NEGATIVE MAGNETORESISTANCE AND ELECTRICAL CONDUCTION
IN GLASSY CARBON

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The electrical properties of glassy carbon (GC) have been the subject of a few investigations, but
the understanding is far from complete. It continues to be a matter of debate and considerably more work
in this area is needed to delineate the electrical properties. We have studied the temperature depend-
ence of the electrical conductivity (\(\sigma\)) of GC heat treated at different temperatures in the range 1000-
2800°C. We have also measured the magnetic field and temperature dependence of the magnetoresistance
of GC heat treated at different temperatures. Our measurements were taken inside a dewar with a 50KG
superconducting magnet in the temperature range 10

to 300°K.

The conductivity was found to increase with
temperature (T) indicating semiconductor behavior
for all the samples. The conductivity exhibits two
different behaviors with HTT separated at HTT 2000°C.
For HTT > 2000°C, \(\sigma\) saturates at low temperatures,
whereas for HTT < 2000°C there is a sharp decrease
as T is reduced as shown in Fig. 1. For the higher
HTT range two contributions to \(\sigma\) were found.
A

| Temperature dependent \(\sigma\) due to boundary scattering,
| and a temperature dependent contribution of the
| form \(\exp (-B^{\sigma}I^2)\) where \(n = 1/4\). This temperature
| dependent part of \(\sigma\) is believed (see fig. 2) to be
| due to the hopping conduction of the localized
| spins.

For the lower HTT range a similar separation is
valid except at the lowest temperatures. Subtract-
ing out the hopping contribution the remainder
exhibits a logarithmic temperature dependence which
saturates into \(\sigma\) by 100°K. This HTT dependence is
characteristic of the Kondo behavior of the localized
spins in the lower HTT range.

GC has negative magnetoresistance (\(\Delta \rho/\rho\)) for all
HTT. The magnitude of this negative magnetoresis-
tance was found to increase as the magnetic field
(H) increases up to \(H = 50KG\), and as the measurement
temperature is lowered the sample's HTT increases.
For HTT below 2000°C the analysis used above was
not successful. The behavior of \(\Delta \rho/\rho\) becomes more
complex, although the general trend remains the same.

We believe that negative \(\Delta \rho/\rho\) arises from field
dependent scattering from localized spins. For this
mechanism it is well known that \(\Delta \rho/\rho = -m^2\) where m
is the effective magnetic moment per spin. Analy-
zing the behavior \(|\Delta \rho/\rho|^2\) a unique dependence was
discovered in the higher HTT range. The negative
\(\Delta \rho/\rho\) is found to be a single valued function of the
parameter \(H/T^2\) as shown in Fig. 3.

Whereas the experimental behavior of \(\sigma\) and
\(\Delta \rho/\rho\) have been established, the understanding is
still not complete. Measurements at lower tempera-
tures are planned to extend the range of our

invention of the electrical properties. Also a
coherent picture can emerge only when correlations
with other electronic properties of GC are made, and
additional experiments are planned for the future.
Theoretical work is also needed to completely
explain some of our experimental observations such
as the \(f(H/T^2)\) dependence of \(\Delta \rho/\rho\).