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New developments in solid state physics using radioactive ions

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Radioactive probe atoms in solids have proven to be unique sensors for internal magnetic and electrical fields and markers to study diffusion phenomena, impurity lattice sites and optical properties of impurity atoms. In contrast to conventional solid state methods applied to study magnetism and structural properties, the use of radioactive probes as sensors of internal fields is unique since the sensor size shrinks to the size of an atomic nucleus, about 10-5 of a typical crystal lattice constant. Moreover the use of radioactive nuclei circumvents sensitivity limitations due to reaction cross sections and thus radioactive probe techniques are among the most sensitive techniques in solid state physics.
A variety of technical developments will lead to a much more versatile and efficient use of radioactive probe techniques in the future. Examples are (i) the fast digital data acquisition for perturbed angular correlation (PAC) with a time resolution below 100 ps in conjunction with (ii) next generation ultrafast scintillation detectors based on rare earth silicates, (iii) detectors for angle resolved conversion electron Mössbauer spectroscopy, (v) high sensitive position resolving semiconductor pixel detectors for imaging decay electron angular distributions and (v) high sensitivity CCD sensors and compact UV lasers for efficient photoluminescence studies.
In this contribution some possible areas of research are outlined where radioactive probe techniques may provide new insights into solid state physics problems with a selectivity and sensitivity not achievable with conventional techniques. Among the examples discussed will be the application of Mössbauer spectroscopy and PAC to thin film magnetism, the possible application of PAC to study future high k dielectric materials, the application of emission channeling to high precision impurity atom lattice location and the application of radioactive probe techniques for investigating nanomaterials, surface and interface properties and advanced metallic alloys such as MAX phases.

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