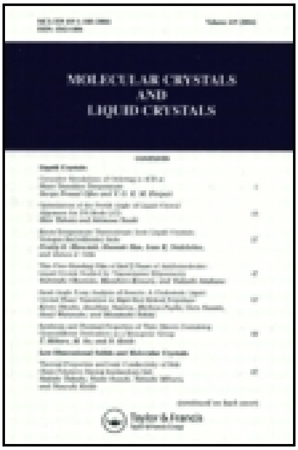

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Galvanomagnetic Properties Of AsF_5 -Intercalated Highly-Oriented Pyrolytic Graphite (HOPG)

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GALVANOMAGNETIC PROPERTIES OF AsF_5-INTERCALATED HIGHLY-ORIENTED PYROLYTIC GRAPHITE (HOPG)

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Abstract Due to the anisotropy of the conductivity in AsF_5-intercalated HOPG, eddy current methods have to be used for the measurement of transport effects. The measurements yield carrier concentration, mobility and charge transfer for $C_{8n}AsF5$ with n=1-4 at temperatures between 4.2K and 300K.

INTRODUCTION

Interest in graphite intercalation compounds results from the high electric conductivity $\sigma_{a,b}$ in the $\vec{a},\vec{b}$ plane of AsF_5-intercalated HOPG[1] at 300K. The high conductivity anisotropy ($\sim 10^6$) requires eddy current methods to avoid inhomogeneous current distribution in the sample when measuring galvanomagnetic effects.

EXPERIMENTAL

Disk shaped samples were prepared by sand blasting and intercalated at room temperature with AsF_5 at a pressure of 1 bar after tempering at 800^o C for 5^h. Eddy current methods exclude the use of standard cryostats and superconducting coils, so that a glass dewar with a cryoflow system had to be used. For conductivity measurements, the samples were arranged coaxially with two coils fitted one into the other. One of the coils was driven by the reference channel output of a lock-in amplifier inducing an eddy current in the sample, while the other coil was connected to the differential input of the instrument to monitor the signal. For magnetoresistance measurements, an additional magnetic field B_o was applied. Hall effect measurements require one contact at the center of the sample and another one at the circumference. The eddy current induced by a coil is subjected to the Lorentz force arising from a magnetic field B_o and yields a radial Hall field probed at the two contacts by means of a lock-in amplifier. The signal V_H is proportional to the Hall mobility μ_H:

$$V_H=\mu_H(r/2)^2B\ dB/dt$$

where r is the sample radius and B the sum of B_o and the alternating magnetic field due to the coil. This meets exactly the requirements of HOPG with large μ_H whereas the large hole concentration p in $C_{8n}AsF_5$ would lead to an extremely small Hall effect in the classical arrangement.

RESULTS AND DISCUSSION

In agreement with other authors the highest room temperature conductivity is reached for stage 2 with $\sigma_{a,b}=2,5x10^5$ S /cm, as seen in Fig.1. The temperature dependence of the conductivity shows metallic behaviour with a temperature independent residual resistivity below 20-50K, in contrast to pristine HOPG which is semimetallic. As shown in Fig.2 the hole concentration p increases with intercalation up to stage 2 by a factor of 100 compared to pristine HOPG, whereas no further increases for stage 1 is observed due to a decrease in the charge transfer f between these two stages, as given in Table 1. f is defined as the ratio of p and the intercalant concentration. The hole concentration is temperature independent in contradiction to other authors[1]. This discrepancy may arise from the below described difference between μ_H and the mobility μ_M deduced from magnetoresistance measurements which has not been taken into account by Zeller et al.[1]

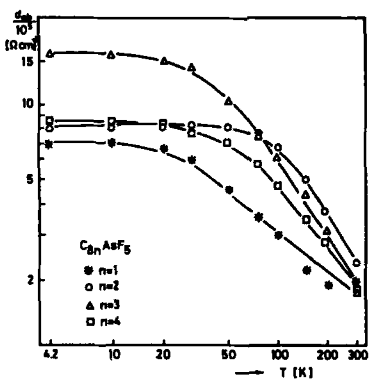

Fig.1 Conductivity in the $\vec{a},\vec{b}$ plane vs. temperature

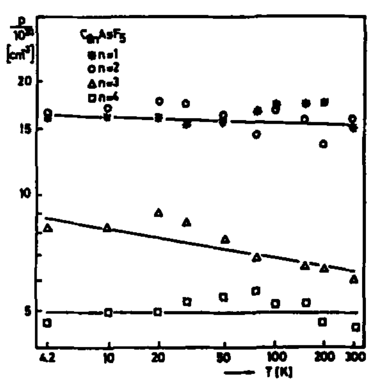

Fig.2 Hole concentration vs. temperature

Increasing intercalation induces defects and therefore reduces the mobility by a factor of 10 compared to pristine HOPG as can be deduced from Fig.3. At 4.2K the magnetoresistance $\Delta\rho/\rho_o$ is proportional to B_o^2 for stage 4 and shows dramatic unexplained anomalies for lower stages, as seen in Fig.4. The mobilities μ_M obtained from the low field magnetoresistance, where $\Delta\rho/\rho_o \sim B_o^2$, are consistent with μ_H except at stages 1 and 2 for the lower temperatures. The ratio μ_M/μ_H at 4.2K is given in

Table 1 together with f determined by other authors from spin susceptibility[2], reflectance spectra[3], conductivity and magnetoresistance[1]. Supported by VW-Stiftung, FRG and Fonds zur Förderung der wiss.Forschung, Austria.

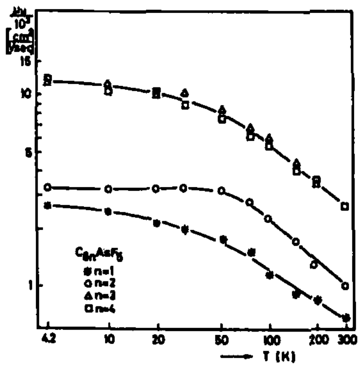

Fig.3 Hall mobility vs. temperature

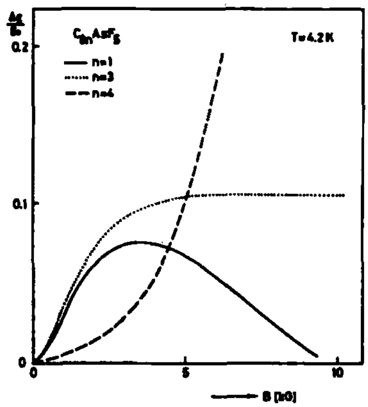

Fig.4 Magnetoresistance vs. temperature

Table 1 Charge transfer f and μ_M/μ_H at 4.2K for stages n=1-4. For values of f given by other authors[1-3] refer to the text.

n	f	f^1	f^2	f^3	μ_M/μ_H
1	0.25	0.15	0.24	0.41	8
2	0.35	--	0.48	0.53	6
3	0.18	--	--	--	1,5
4	0.17	--	--	--	1

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