ANOMALOUS GALVANOMAGNETIC PROPERTIES OF KISH GRAPHITE AT 77 K

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Introduction

Transverse magnetoresistance $\Delta\rho/\rho$ varies strongly with temperature and magnetic field B for nearly perfect crystals of graphite; natural graphite, kish graphite (KG) and highly oriented pyrolytic graphite (HOPG)[1-6]. $\Delta\rho/\rho$ changes continuously from B^2 dependence in a very low field region to linear magnetic field dependence above a quantum magnetic field limit (B >7 T), and then saturate in an extremely high field[1-6]. $\Delta\rho/\rho$ also changes with crystal perfection of graphite materials[2,3,5,6]. The crystal perfection is evaluated by the value of the residual resistivity ratio $\rho_{300K}/\rho_{4.2K}$ (*RRR*). $\Delta\rho/\rho$ increases with the increase of *RRR*, but there is a common relationship in the field dependence of the exponent n in $\Delta\rho/\rho \propto B^n$ for the graphite samples with different *RRR* values[2,3,5,6].

On the other hand, Hall coefficient R_H in low fields has been known to be sensitive to defect concentration in graphite, and varies drastically with *RRR* of graphite. For high quality graphite samples at low temperatures R_H is positive at low fields, increases with increasing magnetic field, passes through a maximum and then decreases (or sometimes it decreases continuously from low fields with increasing magnetic field), changes it sign, decreases further[1,2,4,5]. For HOPG with lower crystallinity, R_H also shows maximum, but is depressed to the negative side at low temperatures[2].

The experimental studies on $\Delta\rho/\rho$ and R_H for HOPG specimens were carried out for those with various crystallinity, while the measurements on the KG specimens were rather restricted in well-crystallized samples, i. e. for those with the RRR values larger than 12[2-6]. Therefore, in the present study, the dependence of $\Delta\rho/\rho$ on magnetic field was measured at 77 K and in fields up to 6.5 T for KG specimens with the *RRR* values lower than 10. Low field behavior of R_H was also examined for these samples.

Experimental procedures

KG specimens were selected out from a number of purified KG flakes by measuring *RRR* values. The *RRR* values were 3.47 - 9.90. The KG specimens with the *RRR* values 12 - 106 and also the HOPG specimens with the RRR values 1.6 - 5.5 were used for comparison. The KG and HOPG specimens were designated by KG or HOPG followed by the *RRR* value. The $\Delta\rho/\rho$ and R_H measurements were carried out by a dc method with direct immersion of the specimen into liquid nitrogen.

Results and discussion

Figure 1 shows the field dependence of $\Delta\rho/\rho$ for the KG and HOPG specimens. $\Delta\rho/\rho$ is approximately proportional to magnetic field in fields above 2 - 3 T for the KG specimens with *RRR* < 10, while for the KG specimens with *RRR* > 12 and even for the HOPG specimens with *RRR* < 6 $\Delta\rho/\rho$ increases more rapidly with increasing magnetic field than that for the KG specimens with *RRR* < 10.

In Figure 2 the field dependence of R_H for the KG and HOPG specimens is shown. The behavior of R_H for the KG specimens with *RRR* > 18 exhibits the intrinsic nature of the carrier system in graphite crystal, and also for HOPG3.6 and 5.5 except at low fields. The behavior of R_H for HOPG1.6 is known to be that for HOPGs with low crystallinity[2]. On the other hand, for the KG specimens with RRR < 10, R_H is positive, decreases with increasing magnetic field at first, passes through a minimum and then increases continuously. At a constant magnetic field, R_H shows a trend to increase with the decrease of *RRR*.

Polycrystalline nature of HOPG crystals can be imaged by a technique in scanning electron microscopy based on electron channeling contrast effect, irrespective of their RRR values[7]. However, the single crystal-like image was observed even for the KG specimen with the rather lower *RRR* value of 4.65[8]. The difference in the microtexture between KG and HOPG seems to be in their formation processes; KG is excess carbons recrystallized as flakes from iron-melt high in carbon and purified to remove metallic impurities, while HOPG is prepared from pyrolytic carbon by heat treatment at high temperatures under mechanical stress. The anomalous galvanomagnetic effects observed for the KG specimens with *RRR* <10 in the present study are presumably related to the remaining iron impurities, even though the impurity concentration is assumed to be very low.

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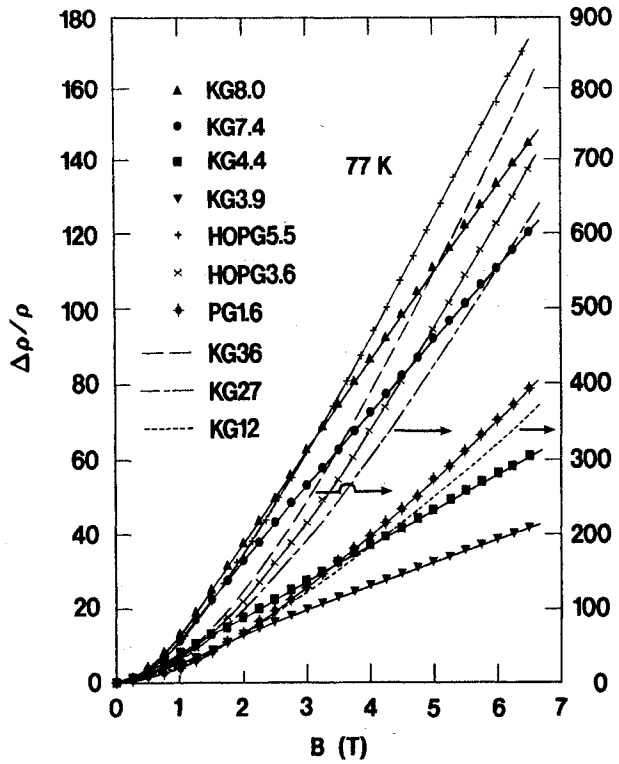

Figure 1- Field dependence of maximum transverse magnetoresistance at 77 K for the specimens.

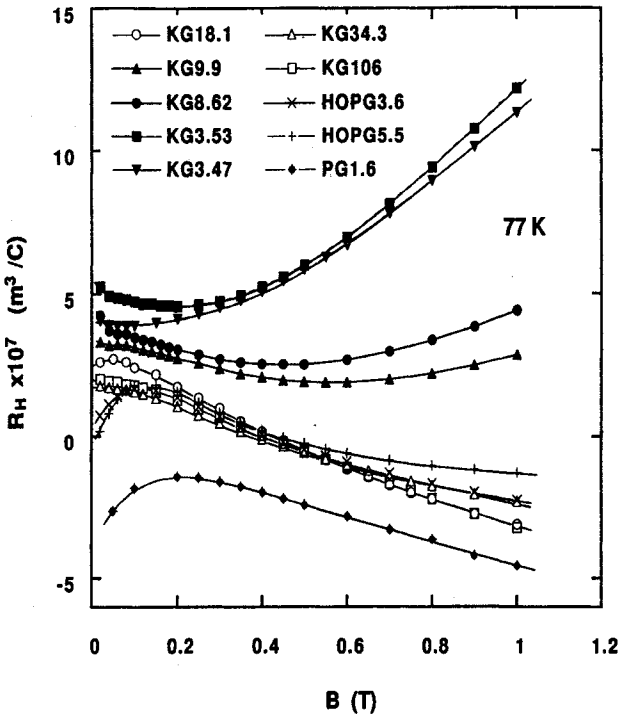

Figure 2- Field dependence of Hall coefficient in fields up to 1 T at 77 K for the specimens.