ION ACCELERATORS FOR MODIFICATION AND ANALYSIS OF MATERIALS: PRESENT STATUS AND AN OUTLOOK TOWARDS THE FUTURE

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The use of ion beams for analysis of materials has a history dating back to 1909, when Geiger and Marsden observed large angle scattering of alpha particles in an experiment which subsequently motivated Rutherford to propose the existence of atomic nuclei. From the 1950s, we've been able to use the energy spectra of scattered ions, nuclear reaction products as well as characteristic x-rays and gammas to draw conclusions about the composition of a sample [1,2]. Starting in the 1970s, with the invention of solid state silicon diode detectors, techniques like Rutherford Backscattering Spectrometry (RBS) and Elastic Recoil Detection (ERD) have become routine tools for thin film analysis. With improvements of both accelerators and data analysis equipment (computers and associated software), we can nowadays use ion scattering at energies from a few keV up to tens of MeV to measure atomic composition depth profiles with monolayer resolution near the surface of a sample and with information depth down to several micrometres. When combining the available techniques, ion beam measurements are sensitive to all elements in the periodic table at levels of a fraction of a monolayer on a surface, or ppm bulk concentrations of trace components. The modification of materials by ion irradiation and dopant introduction through implantation constitute additional important roles of ion accelerators. Since the 1970s, ion implantation has been instrumental for the manufacturing of integrated circuits, and it continues to fill this role today [3-5]. Finally, accelerator mass spectrometry (AMS) and particle induced X-ray emission (PIXE) have been established as standard methods for dating and tracing the origin of a wide variety of samples, from historical artefacts to food items.

Thanks to the unique applications stated above, we identify ion accelerators as key medium sized research infrastructures, along large-scale installations such as synchrotrons and neutron research facilities. In this contribution, we present highlights of the modern applications of ion accelerators with a focus on materials research. The availability of methods for in-situ and in-operando characterization of material systems relevant for sustainable development is discussed. We further investigate the present lack of visibility for, and knowledge about, ion beam methods in the material science community, which relies heavily on neutron- and photon-based techniques. In order to help mitigate this perceived problem we go through the research questions that are best answered by methods available at ion accelerator facilities and motivate the need for maintaining such facilities as materials research infrastructures. We outline the future use of these accelerator infrastructures as specialized low-threshold user facilities where material scientists can perform tailored measurements in a manner similar to how synchrotrons are often employed today.

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