I. Institute of Physics Physics of New Materials
RWTH AACHEN UNIVERSITY

Institute of Physics IA
Phase Change Group
Prof. Dr. rer. nat. Matthias Wuttig

Master Thesis in Physics

Structural relaxation and Glass Transition in PCMs

Phase Change Materials (PCMs) experience a large contrast in physical properties between an amorphous and the crystalline phase: In amorphous PCMs, optical reflectivity is low while electrical resistivity is high compared to the crystalline phase. Rapid phase switching is key ability for realizing phase change data-storage devices, such as Phase Change Random Access Memory (PC-RAM) and probably 3D-XPOINT. In general, crystallization occurs from the Undercooled Liquid phase (UCL) or a glassy phase. As Fig. 1 demonstrates, the temperature dependence of glassy phases and the UCL differs significantly. Hence, it is important to know from which amorphous phase crystallization occurs at a given temperature in order to predict its temperature dependence, since e.g. the crystal growth velocity v_g is directly linked to viscosity η by $\eta^{-\xi}$ and $0 \leq \xi \leq 1$. However, until now, it is unclear and therefore debated in literature on the amorphous phase a PCM crystallizes from.

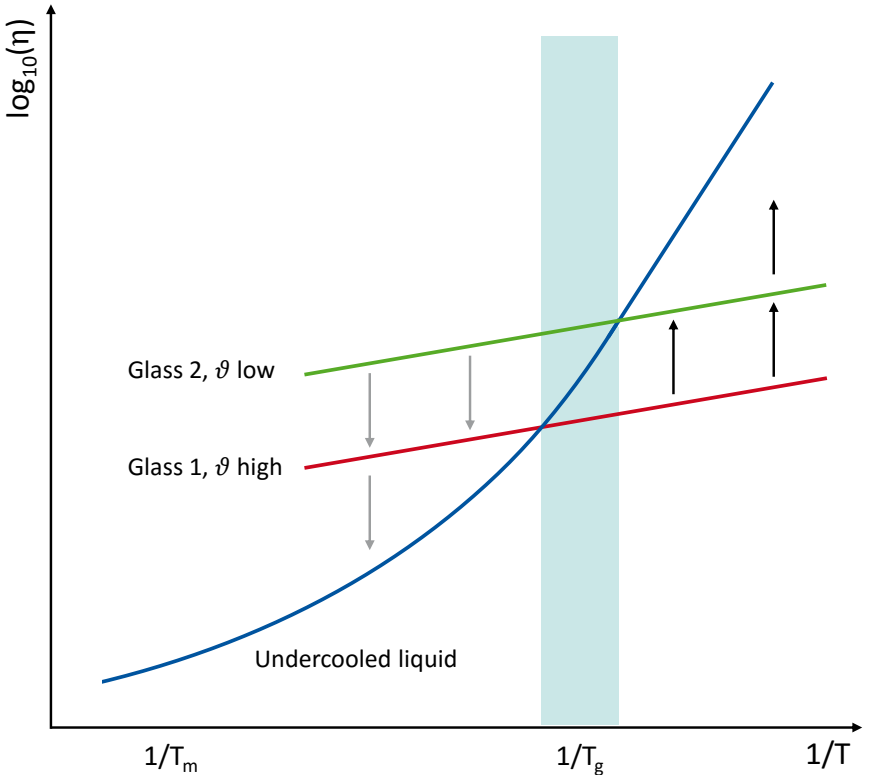

Figure 1: Viscosity of a liquid (blue curve) of composition x as a function of reciprocal temperature. While the UCL is in meta-stable equilibrium, the glass is not and therefore, the UCL and glassy states show different temperature dependencies. Upon cooling from the melt, the temperature of glass transition is cooling rate ϑ dependent. When a glassy state (e.g. red curve) is annealed at $T < T_g$, it undergoes structural relaxation in order to resemble the UCL more as indicated by the arrows (black).

While some PCMs show a glass transitions, others like GeTe do not. Other than suggestions on the glass transition temperature T_g concluded from simulations, there are no experimental values reported for e.g. GeTe in literature. Knowing the value of T_g for a certain composition is important to conclude the amorphous phase the material crystallizes from and how to extrapolate crystallization kinetics to higher temperatures.

In the scope of this thesis, specimen of various PCMs will be investigated utilizing both, Differential Scanning Calorimeter (DSC) and the ultrafast Flash DSC. The aim is first to provide a large database for further investigations, second determine the activation energy of crystallization and third to find evidence for, and based on the data predict, the glass transition temperature and its dependency on the heating rate ϑ.

Requirements for the candidate:

- A steady hand and patience while conducting measurements
- Programming understanding, fast ability to learn MatLab
- Ability to work structured, independently and responsibly
- Profound knowledge on solid state physics

Julian Pries, M. Sc.
pries@physik.rwth-aachen.de
28 A 510, Tel.: 0241 80 27169