Electron Spin Resonance in Irradiated Graphite and Evaporated Carbon Film

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Change of behavior of ESR in artificial polycrystalline graphite with annealing which had been damaged heavily by neutrons was studied. The irradiation was done in reactor at 30°C and the dose was 5.8×10^{20} nvt. Fig. 1 shows results of the change with annealing of the absorption intensity at room temperature, expressed as spin susceptibility per gram, and of the full width of the absorption line. The absorption is air-sensitive when the specimen is ground finely, but not in the form of coarse particles.

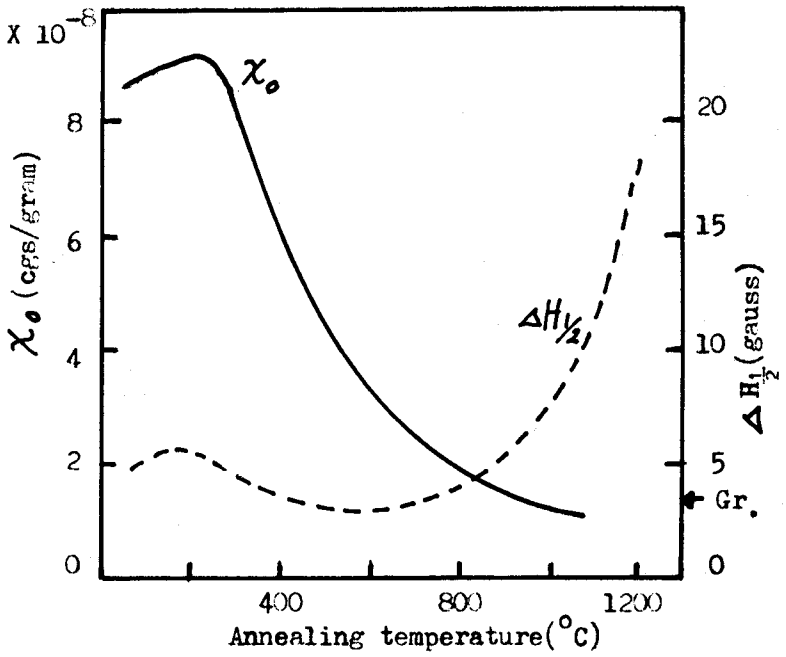

Fig. 1 Change of ESR intensity and line width with annealing

The susceptibility decreases with the progress of annealing, and becomes almost equal to the value of polycrystalline graphite, accompanying with it a rapid increase of the line width; this can be explained by the appearance of the g value anisotropy.

The dependence of the susceptibility upon the ambient temperature was measured for these specimens. The relation $\chi_0 = a + b/T$[1] was obeyed well, which made it possible to separate the observed spin centers into localized spins and charge carriers. Change of the concentration of localized spins and of the density of states at the Fermi level is shown in Fig. 2. It is seen that the localized spins decrease with the progress of annealing and disappears after annealing at 1000°C. On the other hand, the density of states decreases with the rise of the Fermi level as the lattice defects become healed, and reaches finally the graphite value; which, however, is a little smaller than $D(E_f)$ calculated from specific heat data of polycrystalline graphite[2].

It is interesting that the susceptibility of irradiated graphite is approximately equal to the well known maximum in the spin susceptibility of ordinary organic materials when carbonized at around 600°C. This indicates a similarity in the electronic structure of damaged graphite and hydrogen-containing amorphous carbon. Facts such as above and that the localized spins have non-degenerate nature as opposed to charged carriers favor the σ character of the important part of unpaired electrons in amorphous carbons.

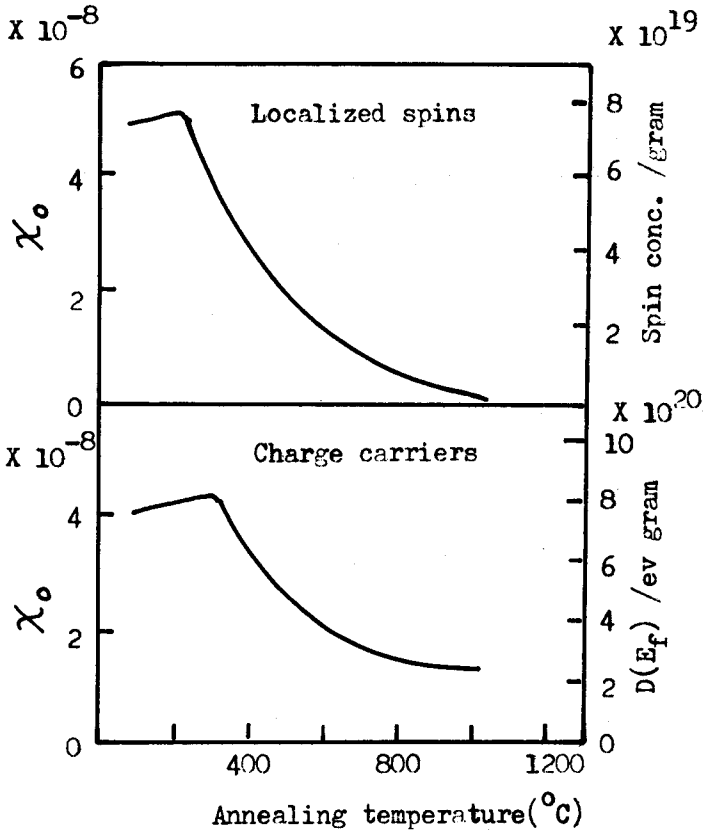

Fig. 2 Effect of annealing upon the concentration of localized spins and the density of states at the Fermi level

ESR experiment was done also on evaporated carbon film, which is known to be quite amorphous. The intensity of absorption was again of the same order as the above cases, and its temperature dependence was akin to Curie's Law. The intensity decreased rapidly with annealing.

1) Mrozowski, S., Carbon 3, 305(1965)
2) Komatsu, K., J. Phys. Chem. Solids 25, 707(1964)