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Electrical Conductivity and Seebeck Coefficient of Si_2Te_3 Single Crystals

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Transport properties of silicon telluride Si_2Te_3, which is the only crystalline compound in the binary system Si-Te, have been studied by several authors (1 to 5). The published data, however, disagree by several orders of magnitude and no results have been reported indicating anisotropy of the transport properties.

We believe that the contradictory results may be due to a conductivity contribution of the surface. Si_2Te_3 is very hygroscopic and decomposes rapidly upon exposure to air, the surface of decomposed crystals being covered with a thin layer of tellurium as observed by Rau and Kannewurf (3). We re-investigated electrical conductivity and thermoelectric power of Si_2Te_3, trying to avoid any surface decomposition.

Single crystals were grown by transport in the vapour phase using the method described by Bailey (2). Usually platelets about 10 mm in diameter and 0.2 mm thick were obtained. Gold, silver, and bismuth contacts were applied by vacuum evaporation and showed Ohmic behavior up to electrical fields of 10^4 V cm^{-1}

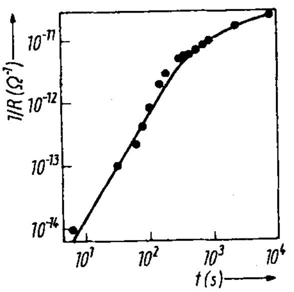

Fig. 1

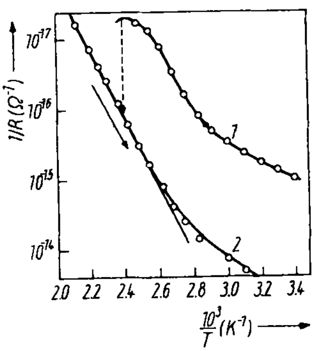

Fig. 2

Fig. 1. Conductance versus time by exposure of the Si_2Te_3 sample to ordinary air

Fig. 2. Conductance of Si_2Te_3 single crystals, curve 1 before heating in high vacuum, curve 2 after sublimation of Te from the surface at 400 K

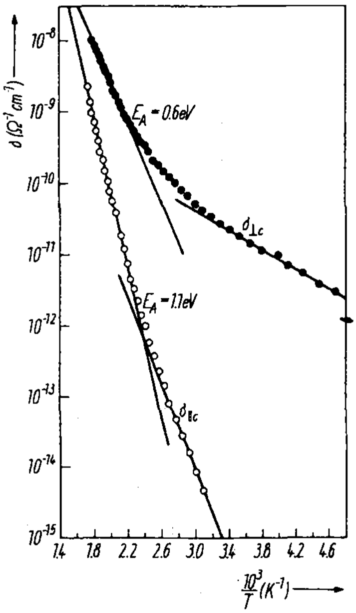

Fig. 3. Conductivity versus temperature of Si_2Te_3 single crystals, o parallel to the c-axis, ● normal to the c-axis

If such a sample is exposed to ordinary air the resistance decreases rapidly with time. When a voltage is applied the current increases by several orders of magnitude during the first minutes after exposure and tends to saturate after some hours (Fig. 1). Samples which are treated in this way do not show any photoconductivity. By heating in a vacuum of 10^{-5} Torr we succeeded in removing the Te layer and restoring the original conductivity of the material. This is indicated in Fig. 2: Curve 1 shows, how the conductance of a sample with decomposed surface increases with temperature; at 400 K the tellurium layer on the surface begins to sublime, resulting in a decrease of the conductance. Finally a conductance is obtained which can be varied reversibly with temperature, thus representing the conductivity of the bulk material. For all our measurements the influence of the surface was controlled in this way.

Our electrical conductivity data parallel and normal to the hexagonal c-axis are shown in Fig. 3 The conductivity is thermally activated in both directions with 1.1 and 0.6 eV, respectively. It should be noted that the anisotropy is very strong and the conductivity parallel c is 10^{-15} $\Omega^{-1}cm^{-1}$ at room temperature; this is six orders of magnitude lower than any conductivity data of Si_2Te_3

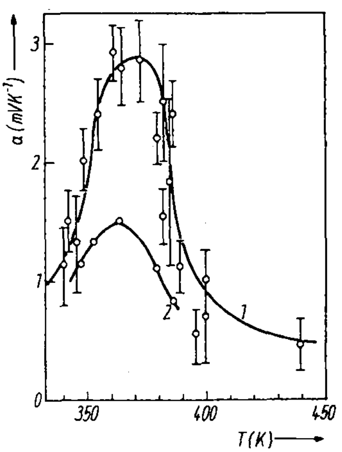

Fig. 4. Seebeck coefficient of Si_2Te_3 single crystals parallel to the c-axis, (1) regenerated surface, (2) decomposed surface

reported before. From the difference of the activation energies one may conclude that the mobility parallel c is thermally activated.

The Seebeck coefficient parallel c (Fig. 4) indicates p-type conduction and exhibits a maximum near 400 K. We assume that the increase of the thermoelectric power below 400 K represents the transition from impurity conduction in an acceptor band to extrinsic conduction. The decrease at high temperatures is attributed to intrinsic conduction. At 400 K a hole concentration of 10^9 cm^{-3} can be estimated corresponding to a mobility of 10^{-2} $cm^2V^{-1}s^{-1}$ parallel c. Normal to the c-axis the mobility is of the order 10^2 $cm^2V^{-1}s^{-1}$. Further investigations are necessary to find out if this material may be regarded as a good approximation of a two-dimensional semiconductor.

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