PPJ - 18.

phys. stat. sol. (a) 35, K65 (1976)
Subject classification: 14.3.1; 22.1.1

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Influence of Stress on the Magnetoresistance of p-Germanium Films

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p-germanium films in the range of thickness from 0.2 to 50 μm were grown on monocrystalline silicon substrates (resistivity $\approx 5\times10^3$ Ωcm) by thermal evaporation of high-resistivity germanium in a vacuum of $\approx 5\times10^{-6}$ Torr (1). The transverse magnetoresistance (MR) was measured on films evaporated on the (111) crystallographic plane of samples with size 2x10x0.25 mm^3. MR is different for the cases when the magnetic field H is perpendicular to the normal of the film plane, $\Delta\varrho(\vec{H}\perp\vec{n})/\varrho_o$, and parallel to it, $\Delta\varrho(\vec{H}\parallel\vec{n})/\varrho_o$. The MR anisotropy

$$K = \frac{\Delta\varrho(\vec{H}\perp\vec{n})}{\Delta\varrho(\vec{H}\parallel\vec{n})} - 1 \qquad (1)$$

varies not only in magnitude but also in sign with film thickness (Fig. 1) and deposition temperature T_o (Fig. 2) as well. In the region of small thicknesses ($d < d_o$, where $d_o \approx 1.5$ μm) and at high T_o we have $K < 0$, i.e. the sign of K coincides with the sign of the MR anisotropy in p-germanium films on sapphire (2). In the last case the MR anisotropy was interpreted on the basis of the size effect (3) and film inhomogeneity into the film depth (4). Another sign of anisotropy, observed on thick films (Fig. 1) and at low deposition temperatures (Fig. 2), enables us to consider it in accordance with (5) to be stimulated by elastic deformation of films (6), (7).

The investigation of the substrate-film system by the profilometer-profilograph showed that films in which $K > 0$ are extended. Although the size ef-

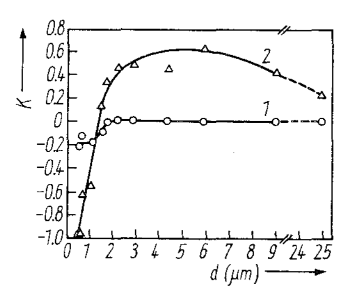

Fig. 1. Dependence of the MR anisotropy coefficient K on the thickness of films deposited at 850 ^{o}C; (1) 293 K, (2) 77 K

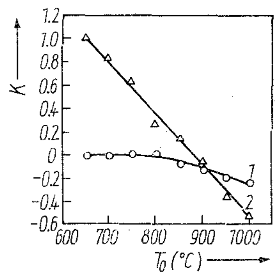

Fig. 2. Dependence of K on the deposition temperature T_o for films with 1.5 to 2 μm thickness; (1) 293 K, (2) 77 K

fect (3) (cooling length of about 0.2 to 0.5 μm in our case) and the inhomogeneity of films into the depth (4) may be essential phenomena, the mechanical stresses in films play the main part in the MR anisotropy, at least, in thick films ($d > d_o$). It was shown in (5) that the MR anisotropy, stimulated by stresses, is high in the deformation range when η (splitting of the degenerate valence bands at the Γ-point) exceeds kT. Stresses in p-germanium films on silicon were measured in (6). Evaluations done according to (6) and (5), showed that at 77 K we have $\eta/kT \approx 1$ to 4, and at 293 K we have $\eta/kT \lessapprox 1$. Therefore at 293 K, the MR anisotropy is either absent on the whole or it is less than at 77 K (Fig. 1, 2).

Thus, discussing the galvanomagnetic effects in heteroepitaxial films one should take into account their elastic deformation.

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(Received April 6, 1976)