HL 34 Impurities/Amorphous semiconductors

Time: Wednesday 17:15–18:30 Room: BEY 154

HL 34.1 Wed 17:15 BEY 154

Measurement of the spatial extension of defect states by probing vacancy interactions — •Philipp Ebert, Ansgar Laubsch, and Knut Urban — Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich

The spatial extension of localized electronic states of defects in semiconductors governs to a large degree the formation of defect bands and thus the properties of semiconductor materials. Unfortunately, the spatial extension of localized defect states is largely unknown. On the one hand theory suffers from the limited size of the supercells used, where states from neighboring defects overlap. On the other hand experiments mostly rely on STM images, where defect states can be directly imaged. However, the electric field between the tip and the sample induces an extensive band bending in semiconducting surfaces, which modifies the spatial extension of the imaged defect states. Here we domonstrate for P vacancies in InP(110) surfaces that the extension of the localized defect state in the band gap can be extracted from measuring the vacancy-vacancy interaction potentials. The interaction potentials are extracted from imaging only the position of the vacancies, which remain unaffected by the electric field of the tip. We find that surface vacancies exhibit a two-dimensional repulsive screened Coulomb interaction at high vacancy concentrations, due to the formation and partial population of a vacancy-related defect band in the band gap. In contrast at low vacancy concentration no two-dimensional screening occurs, since the vacancy states do not overlap. From this we extract that the localized P vacancy state in the band gap has a spatial extension larger that 4.1 nm in diameter.

HL 34.2 Wed 17:30 BEY 154

Threshold Switching by Short Current Pulses in Phase-Change Materials — •Daniel Krebs, Michael Woda, Henning Dieker, Christoph Steimer, and Matthias Wuttig — I. Institute of Physics (IA), RWTH Aachen University, 52056 Aachen, Germany

Changes in the optical properties of chalcogenide alloys between the amorphous and crystalline phase are currently used in rewritable optical data storage. The pronounced optical contrast upon the phase transformation is accompanied by an even larger change in resistivity. This qualifies these materials for memory concept replacing Flash in mobile applications.
While in optical data storage the heat for the phase transition is supplied by a short laser pulse, in the so called PC-RAM current pulses are employed. While the resistance changes can exceed three orders of magnitude the voltage required to trigger the phase change (set operation) does not rise exceedingly in comparison with the read voltage, due to threshold switching of the highly resistive amorphous state.
To get a better understanding of the correlation between threshold switching, structural, optical, and electronical properties we have systematically varied the stoichiometry of the investigated phase change materials and characterised there properties by different techniques including x-ray diffraction, optical spectroscopy and electrical measurements.

HL 34.3 Wed 17:45 BEY 154

Local atomic order and optical properties in amorphous and laser-crystallized phase-change materials — •Wojciech Wełnic[1,2], Silvana Botti[2], Matthias Wuttig[1], and Lucia Reining[2] — [1]I. Physikalisches Institut IA, RWTH Aachen, 52056 Aachen, Germany — [2]Laboratoire des Solides Irradies, École Polytechnique, Palaiseau, France

Understanding the optical contrast between the amorphous and the crystalline state is one of the scientific challenges in phase change materials. In this work we present optical spectra calculations for crystalline and amorphous GeTe a prototype phase-change alloy.
Recent experimental data reveal that covalent semiconductors like GeTe or the ternary alloy $Ge_1Sb_2Te_4$ exhibit a profound change in local atomic order upon the phase transition from the crystalline to the amorphous state: Ge atoms which occupy octahedral sites in the crystalline state become tetrahedrally coordinated in the amorphous state. Based on these findings a simple structural model of amorphous GeTe was constructed to perform *ab initio* ground state and excited state calculations to reveal the change in optical properties.
The optical spectra are calculated in the Random Phase Approximation. The eigenvalues are corrected with the GW Approximation and two-particle excitations are taken into account within the framework of the Bethe-Salpeter-Equation. The results are in good qualitative agreement with experimental data and furthermore explain the profound change in absorption upon amorphization.

HL 34.4 Wed 18:00 BEY 154

Investigation of spin-dependent transport in a-Si:H/c-Si solar cells with pulsed electrically detected magnetic resonance — •Jan Behrends[1,2], Christoph Böhme[1,3], Karsten von Maydell[1], and Manfred Schmidt[1] — [1]Hahn-Meitner-Institut Berlin, Abt. Silizium-Photovoltaik, Berlin, Germany — [2]Institut für Physik, Carl von Ossietzky Universität, Oldenburg, Germany — [3]Department of Physics, University of Utah, Salt Lake City, UT, USA

Spin-coherent transport of charge carriers in heterostructure solar cells based on slightly B-doped crystalline silicon (c-Si) and strongly P-doped hydrogenated amorphous silicon (n-a-Si:H) has been investigated at different bias voltages by pulsed electrically detected magnetic resonance. The analysis of the coherent spin motion provides an insight into transport through the n-a-Si:H/c-Si heterojunction involving localised states at the interface and in a-Si:H. The experiment was carried out at T = 10 K under illumination. The photocurrent changes after a coherent electron spin resonant (ESR) excitation are superimposed by Rabi oscillations that are induced by the ESR pulse. Under reverse bias of the pn-junction a general increase of the photocurrent followed by a small decrease was observed at g = 2.005(1). This signal is assumed to originate from electron hopping through conduction band tail states. Under forward bias, the signal changes its sign and a second resonance at g = 1.999(1) with different dynamics appears in addition. Line widths, intensities, and decay time constants (also of the Rabi oscillations) were determined quantitatively and will be discussed with regard to hopping and recombination time constants.

HL 34.5 Wed 18:15 BEY 154

Structuring and characterisation of electronic phase change memories — •Michael Woda, Henning Dieker, Christoph Steimer, and Matthias Wuttig — I. Insitute of Physics (IA), RWTH Aachen University, 52056 Aachen, Germany

Chalcogenide based phase change materials exhibit an optical contrast between their amorphous and crystalline phase which can be switched rapidly and reversibly by laser pulses. The change in reflectivity is used in optical data storage applications such as CD and DVD.
In addition phase change alloys show a remarkable change in resistivity of several orders of magnitude. Phase change memories (or PCRAM, Ovonic memory) utilize this electronic contrast and use different short current pulses for reading and writing. It is a promising candidate to compete with existing non volatile flash memory applications.
As a characteristic feature threshold switching occurs at an applied voltage when the material is in the low conductive amorphous state. Threshold switching is necessary for phase transitions at low operating voltages. For a successful choice of material and memory development a good understanding of the switching effect has to be achieved.
Different ways of structuring phase change memory bits are presented. Electric characterization methods for determining the threshold voltage are shown. An outlook how to clarify the physical origin of the threshold switching is given.