Diamagnetic Susceptibility of Rhombohedral Graphite

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INTRODUCTION

The most common structure of graphite is the hexagonal Bernal Structure which has been extensively studied both theoretically and experimentally. Another form of graphite is the rhombohedral structure which can be introduced artificially, for instance, by grinding graphite crystals.

Physical properties of rhombhedral graphite have not been fully investigated, in particular, from experimental point of view. Gasparaux [1] has measured the diamagnetic susceptibility of powered graphite crystals having a variety of rhombohedral content and has evaluated the susceptibility of rhombohedral graphite between 77K and 300K.

In the present work, we have evaluated the susceptibility between 4.2K and 300K using specimens similar to those employed by Gasparaux. The experimental results have been analyzed in terms of the theory developed by McClure [2] for rhombohedral graphite.

EXPERIMENTAL

Graphite specimens used in the present work is natural graphite compact (hereafter NGC) which is molded from powered natural crystals of graphite into a rectangular parallelepiped under a uniaxial stress. Since the specimens is prepared through grinding process, the rhombohedral structure is expected to be present.

X-ray diffraction studies were carried out to evaluate the rhombohedral content; hexagonal and rhombohedral (101) diffraction intensities were compared with theoretical intensities.

RESULTS AND ANALYSES

Three specimens heat treated at 400℃, 900℃ and 1500℃ respectively are selected for the susceptibility measurement. Heat treatment above 1500℃ result in the recovery of such defects as vacancies functioning as acceptors and the susceptibility is found to increase with H.T.T. above 1500℃ in spite of the decrease in the rhombohedral content. Table 1 summarizes the volume function (f) of the rhombohedral structure for the three specimens.

Specimen	H.T.T.	Volume Fraction
NGC400	400℃	22.4%
NGC900	900℃	19.7%
NGC1500	1500℃	18.1%

Table. 1

Fig.1 shows temperature dependence of the magnetic anisotropy for the three specimens. Since the magnetic susceptibility is an additive physical quantity, the observed susceptibility (χ_{obs}) is expressed by $\chi_{obs} = f\chi_R + (1-f)\chi_H$ where χ_R and χ_H denote rhonbohedral and hexagonal susceptibility respectively. Fig.2 demonstrates temperature dependence of the rhombohedral susceptibility thus obtained from the two combinations of NGC 400℃ with NGC 900℃, and NGC 400℃ with NGC 1500℃. The two values agree very well with each other. The result obtained by Gasparaux [1] is also shown for comparison. The present work reveals that χ vs T relation for rhombohedral graphite has a peak around 60K. The value of rhombohedral susceptibility is considerably larger that that of hexagonal one as represented by Kish graphite in Fig.2. The solid curve is a theoretical one discussed below.

Fig.3 shows theoretical results computed in the present work on the basis of the theory developed by McClure [2] for rhombohedral graphite. The Fermi level $E_F=0$ corresponds to the pure state. As already pointed out by McClure, a small peak is observed at about 60K in χ vs T diagram for the pure state.

The solid state curve in Fig.2 is the theoretical one computed to fit the experimental results. The best fit is obtained for $\gamma_0=3.1$eV, A=0.012eV and $|E_F|=0.0159$eV.

The E_F value suggests that the Fermi level is depressed by introducing such defects as vacancies during specimens preparation. In the present specimens, E_F should be negative and -0.0159eV.

REFERENCES

1. H.Gasparaux Carbon 5, 441 (1967)

2 J. W. McClure Carbon 7, 425 (1969)

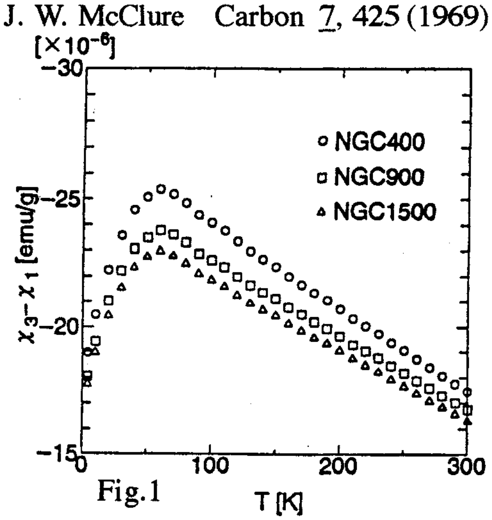

Fig.1

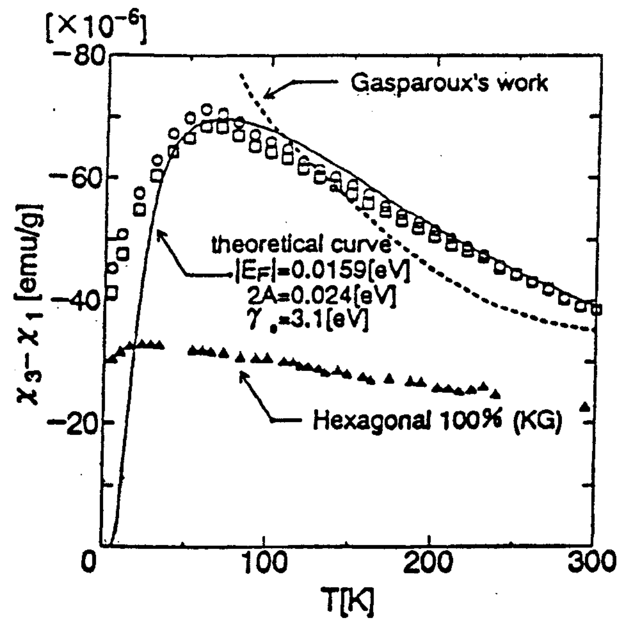

Fig.2

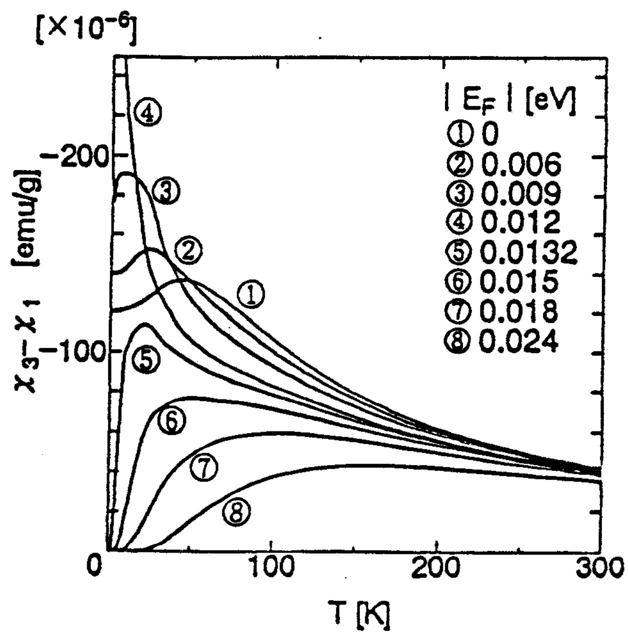

Fig.3