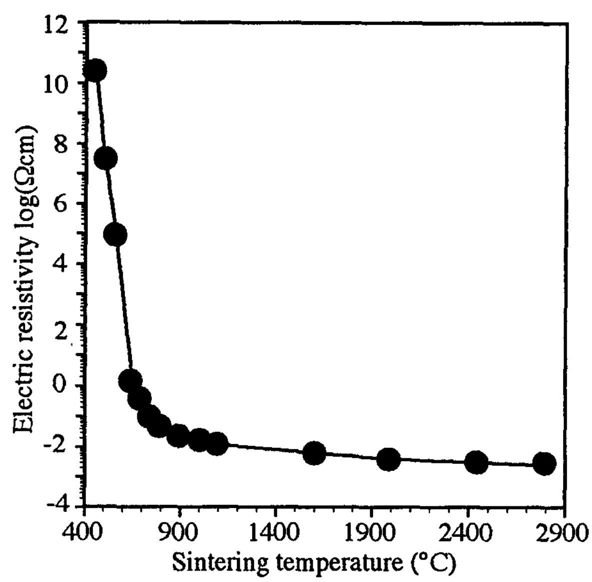


Figure 1. Relationship between sintering temperature and resistivity

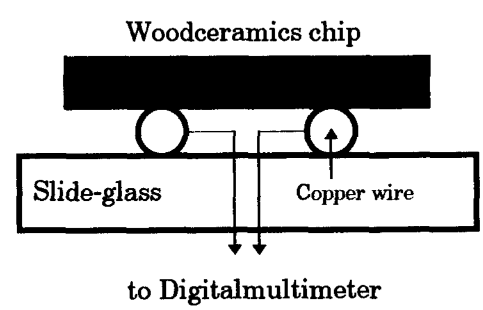


Figure 2. Structure of humidity sensor

We constructed a vinyl-covered box of approximately 1×1×0.7 m and measured the relative humidity and resistance inside this box. We used a digital multimeter to measure the resistance, and an Assmann ventilated psychrometer, which is the most reliable type of device, to measure the relative humidity.

3. RESULTS AND DISSCUSSION

The resistance of the specimens made from WCS sintered at above 700℃ was not more than 50 Ω, a value which changed little as the humidity changed.

The resistance of as-cut and polished specimens made from WCS sintered at 650℃ were both approximately 1 k Ω, but polished specimens had low sensitivity. On the contrary, the resistance of the as-cut specimens decreased as relative humidity increased, and increased as the humidity decreased.

Figure 3 shows the relationship between relative humidity and resistance. The resistance decreases linearly as the humidity increases from 40% to 80%, and the hysteresis is small for this humidity range.

These results suggested that the condition of the specimen surface greatly affects the sensitivity, so we investigated this characteristic in greater detail. We accurately measured the sizes of the specimens and calculated the densities and volume resistivities, assuming that the specimens were complete parallelepipeds. We compared the calculated results with the bulk values.

Table 1 lists the results. The values of polished specimens were almost equal to the bulk values. The as-cut specimens had a slightly larger resistivity than that of the polished specimens, and their density was only about 80%. We consider that the resistivity of the as-cut specimen is lager because it has

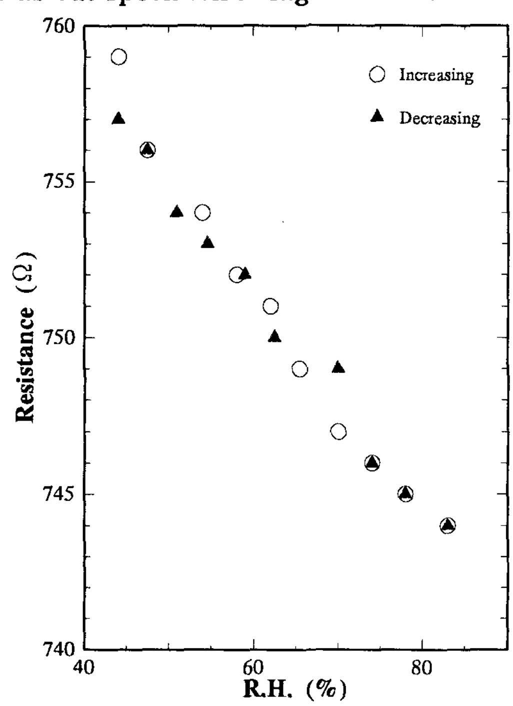


Figure 3. Relationship between relative humidity and resistance

Table 1.
WCS Specimen density and resistivity

	Density(g/cm^3)	Resistivity(Ω cm)
As-cut	0.76	13
Polished	0.94	11
Bulk	0.95-1.0	10-20

many hollows on the surface, which reduces the apparent density and narrows the conductive range. The actual surface area of as-cut specimen is also considerably larger than that of the polished specimens because of these hollows.

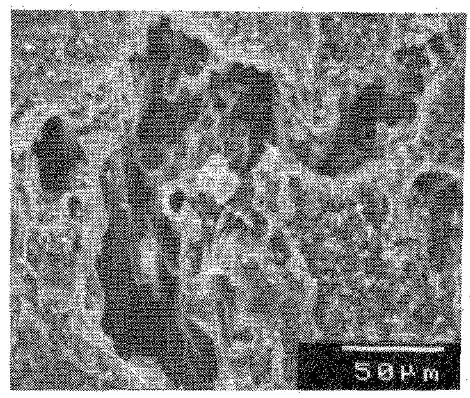
Figure 4 shows the SEM photographs of the surfaces of the polished and as-cut specimens. The surface of the polished specimen is smooth, whereas the surface of the as-cut specimen has many hollows. However , the hollows are not joined. We believe that the humidity sensitivity of the WCS is caused by the presence of these hollows, but the mechanism is not clear.

4. CONCLUSIONS

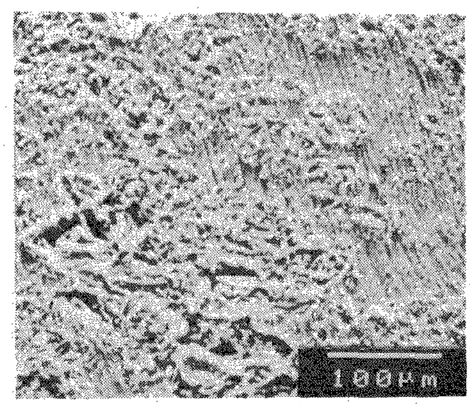
From the experiments, we draw the following four conclusions:

1. The WCS resistance decreases as the as relative humidity increases, and increases the humidity decreases.
2. The WCS sintered at 650℃ also has a higher sensitivity and 1 k Ω which adequate for conversion to electrical signals.
3. As-cut specimens have greater sensitivity than polished ones.
4. The surface of an as-cut specimen has many hollows. We believe that WCS is sensitive to humidity because of the presence of these hollows. The hollows also increase the actual surface area.

However, the hollows are not joined. To increase the sensitivity, we must research how to produce joined hollows on the sensor surface and a cleaning method that allows the sensor to be used repeatedly.



(a) As-cut specimen



(b) Polished specimen

Figure 4. SEM photograph of surface

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