
The Impact of Disorder on Transport in crystalline Chalcogenides

Matthias Wuttig*¹

¹I. Physikalisches Institut der RWTH, Lehrstuhl für Physik neuer Materialien – D-52056 Aachen, Germany

Abstract

Understanding charge transport in chalcogenides such as phase change materials is crucial to extend the application range of these exciting materials, which are among the most promising solids in information technology. These materials can be very rapidly switched between the amorphous and the crystalline state, indicative for peculiar crystallization behaviour. They are already employed in rewriteable optical data storage, where the pronounced difference of optical properties between the amorphous and crystalline state is used. This unconventional class of materials is also the basis of a storage concept to replace flash memory. This talk will discuss the unique material properties which characterize phase change materials. With this goal in mind we have studied the resistivity of crystalline phase change materials. A pronounced dependence of the room temperature resistivity upon annealing temperature is observed for crystalline phase change materials such as Ge₁Sb₂Te₄ or Ge₂Sb₂Te₅. This finding is corroborated by low temperature measurements as well as FTIR data, which confirm that a metal – insulator transition is observed without a change in crystallographic state. This is indicative for an electronically driven MIT [1]. Such an MIT can be achieved if the electron correlation exceeds a critical value (Mott MIT). A second route to insulating behavior has been identified by Anderson, who showed that increasing disorder turns a metal with delocalized electronic states at the Fermi energy into an insulator with localized states. In this talk, arguments for a disorder induced localization of charge carriers will be presented. The observations are compared with doped semiconductors such as Si:P, where *both* disorder and correlations are crucial to describe the charge transport. Experimental and theoretical attempts to unravel the origin of disorder induced localization will be presented. These calculations reveal that it is the ordering of vacancies into vacancy layers which drives the transition to the metallic state [2]. The potential of this remarkable impact of disorder for applications as well as our fundamental understanding of solids is discussed.

T. Siegrist et al., Nature Materials 10, 202, (2011)

W. Zhang et al., Nature Materials 11, 952 (2012)

*Speaker