Physics Seminar

Dr Thomas Prokscha

Lab for Muon Spin Spectroscopy, Paul Scherrer Institute, Switzerland

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Marconi Building, N115, 12:00

Title: The low-energy muon facility at PSI and muon applications: thin film, interfaces and photo-induced studies

The unique low-energy muon facility (LEM) at PSI generates and uses low-energy positive muons with keV energie for nanometer-depth-scale investigations of thin-film materials, heterostructures, and near-surface regions in a wic field of applications in condensed matter research, comprising superconductors, multi-ferroic materials, strong correlated electron systems, and semiconductor surfaces and interfaces. I will give an overview of the facility, wher we are using a moderation technique to generate epithermal positive muons with a mean energy of 15 eV and a energy width of about 20 eV FWHM, by sending a high-intensity accelerator generated MeV muon beam on cryogenic moderator, consisting of a solid Ar/N_2 layer deposited on a 10-K cold Ag foil. These epithermal muons ai electrostatically accelerated up to an energy of 20 keV, and transported by electrostatic elements to a sample regioi where low-energy muon spin rotation experiments (LE-µSR) are carried out. The implantation energy of the muons the sample can be varied between 1 and 30 keV, corresponding to mean implantation depths of a few nm up t about 200 nm, thus allowing for depth resolved µSR investigations.

With the opening of LEM as a user facility in 2006 a new era of µSR applications in superconductivity, magnetisr semiconductors and organic materials has been launched. The depth profiling of magnetic fields in thin films an heterostructures revealed fascinating new results which is demonstrated by numerous publications in high-impa journals [1]. With selected examples in superconductivity and magnetism I will illustrate the capabilities of this st emerging technique. A recent extension is the combination of LE-µSR and illumination to study photo-induced effec at the surface of semiconductors. Besides applying electric fields to control charge carrier concentration photo-generated carriers provide another fascinating possibility to tune charge carrier concentrations a semiconductor surfaces or interfaces. LE-µSR is ideally suited to study photo-induced charge carrier concentratic profiles at the surface or interfaces of semiconductors due to the tunable muon range between a few nanometer an about 200 nanometer, providing a perfect overlap of muon stopping distributions and the region of highest photo absorption close to the surface. The change in carrier concentration is detected by a change of the µSR depolarizatic rates or/and a change of muon charge fractions (Mu^+, Mu^0, or Mu^-). I present results of recent experiments on Ge where we discovered a persistent, photo-induced inversion of the surface layer of n-type Ge [2], and observed depletion of holes at the surface of p-type Ge, where the depletion can be persistently removed by illumination.

[1] M.G. Flokstra et al., Nat. Phys. **12**, 57 (2016); F.A. Ma'mari et al., Nature **524**, 69 (2015); L. Anghinolfi et al., Nat. Comm. **6**, 8278 (2015); H. Saadaoui et al., Nat. Comm. **6**, 6041 (2015); E. Stilp et al., Sci. Rep. **4**, 6250 (2014); and more on the LEM publications web site: https://www.psi.ch/low-energy-muons/lem-publications.

[2] T. Prokscha et al., Sci. Rep. **3**, 2569 (2013).