Overlapping Phenomena and Dislocation Energy Levels in Germanium (*)

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Summary. — The dependence on dislocation density of Hall coefficient and resistivity was examined at temperatures ranging from liquid nitrogen to 190°F K, in n-type germanium. Over the whole temperature range the dependence on dislocation density has two branches, which precede the transition to p-type occurring at higher dislocation densities. The results were discussed on the basis of two different models assuming that the dislocations are surrounded either by space-charge cylinders plus low-mobility rings or by space-charge cylinders only. In both cases the experimental data correspond to dislocation energy levels in the upper midgap. Thus the possibility that the p-type characteristics are connected with acceptor levels other than those of the dislocations, but probably with point defect associates was considered. Inhomogeneity effects were also taken into account; these can explain the absence of a plateau in the effective donor concentration dependence on temperature as well as the transition to p-type.

1. — Introduction.

The bibliographical data concerning the dislocation energy levels in germanium can be roughly classified into two groups:

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from conductivity and Hall coefficient measurements on $n$-type material, dislocation levels in the upper midgap at $(0.2 \div 0.35)$ eV from the conduction band ($^{1,2}$);

from photoconductivity measurements and from other observations on $p$-type germanium, levels in the lower midgap at $(0.09 \div 0.2)$ eV from the valence band ($^{4,6}$).

A possibility of overcoming this discrepancy can be found in a hypothesis of BROUDY ($^{7}$), according to which the dislocation levels result at $\sim 0.2$ eV from the valence band also in $n$-type germanium if one assumes that not only the dislocation space-charge cylinders, but also low-mobility rings encircling them affect the electrical properties.

In previous papers ($^{5,9}$) we showed, on the other hand, that the high-density dislocation effects can be explained in terms of overlapping of low-mobility rings and of space-charge cylinders, thus giving direct indications of some parameters previously introduced only on hypothetical grounds. This allowed us to check, in the present research, Broudy's results, with particular reference to the dislocation energy levels.

Since some magnetoresistivity measurements of VAN WEEREN ($^{10}$) cast doubts on the existence of the low-mobility regions, the possibility has also been taken into account by us, to explain the high-dislocation-density phenomena in terms of overlapping of the space-charge cylinders only.

On the basis of these observations, all leading to dislocation energy levels in the upper midgap, the hypothesis will be introduced that the transition to $p$-type, occurring at the higher dislocation densities ($^{11}$), is due to point defect associates.

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