28. THERMAL CONDUCTIVITIES OF ELECTRON IRRADIATED DIAMONDS

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Irradiation of diamond with fast electrons gives damage which can be observed as a reduction of the thermal conductivity. In order to study this effect diamonds were irradiated at temperatures up to 500K and their thermal conductivities were measured between 320 and 450K. Figure 1 shows the effect for one type IIa diamond after several irradiations with electrons of 1.50 MeV. The thermal resistivity associated with this reduction was found to depend linearly on the irradiation dose. The dose was converted to vacancy concentration by means of Mitchell's calculations [1] using 80 eV as the value of the displacement energy of carbon atoms. It was found for type IIa diamonds that

$$R(400) = 2\times10^{-21}\, n_v \ \mathrm{W^{-1}cmK}$$

where $R(T)$ is radiation induced resistivity and n_v vacancy concentration in cm^{-3}. It is assumed that displaced carbon atoms give negligible contribution to R above room temperature. Irradiations with electrons of 0.90 and 0.60 MeV led to results in agreement with those for 1.50 MeV electrons. This supports the value of 80 eV for the displacement energy.

Annealing experiments were carried out to investigate the stability of the resistivity R with the following results. The value of R was unaffected by annealing at temperatures up to 800K. Above this temperature it decreased until at 1600K the conductivity was restored to a value close to that of unirradiated diamond.

A few type I diamonds were also irradiated with 1.50 MeV electrons. The values of R turned out to be larger than those of type IIa diamond. This might be caused by the displacement of nitrogen atoms.

The conductivity between 1 and 20K of electron irradiated diamonds was measured by Vandersande [2]. His interpretation of the data was in terms of clustering of displaced carbon atoms because phonon scattering at large defects is important in this temperature range. This differs from the analysis of our measurements as a function of the vacancy concentration since point defect scattering is dominant above room temperature. The conductivities of irradiated type IIa and unirradiated type I diamonds have been compared taking into account that point defect scattering depends on the concentration of defects, on the difference in mass between defect and carbon, and on the strain associated with defects [3,4]. We conclude that vacancies give more strain than nitrogen atoms. A remarkable point is that the temperature dependence of the conductivity for diamonds containing vacancies differs from that for diamonds containing nitrogen [5].

References

1. E.W.J. Mitchell, Physical Properties of Diamond, edited by R. Berman (Clarendon Press, Oxford, 1965).

2. J.W. Vandersande, Phys. Rev. B15, 2355 (1977).

3. L.A. Turk and P.G. Klemens, Phys. Rev. B9, 4422 (1974).

4. R. Berman and M. Martinez, Diamond Research 1976, p. 7.

5. E.A. Burgemeister, Physica, 93B, 165 (1978) and 94B, 366 (1978).

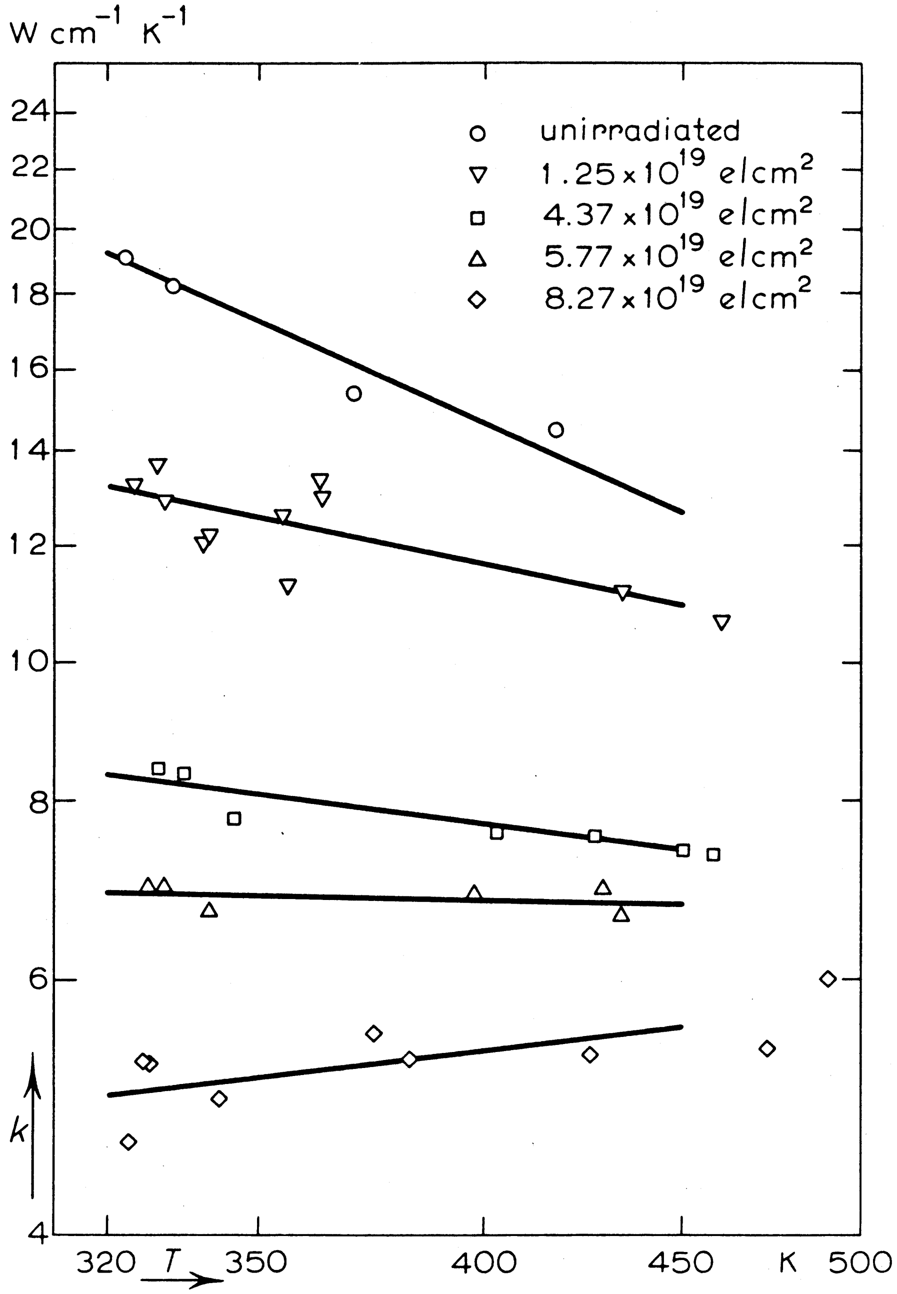

Fig. 1 (paper 28). thermal conductivity against temperature.