Electronic excitation and charge exchange processes in solids induced by keV ions

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Accurate quantitative knowledge of energy deposition of ions in matter is crucial for the characterization and modification of materials e.g. in ion beam analysis, ion irradiation, ion implantation and sputtering. Moreover, in the low-velocity regime (below the Bohr velocity), studying electronic excitations and energy dissipation mechanisms can shed further light on the contributions of different dynamic processes to target excitation. Such dynamic processes include Auger charge exchange processes in atomic collisions, electron promotion, collision-induced reionization and formation of molecular orbitals. Each one of these processes contributes to a different extent to the ion-solid interaction depending on the interaction distance between ion and target atoms accessible e.g. along channeling and random trajectories in crystalline targets [1,2].

We present ion transmission experiments using the Time-of-Flight Medium Energy Ion Scattering System at Uppsala University [3,4]. We investigated energy deposition phenomena in conjunction with measurements of the exit charge states implementing ion beams from H to Ne directed through 50 nm Si (100) and SiC (100) single crystalline membranes. The large solid angle, position-sensitive detector allows for identifying and selecting axially channeled projectiles and particles transmitted through low-index crystal axes as well as selecting crystal rotations in which the beam is not aligned with any plane or low-index axis of the crystal ("pseudo"-random). Our results highlight clear energy dependence of energy loss ratios (channeling vs random) with different behavior depending on the ion species. We analyze the observed differences in the measured exit charge state in channeling and random orientations in correlation with the impact parameter dependence. The higher energy loss, the higher mean charge state, and the higher straggling measured previously [5] in random orientation, point to strong contributions from local processes e.g. electron promotion and collision-induced reionization. Lastly, we consider their relevance for applications [6].

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Ultra-small CO_2 samples measured at an EA-IRMS-AMS system at CologneAMS*

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Water is the defining feature of the habitable Earth; it is essential for all life as we know it. Evolution of life in extremely water limited environments, which cover significant portions on of the Earth, is not well understood. It is the aim of the CRC1211 project "Evolution at the Dry Limit," to pioneer the research on the mutual evolutionary relationships between Earth surface processes and biota. The target areas are arid to hyper-arid systems, where both biota and Earth surface process are severely and predominantly limited by the availability of water.

To enhance our understanding of arid landscapes, precise dating analysis of soil samples from deserts like the Atacama Desert are required. These soil samples result in ultra-small CO_2 samples with a carbon content ranging from 2-20µg. At CologneAMS, ultra-small samples are analyzed as CO_2 gas using a new setup consisting of an elemental analyzer (EA), an isotope ratio mass spectrometer (IRMS), and the 6MV AMS system, facilitated by a gas injection system (GIS). This EA-IRMS-AMS setup enables fully automated, online analysis of $^{14}C/^{12}C$ ratios, providing accurate and precise $\delta^{13}C$ values [1].

At the beginning of the measurement, samples are oxidized into CO_2 gas in the EA. Subsequently, only 10 percent of the sample gas is measured for its $\delta^{13}C$ values with the IRMS, while the remaining portion is transferred to the GIS and then to the AMS. Measurement times usually range from 1-10 minutes. To extend the measuring time and minimize sample material loss during ion source output stabilization, the sample is diluted with the addition of blank gas. Dilution occurs within the GIS syringe, where a precise amount of blank gas is introduced to the sample, allowing time for ion source output stabilization and prolonging the measuring time [2].

Furthermore, our investigation focused on improving fractionation correction in ^{14}C data evaluation. By simultaneously measuring $\delta^{13}C$ values with AMS and IRMS, we found agreement within their respective error margins. Despite $\delta^{13}C$ AMS values showing significantly higher scatter than $\delta^{13}C$ IRMS values, we concluded that $\delta^{13}C$ IRMS values could enhance fractionation correction in AMS measurements [1].

This contribution provides an overview of the first size series with ultra-small samples analyzed using the EA-IRMS-AMS system and a possibility of benefiting from the additional $\delta^{13}C$ IRMS values.

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Preparation and characterization of all-solid Li-Ion battery components using neutron and ion beam methods*

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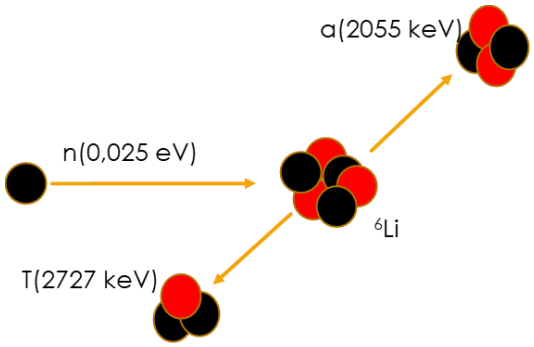
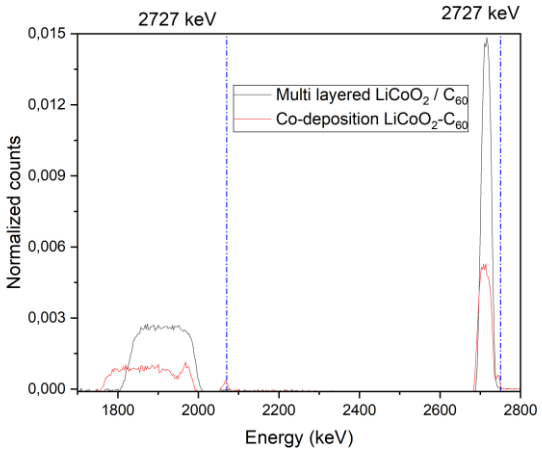
Thin film electrodes for All-Solid-State Li-Ion Batteries (ASSLIB), based on the $LiCoO_2$ composite and C_{60} buckyballs, were prepared by ion beam sputtering and vapor evaporation methods, respectfully. Various analytical methods, based on thermal neutron and ion beams, were used to study the behavior of the manufactured electrode samples. Submicrometer-thick films were investigated using Rutherford Back Scattering (RBS) for Co depth profiling, and Neutron Depth Profiling (NDP) for lithium spatial distribution [1]. Lithiation and delithiation processes were studied in-situ by NDP using several charge/discharge cycles. Nuclear methods give direct information about electrode modification and reveal in particular the inhomogeneous distribution of elements across the entire electrode thickness induced by voltage. A multilayer configuration with a thin C_{60} film on the top was found to prevent lithium diffusion without applied voltage. The results from RBS and NDP are in agreement with AFM analysis performed previously [2] and currently on the pristine and cycled electrodes.



The $^6Li(n_{th},\alpha)T$ reaction used for the NDP analysis of ASSLIBs.



NDP spectra of as deposited spectra.

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