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 dependence of the electrical conductivity (σ) of GC heat treated at different temperatures in the range 1000-2800^{o}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^{o}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^{o}C. For HTT > 2000^{o}C, σ saturates at low temperatures, whereas for HTT < 2000^{o}C there is a sharp decrease as T is reduced as shown in Fig. 1. For the higher HTT range two contributions to σ were found. A temperature independent σ_o due to boundary scattering, and a temperature dependent contribution of the form exp $(-BT^{-n})$ where $n = 1/4$. This temperature dependent part of σ 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. Subtracting out the hopping contribution the remainder exhibits a logarithmic temperature dependence which saturates into σ_o by 100^{o}K. This lnT 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 magnetoresistance 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^{o}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 $\Delta\rho/\rho \propto -m^2$ where m is the effective magnetic moment per spin. Analyzing the behavior $|\Delta\rho/\rho|^{1/2}$ 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 $H/T^{1/2}$ as shown in fig. 3.

Whereas the experimental behavior of σ and $\Delta\rho/\rho$ have been established, the understanding is still not complete. Measurements at lower temperatures are planned to extend the range of our investigation 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 $f(H/T^{1/2})$ dependence of $\Delta\rho/\rho$.

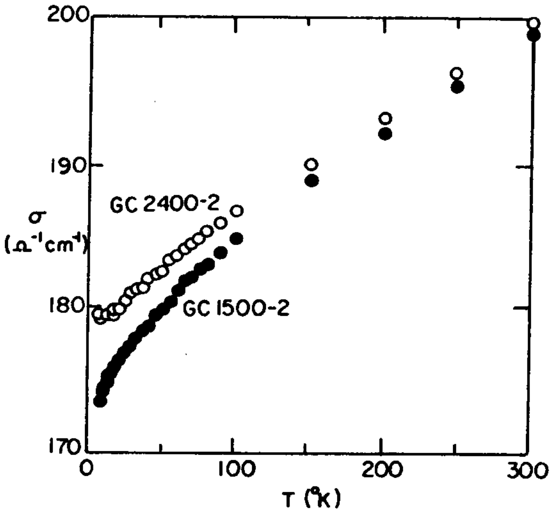

Figure 1

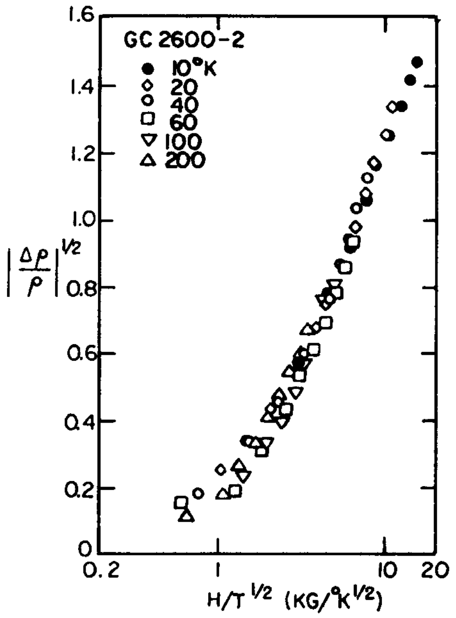

Figure 3

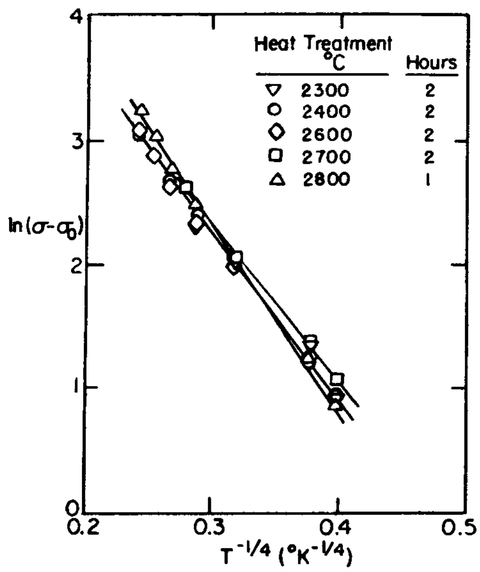

Figure 2