MICROSTRUCTURE INFLUENCE ON ELECTRICAL PROPERTIES OF CARBON-CERAMIC COMPOSITES

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Introduction

Electrical properties place composites in great demand as components in ordinary and power electronic circuits. Carbon-ceramic composites, medium sintered, include various structural elements, which perform well-defined functionalities. A combination of the structural elements, arranged in a definite programmed pattern and at the optimum quantitative ratio, provides the required set of properties and an appropriate filler-matrix interface [1]. This kind of composite exploits interference between the microregional domain. For electrical applications these materials are mainly two-phase composites of conducting particles and an insulating phase [2]. The aim of this work was to design carbon-ceramic composite using carbon materials (graphite, carbon black) as a conducting phase with predicted electrophysical properties for bulk resistor applications. In this paper we present the influence of different binder: coal tar pitch (CTP), phenolformaldehyde resin (PR), and sodium silicate (SS) on carbon-ceramic composites microstructure.

Experimental

The processing route of samples is presented in Fig. 1, and Table 1 include the compositions of samples. X-ray diffractometry, optical microscopy and SEM have defined the microstructure features.
The electrical properties were established by resistivity measurements.

Result and discussions

The composites with RP or CTP are composed of natural graphite, Al_2O_3 and carbon black in a carbon matrix (samples JSN, JSA and JS1). The initial mix of C-Ceramic composites bonded with SS is composed of natural graphite and Al_2O_3 particles in a kaolin matrix.
The X-ray pattern highlighted that CTP and PR supply C in excess, developing a C matrix, Fig.2.
At the same composition (JSA and JSN) electrical resistivity is seven times lower with PR binder, Fig. 3. Phenomena is attributed to intensive shrinkage (Fig. 4a, 4b) from resin during heat treatment defining a lower porosity compared with JSA (Fig. 5a, 5b).
Keeping constant the carbon content (10 wt%) for sample JS1 and P12, the binder has a dramatically influence increasing the resistivity from 1055 x 10^{-4} $\Omega\cdot$cm (CTP binder) to 355 x 10^{5} $\Omega\cdot$cm (SS binder).

Conclusions

- When an electrical field is applied through a composite sample the ohmic resistance depend on the constructive design. The flux will prefer the conductive array formed by the boundary phase, having small losses.
- The continuous carbon bonding phase means that the overall dc conductivity remains high even though a continuous substantial part of material maybe present as an insulator.
- The existence of pores restricts the cross sectional area for conduction to a fraction of the area otherwise available and consequently, electrical properties are frequently correlated with porosity.

References

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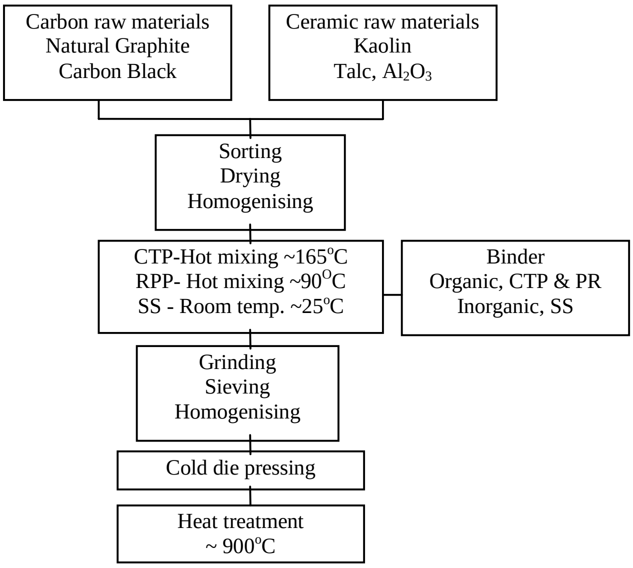

Fig. 1. Processing route for C-Ceramic composites.

Table 1. Sample compositions.

	Conducting Phase		Insulating Phase			Binder		
	G % wt	*CB % wt*	*Al_2O_3 % wt*	*K % wt*	*T % wt*	*CTP % wt*	*PR % wt*	*SS % wt*
JSN	25	10	-	25	10	-	30	-
JSA	25	10	-	25	10	30	-	-
JS1	7	3	49	8	3	30	-	-
P12	10	-	37	45	-	-	-	8

G-Natural graphite K-Kaolin CB-Carbon black T-Talc

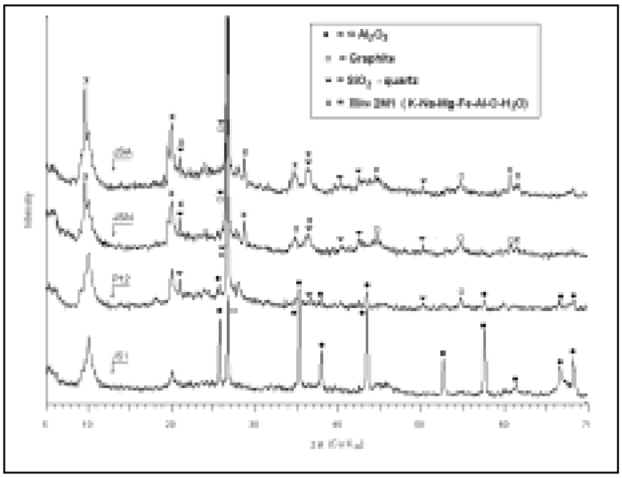

Fig. 2. X-ray diffraction of composite sample, JSA, JSN, JS1 and P12.

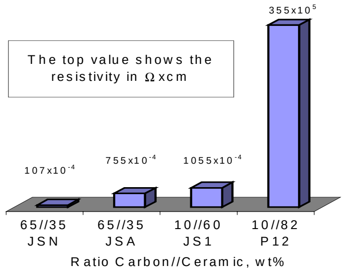

Fig. 3. The schematic view of resistivity values as a function of carbon/ceramic ratio

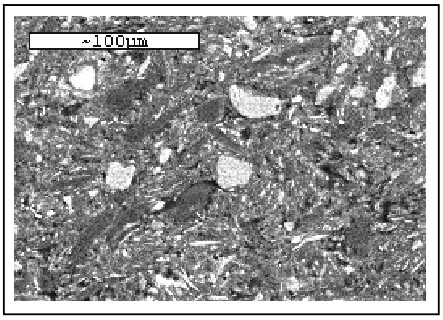

Fig. 4 a. SEM image of JSN sample

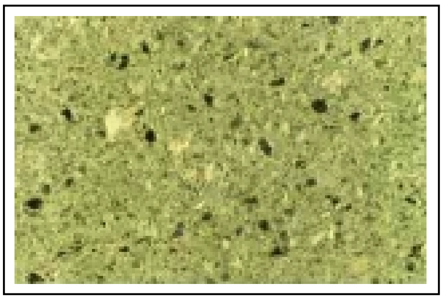

Fig. 4 b. Sample JSN, 10x, Brightfield, showing a homogeneous microstructure of the sample. The pressing direction is approximately from the top to the bottom image.

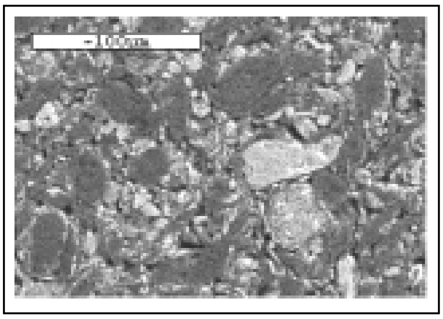

Fig. 5 a. SEM image of JSA sample

Fig. 5 b. Sample JSA, 20x, Polarized light & DIC. The pressing direction is perpendicular onto the image plane.