The Impact of Disorder on Transport in crystalline Phase Change Materials

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Understanding charge transport in phase change materials is crucial to extend the application range of these exciting materials. The reduction of drift, i.e. the increase of the resistivity of the amorphous phase with time, for example, would facilitate the development of multilevel memories. Tailoring the transport of charge and heat in the crystalline state could help in reducing the power consumption upon amorphization. With this goal in mind we have studied the resistivity and the thermal transport 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 $Ge_1Sb_2Te_4$ or $Ge_2Sb_2Te_5$. 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]. A similar transition is also observed for the thermal conductivity.

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]. This vacancy ordering also has a pronounced impact on the thermal conductivity. The potential of this remarkable impact of disorder for applications as well as our fundamental understanding of solids is discussed.

[1] T. Siegrist et al., Nature Materials 10, 202, (2011)
[2] W. Zhang et al., Nature Materials, 11, 952 (2012).