MI 1: Festkörpercharakterisierung mit Positronen

Die Positronenannihilation hat sich seit einigen Jahrzehnten als Methode zur Untersuchung der Real- und Elektronenstruktur von kristallinen Festkörpern bewährt. Positronen, die in Strukturdefekten eingefangen werden (Leerstellen, Leerstellencluster, Versetzungen, Korngrenzen, Ausscheidungen) ändern ihre Annihilationsparameter, so dass Aussagen zur Art und Dichte der Defekte getroffen werden können. In den letzten Jahren ist eine weitere Anwendung in dielektrischen Stoffen hinzugekommen: hier bildet sich Positronium, dessen Lebensdauer ein Maß für das offene Volumen in der Probe ist. So kann bspw. das Volumen zwischen Polymerketten oder Porengrößen in Mikro- und Mesoporen charakterisiert werden. In den drei Tutorial-Vorträgen werden diese Aspekte näher erläutert. Weiterhin werden die beiden Nutzeranlagen für alle Aspekte der Positronenannihilation am FRM-II und an ELBE (HZDR) detailliert vorgestellt. Es wird erläutert, wie man als externer Nutzer Strahlzeit erhalten kann.

Chair: R. Krause-Rehberg (Martin-Luther-Universität Halle-Wittenberg)

Time: Sunday 16:00–18:15 Location: HSZ 201

Tutorial MI 1.1 Sun 16:00 HSZ 201

Positrons probing matter: What we learn about lattice defects and electronic structure using positron beams — •Christoph Hugenschmidt — E21 Physik-Department und FRM II, Technische Universität München, Lichtenbergstraße 1, 85747 Garching

Monoenergetic positrons beams are applied in a large variety of experiments in solid state physics and material science. Examples are spatially resolved defect maps of plastically deformed or irradiated metals, non-destructive investigation of layered systems, the annealing behaviour of defects or the free volume in polymers. At the surface, the annihilation of positrons with core electrons initiates the emission of Auger-electrons that allows the examination of the topmost atomic layer. In addition, the electronic structure such as anisotropies of the Fermi surface can be studied too.

Within this contribution the basic properties of positron annihilation studies will be explained. The benefit of positron beam experiments will be elucidated by selected experiments, such as (i) defect sensitive positron lifetime experiments, (ii) elemental selective (coincident) Doppler broadening spectroscopy of the annihilation line, (iii) angular correlation of annihilation radiation experiments, and (iv) time-dependent positron annihilation induced Auger-electron spectroscopy.

The neutron induced positron source NEPOMUC provides the world's highest intensity of more than 10^9 moderated positrons per second. An overview of the NEPOMUC beam facility and the positron instrumentation is given and future developments and applications of the high-intensity positron beam will be discussed.

Tutorial MI 1.2 Sun 16:45 HSZ 201

Theoretical electron and electron-positron momentum densities of transition metals and their compounds in the presence of many-body correlation effects — •Liviu Chioncel — Theoretische Physik III, Zentrum für Elektronische Korrelationen und Magnetismus Institut für Physik Universität Augsburg — Augsburg Center for Innovative Technology

Valuable information about the nature of many-electron interactions in transition metals and their compounds is obtained from experiments based on Compton and positron annihilation spectroscopy the later especially in the form of angular correlation of annihilation radiation measurements. These experiments access the electron momentum density and the momentum density of annihilating electron-positron pairs. Here we review theoretical state of the art techniques that combine Density Functional and Dynamical Mean Field Theory which allows to calculate the electron momentum densities. We survey recent experiments and calculations for paramagnetic and ferromagnetic transition metals and half-metallic ferromagnets.

Tutorial MI 1.3 Sun 17:30 HSZ 201

Positron annihilation studies at an electron accelerator: From thin films to bulk samples and 3-D imaging — •Andreas Wagner — Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstr. 400, 01328 Dresden, Germany

Positron annihilation lifetime spectroscopy serves as a perfect tool for studies of open-volume defects in solid materials such as vacancies, vacancy agglomerates, and dislocations. Moreover, structures in porous media can be investigated ranging from 0.3 nm to 30 nm employing the variation of the positronium lifetime with the pore size. While lifetime measurements close to the material's surface can be performed at positron-beam installations, bulk materials, fluids, gases, bio-materials or composite structures cannot or only destructively accessed by positron beams. In the tutorial, a set of new installations at the superconducting electron linear accelerator ELBE will be discussed. Key to all experiments is the timing resolution and the variability in pulse repetition rate which enables new ways of materials research with positrons. Depth dependent defect studies (both annihilation lifetime and Doppler-broadening) on thin films are enabled by a tunable monoenergetic positron beam. Experiments using high-energy electron-bremsstrahlung as a source for pair production inside the investigated samples release vacuum constraints and allow studying structural defects on the atomic scale even for radioactive samples with significant intrinsic activities. Some recent examples and results will be given and a facility extension for in-situ defect generation studies will be presented.