THE THERMAL CONDUCTIVITY OF THE GROUP V SEMIMETALS

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The relative contribution of the various low temperature thermal conductivity mechanisms are analyzed in the three group V semimetals; bismuth, antimony and arsenic.

INTRODUCTION

Many experimental data on the thermal conductivity of the group V semimetals have recently been reported. It is aimed here to review them briefly showing how the rhombohedral crystal structure and the resulting electronic band structure singularize the group V semimetals from the less exotic isotropic insulators or metallic conductors. Fig.1 illustrates a typical behaviour of the thermal conductivity of bismuth, antimony and arsenic below room temperature. Also, it may be seen from Table I that most low temperature heat transport mechanisms contribute to the thermal conductivity of these semimetals.

The rhombohedral structure, which may be considered as a slightly distorted cubic one, is responsible for the small overlap of the conduction and valence bands. Fig.2 shows a schematic representation of this band structure together with some relevant band parameters for the three group V semimetals. In momentum space the electron and hole Fermi surfaces consist of ellipsoids in the case of Bi and Sb and have a rather more complicated shape in the case of As (1). As another result of the rhombohedral structure, the transport properties of the group V semimetals are highly anisotropic. The zero-field thermal conductivity \( \kappa \) has two components, one along the trigonal axis; \( \kappa_{//} \), and the other in the
Fig. 1 The thermal conductivity of the group V semimetals Bi, Sb and As versus temperature. The three maxima which are those of $\kappa_\text{E}$ lie around 4, 10 and 30 K for Bi, Sb and As respectively; the Debye temperatures being 120, 200 and 280 K respectively. Note that in the higher temperature range where $\kappa_\text{E}$ dominates in Sb and As, and is important in Bi, the thermal conductivity increases with increasing density of carriers as expected.