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

Institute of Physics IA
Phase Change Group
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Master Thesis in Physics

Crystallization of 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 3D-XPOINT. In general, crystallization occurs from amorphous phases, i.e. Undercooled Liquid (UCL) or a glassy state. The difference in temperature dependence of viscosity η is demonstrated in Fig. 1. Since viscosity is an inverse measure of atomic mobility, crystallization speed is strongly dependent on the actual amorphous phase. In the glass, structural relaxation changes the atomic mobility (black arrows, Fig. 1) and thus crystallization speed, while in the UCL no such change is expected.

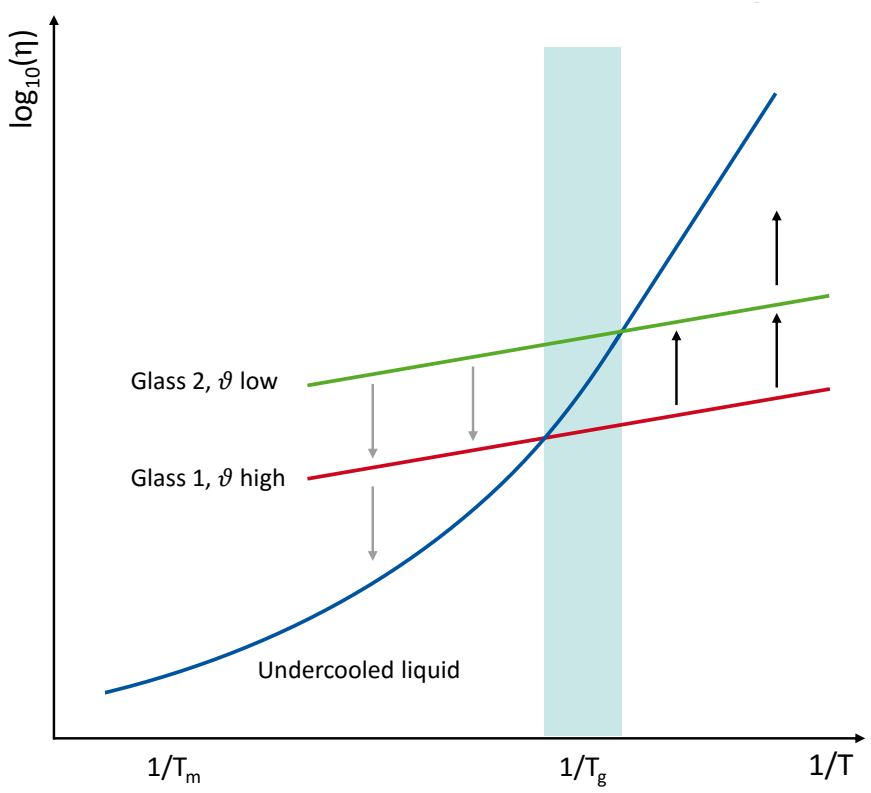

Figure 1: Viscosity of a liquid (blue curve) as a function of reciprocal temperature. Viscosity is an inverse measure of atomic mobility. While the UCL is in meta-stable equilibrium, the glass is not and therefore, the UCL and glassy states show different temperature dependence. Upon cooling from the 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).

In this work, FDSC (Flash Differential Scanning Calorimetry) that reaches heating rates up to 40,000 K/s will be used to search for characteristic sings of the glassy phase in the measured thermographs. In addition, samples will be pre-annealed to allow for possible structural relaxation to change the crystallization process that will be measured subsequently. This change shall be correlated with the enthalpy released during the pre-annealing that can be measured with a conventional DSC.

All these measurements will be connected to microscopic crystallization kinetics data that either exist or will be taken in Transmission Electron Microscopy (TEM). Thereby, the question if crystallization occurs from the UCL or a glassy phase will be answered. Furthermore, the possible link between crystallization kinetics and glass dynamics will be explored.

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

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