I. Physikalisches Institut (IA)
Phase-Change Materials
Prof. Dr. rer. nat. Matthias Wuttig

Topic for a Master Thesis

„Fabrication and testing of MBE-grown GeSnTe -PCM devices “

Phase change materials (PCM) exhibit a stable amorphous and crystalline phase under ambient conditions. Reversible Switching between the two phases allows the application of PCMs in chips for neuromorphic computing and memory devices. Most of these phase change materials feature a newly proposed chemical bond type coined metavalent bonding (MVB). Typical PCM-devices feature materials like various GeSbTe-stoichiometries, Sb_2Te_3 or GeTe. Another material class of high interest for PCM applications are GeSnTe alloys, which exhibit metavalent bonding and desirable switching characteristics.

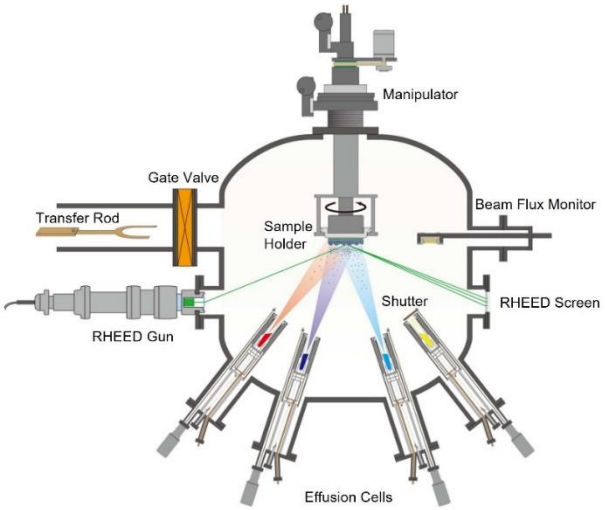

Fig 1: *Schematic of a typical MBE system with all major components similar to the MBE chamber at the Nanocluster in the Forschungszentrum Jülich. Adapted from [2].*

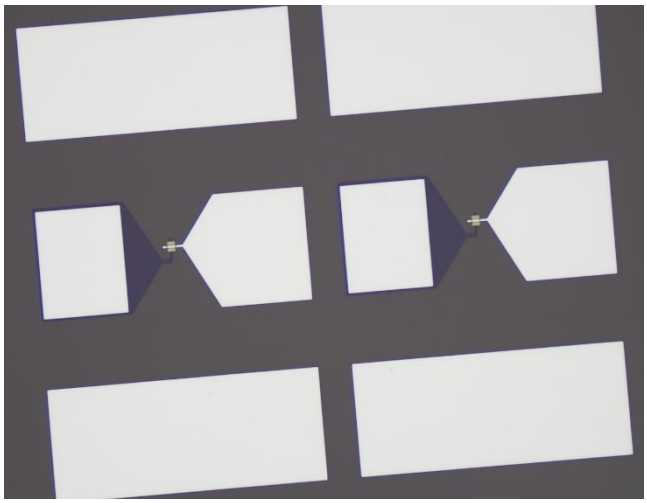

Fig 2: *Microscopy image of two PCM cells fabricated at the FZ Juelich in the Helmholtz Nanofacility.*

The goal of this work is the implementation of a fabrication process for GeSnTe thin film PCM-Devices. The thin films are grown under ultra high vacuum in a Molecular Beam Epitaxy (MBE) setup in the FZ Juelich. Once the fabrication process is implented, different stoichiometries of GeSnTe should be employed in the devices and tested with the Phase Change Electrical Tester (PET).
Prior to this work, the general growth process of GeSnTe has already been optimized. The beginning of this project will therefor focus on the optimized growth of GeSnTe on device bottom-electrodes and the optimization of subsequent dry- and wet-etching steps. Once a working GeSnTe-device is impleneted, different stoichiometries will be tested and characterized for their advatages in PCM-cells.

In the scope of this thesis the $(GeTe)_x(SnTe)_{1-x}$-samples will be fabricated by Molecular Beam Epitaxy (MBE) to achieve high quality films in the devices. Scanning electron microscopy (SEM) and x-ray diffraction (XRD) will be exploited to investigate the thin films. The fabrication process of the devices including lithography and dry- and wet-etching as well as all related processes will be carried out in the clean room of the Helmholtz Nanofacility.

The experimental work on this thesis will be conducted at the Forschungszentrum Juelich, specifically at the Helmholtz Nanofacility, and small parts at the RWTH Aachen. The sample fabrication including most analysis methods will be performed in Juelich. The switching experiments of the devices will be conducted in Aachen.

If you are interested to work on this project in the innovative laboratories of the FZ Juelich, contact us!

[1] M. Wuttig and B. Kooi. „Chalcogenides by Design: Functionality through Metavalent Bonding and Confinement.“ Adv. Mater. (2020).

[2] M. Shimozawa *et al.* "From Kondo Lattices to Kondo Superlattices". Rep. Prog. Phys. (2016).

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