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

Approaching the Glass Transition of Prominent Phase Change Materials

Phase change materials (PCMs) are solid materials which occur in two different stable phases, namely the disordered amorphous phase and the ordered crystalline phase. A tremendous contrast in the electrical and optical properties of the two phases can be observed. If the PCM meet the property that both phases are stable at room temperature, the phase transformation has non-volatile switching character, which ensure low energy consumption in applications, like phase-change random access memory (PCRAM).

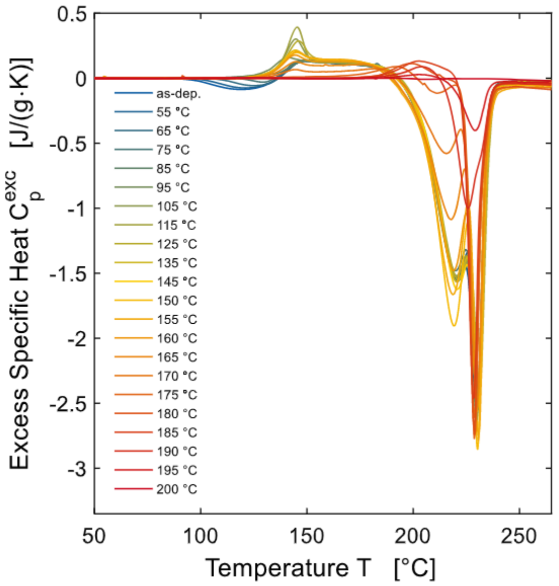

Figure 1. Excess Specific Heat Capacity C_p^{exc} of amorphous $Ge_{15}Te_{85}$ powder obtained by DSC after an annealing at the shown temperature for 1 h and subsequent heating with a rate of $\vartheta_h = 40$ K/min. Taken from [1].

For most of these PCMs this property contrast can be explained by a change of the chemical bonding upon crystallization: while the amorphous phase is covalently bonded, the crystalline phase employs an unconventional bonding mechanism, which differs from covalent, ionic and metallic bonding, denoted as metavalent bonding.

To better understand the crystallization kinetics of these materials it is of high interest to determine their glass transition temperature T_g. For some of the most prominent PCMs like GeTe, $Ge_2Sb_2Te_5$ or Sb_2Te_3 the glass transition is obscured by the crystallization. Therefore, the determination of the glass transition temperature T_g is prevented. For GeTe it was shown that the glass transition temperature can be estimated through a progressive crystallization of the eutectic composition $Ge_{15}Te_{85}$. This is done by a sub-T_g annealing which leads to a gradual change in the composition of the amorphous surrounding toward that of GeTe. This gives rise to a new endotherm whose onset temperature gradually approaches the T_g of GeTe, which can be seen in Fig. 1. The figure shows the excess specific heat capacity C_p^{exc} measured with the differential scanning calorimeter (DSC). Exothermic events have a downward deflection and endothermic events have an upward deflection.

In this work, this method will be used to reveal the glass transition of $Ge_2Sb_2Te_5$ and Sb_2Te_3. Therefore, a combination of structural and calorimetric investigations will be made with X-ray diffraction (XRD) and differential scanning calorimeter (DSC) measurements. The Tellurium rich eutectics $Ge_8Sb_8Te_{84}$ and Sb_7Te_{93} are prepared by magnetron sputter deposition.

Thus, a wide range of tasks awaits you, including sample preparation, measurement of the samples using various techniques, and evaluation of the measurement data.

[1] Pries, Julian, et al. "Approaching the Glass Transition Temperature of GeTe by Crystallizing Ge15Te85." physica status solidi (RRL)–Rapid Research Letters 15.3 (2021): 2000478.

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