# ELECTRICAL CONDUCTIVITY OF CARBON-COATED CERAMIC FIBER COMPOSITES

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## Introduction

The carbon-coated ceramic fiber composite (CCFC) is a porous monolith composed of ceramic fiber as a substrate and carbon coated on the substrate. The CCFC becomes an adsorbent material by activation useful for hazardous gas removal [1]. Since carbon is electrically conductive, the CCFC may be regenerative for desorption by Joule heating using an electrical current passed through the composite. Here, we present the preparation of the CFCC and the results of electrical conductivity measurements.

## Experimental

Alumino-silicate ceramic fibers chopped to a few millimeters in length were used as a support for carbon coating. The ceramic fibers have no porosity and the nominal diameter of 3 ㎛. Preforms of CFCC were prepared using a vacuum molding process. The chopped fibers were mechanically slurried in water, and phenolic resin powder was added to the water-fiber mixture. The slurry was vacuum molded into disc shape of about 50mm in diameter and 10mm in thickness. After drying and curing of the molded samples, carbonization of phenolic resin binder was achieved up to 850℃ in flowing $N_2$. Soon after the samples carbonizing arrived at the carbonization temperature of 850℃, they were activated in a mixture of steam-$N_2$ flow at the temperature for 30 minutes. The ratio of steam and $N_2$ was varied to yield different burn-off. In this way ceramic fiber filters coated with various amount of activated carbon were obtained. Carbon content of a CFCC sample was measured by weight loss after the burning off the coated carbon in air. Electrical resistance of rectangular samples cutted from the disc shaped CFCC was measured at room temperature by two-probe method using a digital multi-meter (DMM). The ohmic contact between the sample and the probe was achieved with a silver paste.

## Results and Discussion

Fig. 1 is the typical microstructure of a CFCC sample. The ceramic fibers are coated with activated carbon produced from melted phenolic resin which forms smooth rounded coating around ceramic fibers. Results of mercury porosimetry for the filter samples showed mono-dispersed macropore size distribution. Sizes of macropores formed by carbon coated ceramic fibers were in the range 20-120 ㎛. Average size of macropores varied around 42-52 ㎛, depending on the condition of sample preparation. As shown in Fig. 2, electrical conductivity of the sample increases from 0.07 S/cm to 0.5 S/cm, as the carbon content per one gram of sample increases from 54 mg/g to 183 mg/g.

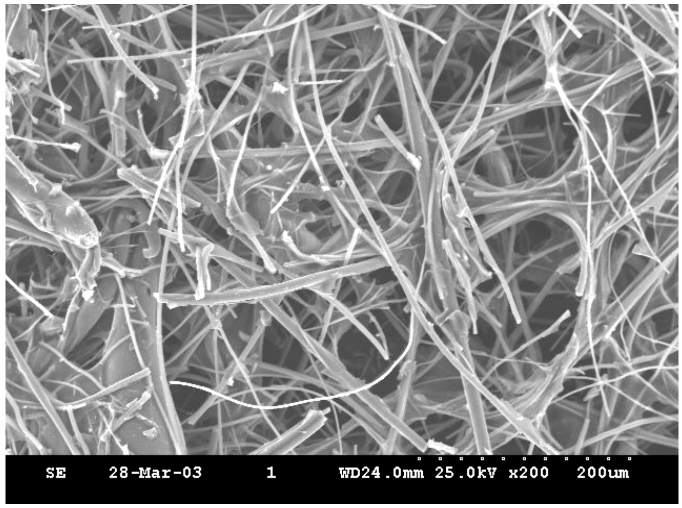


Fig. 1. Microstructure of a CFCC sample.

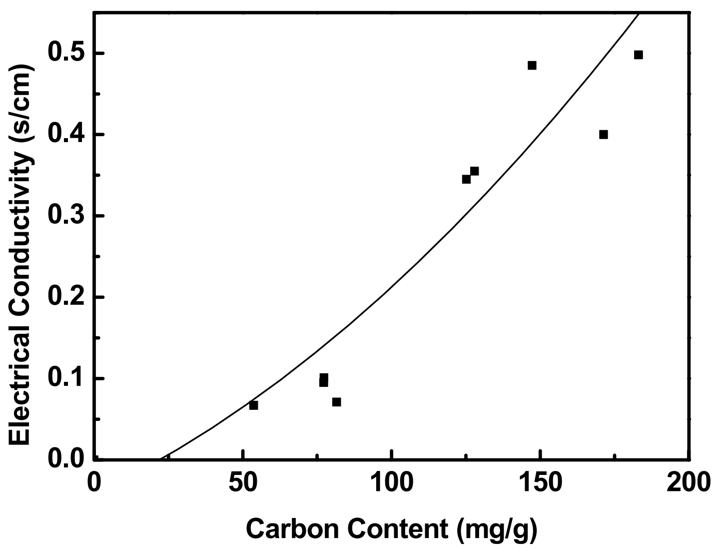


Fig. 2. Electrical conductivity of CFCC samples.

These values of the CFCC samples electrical conductivity are between two and one order of magnitude lower than the ones prepared by carbon fibers and phenolic resin [2].

As the carbon content of the CFCC is lower, the electrical conductivity decreases more rapidly. This may be attributed to contact resistance of the phenolic resin-derived carbon coating.

The effective electrical conductivity of the coated-carbon in a CFCC plate sample was estimated by assuming that the plate consisted of electrically non-conductive ceramic fibers coated with conductive activated carbon parallel to current flow. Then, the measured effective resistance $\mathbf{R}_{eff}$ for the carbon coated fiber media can be expressed as

$$\mathbf{R}_{eff} = \rho_{eff} \cdot L/A \qquad (1)$$

where $\rho_{eff,}$ L and A are the effective resistivity, the electrode distance and the cross-sectional area of a plate as shown in Fig. 1, respectively. Using $X_{SiC} = A_{fiber}/A$ , $X_P = A_P/A$ and $X_C = A_C/A$, the effective conductivity according to the series rule of mixtures is expressed as [3]

$$\sigma_{eff} = 1/\rho_{eff} = X_{fiber} \cdot \sigma_{ifiber} + X_P \cdot \sigma_P + X_C \cdot \sigma_C \qquad (2)$$

where $A_{fiber,}$ $A_P$ and $A_C$ denote the fractional cross-sectional area of the ceramic fiber, pore and carbon layer, $A_{fiber} + A_P + A_C = A$, $X_{fiber,}$ $X_P$ and $X_C$ are the volume fractions of the ceramic fiber, pore and carbon phases, and $\sigma_C$ and $\sigma_{fiber}$ are the electrical conductivities of the carbon and ceramic fiber phases at room temperature, respectively. Using the data shown in Fig. 1, the electrical conductivity of the coated-carbon was estimated as 56 S/cm. This conductivity is considerably lower than that of other known carbons.

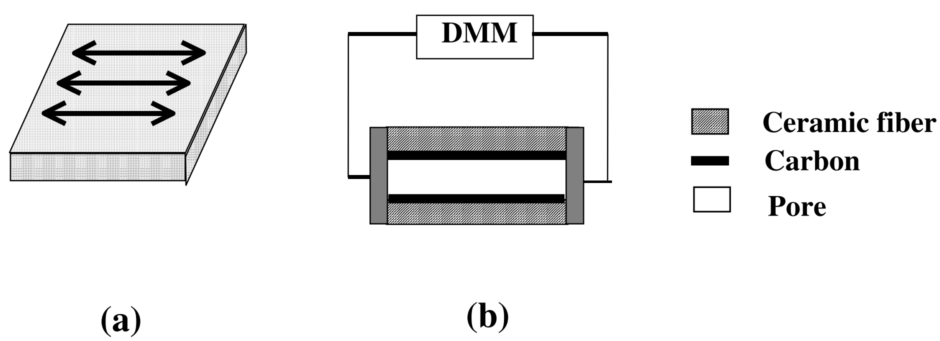


Fig. 3. A parallel circuit model for the calculation of an effective electrical conductivity. (a) a plate of CFCC sample and (b) a parallel circuit model.

## Conclusions

A porous monolithic carbon-coated ceramic fiber composite (CCFC) has been prepared that has lower electrical conductivity than the conventional carbon fiber composites. By varying the carbon content of a CFCC, it is possible to choose the appropriate voltage for the desorption of adsorbed gases by Joule heating using an electrical current passed through the composite.


## Acknowledgement

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