DS 34: Focus Session: Resistive Switching by Redox and Phase Change Phenomena V (Structure, growth and general properties of PC materials)

Time: Wednesday 18:30–20:00 Location: CHE 89

Invited Talk DS 34.1 Wed 18:30 CHE 89

Materials engineering for phase change memory — •Simone Raoux[1] and Huai-Yu Cheng[2] — [1]IBM/Macronix PCRAM Joint Project, IBM T. J. Watson Research Center, P. O. Box 218, Yorktown Heights, NY 10598, USA — [2]IBM/Macronix PCRAM Joint Project, Macronix International Co., Ltd., Emerging Central Lab., 16 Li-Hsin Rd., Science Park, Hsinchu, Taiwan, ROC

Phase change memory is an emerging storage technology based on the unique combination of properties of phase change materials. Phase change materials exist an amorphous and a crystalline phase with distinctly different properties, and it is possible to switch the material repeatedly and rapidly between these two phases. The large difference in electrical resistance is used on phase change memory to store information. Phase change memory can have several potential applications such as storage class memory, embedded memory, replacement of DRAM (dynamic random access memory). We have explored various novel phase change materials and optimized their properties for specific applications. These materials include Ge-Sb-Te based alloys and Ga-Sb based alloys. A overview of the materials properties as function of composition is given with a focus on materials for high temperature applications, materials for high cyclability, and materials for ultra-fast switching.

DS 34.2 Wed 19:00 CHE 89

Application of the Mössbauer effect in Ge-Sb-Te and Sn-Sb-Te phase change materials — •Ronnie Ernst Simon[1,2], Ilya Sergueev[3], and Raphaël Pierre Hermann[1,2] — [1]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institut PGI, Jara-FIT Forschungszentrum Jülich GmbH, D-52425 Jülich Germany — [2]Faculté des Sciences, Université de Liège, B-4000 Liège, Belgium — [3]Deutsches Elektronen-Synchrotron, D-22607 Hamburg, Germany

Phase change materials exhibit a significant change of the electrical resistivity upon crystallization which renders these materials promising candidates for resistive switches and non-volatile electronic memories. In order to understand the switching mechanism between the amorphous and crystalline phases a detailed knowledge of the structure on a microscopic scale is crucial. Mössbauer spectroscopy and nuclear forward scattering of synchrotron radiation which are both based on the application of the Mössbauer effect are suitable techniques for local structure investigations. We performed conventional ^{121}Sb Mössbauer spectroscopy and ^{73}Ge and ^{119}Sn nuclear forward scattering measurements in Ge-Sb-Te and Sn-Sb-Te phase change materials in order to study hyperfine interactions. Measurements were performed as a function of temperature, stoichiometry and crystallinity and reveal valence changes upon crystallization. The DESY (Petra III, P01) and ESRF (ID18) are acknowledged for the provision of beamtime.

DS 34.3 Wed 19:15 CHE 89

Atomic resolution investigation of defect structures in textured metastable $Ge_2Sb_2Te_5$ by aberration corrected high resolution STEM — •Ulrich Ross, Andriy Lotnyk, Erik Thelander, and Bernd Rauschenbach — Leibniz-Institut für Oberflächenmodifizierung e.V. Permoserstr. 15 D-04318 Leipzig

Local features in the structure of phase change materials (PCM) are of foremost importance for the characteristic phase transformation mechanics made use of in data storage applications. Specifically, distribution of vacancies as well as stabilization of an ordered sublattice in the amorphous and metastable phase are believed to significantly influence the performance of PCM-based devices. However, very few studies have been able to resolve the local nanostructure in an experimental setting.

We have employed a state of the art FEI Titan^3 G2 60-300kV probe aberration corrected transmission electron microscope in order to investigate the atomic structure of pulsed laser deposited metastable $Ge_2Sb_2Te_5$ (GST) with sub-angstrom resolution. Quantitative image simulations were carried out in order to evaluate local chemical information. The results of the investigation are discussed in the context of past and current structure models of metastable GST, and a brief outlook on the possibility of in-situ heating atomic resolution imaging experiments is given.

DS 34.4 Wed 19:30 CHE 89

Metal Organic Chemical Vapour Deposition of monocrystalline $Ge_1Sb_2Te_4$ (GST) and Sb_2Te_3 — •Martin Schuck[1,2], Sally Riess[1,2], Marcel Schreiber[1,2], Gregor Mussler[1,2], Toma Stoica[1,2], Hilde Hardtdegen[1,2], and Detlev Grützmacher[1,2] — [1]Peter Grünberg Institut 9, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA - Fundamentals of Future Information Technology

GST is considered as one of the most promising materials for non-volatile phase-change memories. The phase change between its amorphous and crystalline phase is switched by current pulses of different intensity and duration. For this application the alloys along the $GeTe - Sb_2Te_3$ pseudobinary are the most suitable, since they are characterized by fast switching speed and high scalability. Their crystallization characteristics are determined by their composition, which therefore needs to be controlled.

Here we present the MOCVD growth of $Ge_1Sb_2Te_4$ (GST) and Sb_2Te_3 on Si(111) substrates using triethylantimony (TESb), diethyltelluride (DETe) and digermane as precursors and pure N_2 as the carrier gas. A systematic variation of reactor pressure and growth temperature was carried out to obtain crystalline flat layers of only one composition. The deposited material was characterized by means of X-Ray Diffraction, Raman spectroscopy, atomic force and scanning electron microscopy. It was found that, depending on the growth temperature, at low reactor pressure only 2 alloys were found: $Ge_1Sb_2Te_4$ (GST) and Sb_2Te_3. The study on the influence of the growth parameters on material properties will be presented.

DS 34.5 Wed 19:45 CHE 89

Thermal annealing studies on GeSbTe alloy-films grown on Si(111) by Molecular Beam Epitaxy — •Valeria Bragaglia, Rui Ning Wang, Jos Boschker, and Raffaella Calarco — Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany

Phase change materials are already a well established technology for data storage, in virtue of the strong optical and electrical contrast exhibited between the amorphous and the crystalline phase; additionally the switching between those two states can take place fast and reversibly. The study and comprehension of the crystallization process is then of fundamental importance. Effects of thermal crystallization on the structure of GST alloys have been widely studied. In general the films used in those investigations are produced by sputtering technique and grown on Si substrates with native SiO_2. The resulting crystalline phase is thus polycrystalline.

In this study we present the structural change upon annealing of amorphous and metastable-cubic GST films deposited on Si(111) by molecular beam epitaxy. High degree of ordering in the out-of-plane direction is achieved by annealing an amorphous GST film deposited on Si(111), as opposed to previous annealing experiments on GST deposited on non crystalline substrates. Additional annealing experiments were performed in order to find the best way to improve the quality of the GST films and find out a possible model of crystallization.