I. Physikalisches Institut (IA)
Physik neuer Materialien

RWTH AACHEN UNIVERSITY

I. Physikalisches Institut (IA)
Phasenwechselmaterialien
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Topic for a Master Thesis

„Scaling of the disorder induced Metal-Insulator Transition in the Pseudo-Binary Line $Ge_xSn_{1-x}Sb_2Te_4$“

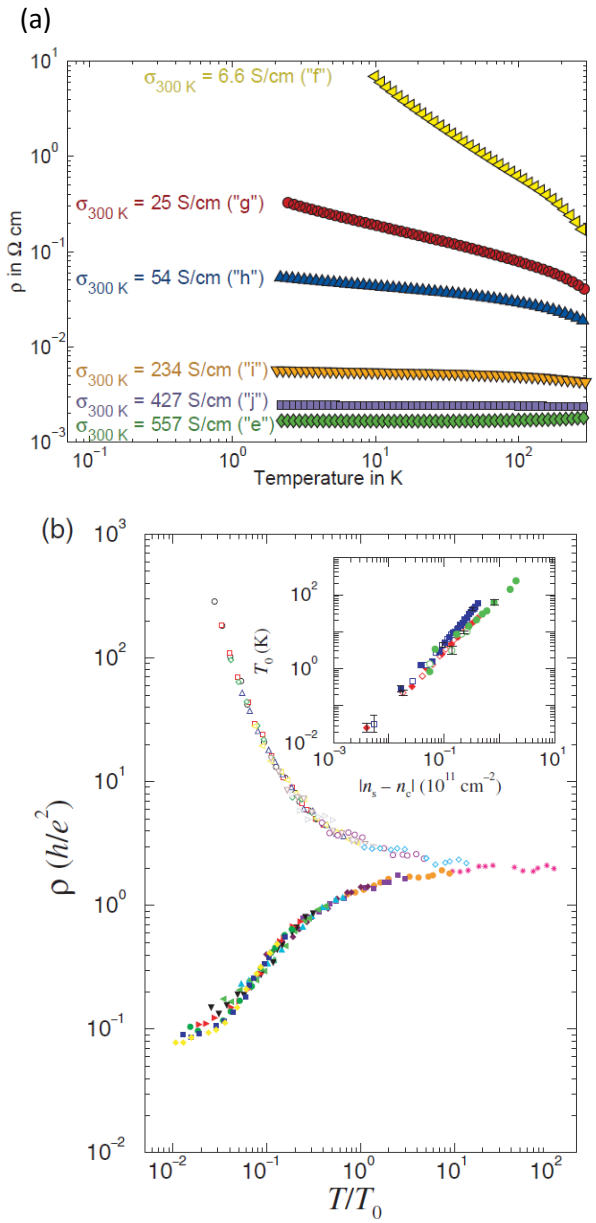

Fig 1:a) Low-T resistivity measurements on $Ge_1Sb_2Te_4$ unravel an MIT between sample "g" and "h" [3] b) Scaling of a two-dimensional electron system with $T_0(n)$ results in a "collapse" of all resistivity curves and allows the distinction between insulators (upper branch) and metals (lower branch) [4]

Phase-change materials (PCMs) with a high amount of intrinsic vacancies, like $Ge_1Sb_2Te_4$, are proven to be a unique platform for the investigation of many-body localization effects [1,2,3]. The combination of intermediate charge carrier concentration, diminishing electron-electron interactions, and a high amount of structural disorder, due to the stoichiometric vacancies, results in the most purely disorder driven metal-insulator transition (MIT), known so far (Fig. 1a).

The description of the electrical resistivity with a scaling functional like:

$$\rho(T,n) = \rho\left(\frac{T}{T_0\,(n)}\right)$$

where T is the temperature, n the carrier concentration and $T_0(n)$ a scaling parameter, was employed in the investigation of many quantum phase-transitions [4]. It yields a deeper physical understanding of the underlying mechanisms by identifying a critical point e.g. n_c at which a separation into different phases is possible (Fig. 1b).

While this method is very common for the analysis of the MIT in doped semiconductors, which almost entirely depend on the degree of doping, the identification of such an ordering parameter for the disorder-driven MIT is aggravated by the struggle to experimentally quantify the degree of disorder in a crystal lattice.

The goal of this thesis is to investigate the metal-insulator transition for $Ge_xSn_{1-x}Sb_2Te_4$ alloys with a high amount of tin. In these materials the structural properties hardly vary with a change in x, while an additional degree of tunability for the charge carrier concentration is obtained. Multiple candidates for the critical scaling parameter to describe the disorder-driven metal-insulator transition should be identified with a combination of low-temperature transport measurements and theoretical modelling.

[1] Siegrist et al., *"Disorder-induced localization in crystalline phase-change materials",* Nature Materials (2011), DOI: 10.1038/NMAT2934

[2] Zhang et al., *"Role of vacancies in metal-insulator transitions of crystalline phase-change materials",* Nature Materials (2012), DOI: 10.1038/NMAT3456

[3] Volker et al., *"Low-Temperature Transport in Crystalline $Ge_1Sb_2Te_4$"*, Advanced Functional Materials (2015), DOI: 10.1002/adfm.201500830

[4] Kravchenko et al.,*" Metal-insulator transition in two-dimensional electron systems"*, Reports on Progress in Physics (2004), DOI: 10.1088/0034-4885/67/1/R01

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