Physics Seminar

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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 energies for nanometer-depth-scale investigations of thin-film materials, heterostructures, and near-surface regions in a wide 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, where we are using a moderation technique to generate epithermal positive muons with a mean energy of 15 eV and an 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/N₂ layer deposited on a 10-K cold Ag foil. These epithermal muons are electrostatically accelerated up to an energy of 20 keV, and transported by electrostatic elements to a sample region 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 to 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, magnetism, semiconductors and organic materials has been launched. The depth profiling of magnetic fields in thin films or heterostructures revealed fascinating new results which is demonstrated by numerous publications in high-impact journals [1]. With selected examples in superconductivity and magnetism I will illustrate the capabilities of this emerging technique. A recent extension is the combination of LE-μSR and illumination to study photo-induced effects 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 in semiconductor surfaces or interfaces. LE-μSR is ideally suited to study photo-induced charge carrier concentration profiles at the surface or interfaces of semiconductors due to the tunable muon range between a few nanometer and 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 depolarization rates or a change of muon charge fractions (Mu⁺, Mu⁰, 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.
