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Deuterium Microscopy using Deuteron-Deuteron Scattering

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Nearly background free analysis of light elements is possible using the coincidence pattern of elastic scattering reactions. This has been demonstrated for hydrogen analysis, by using proton-proton (pp) scattering [1]. Microscopy with sub-µm-resolution and sensitivity below 0.1 at-ppm for hydrogen analysis becomes possible at MeV energies due to the large elastic scattering cross section enhancement and lowest irradiation damage potential [2].

Using 17 MeV deuterons as the primary beam, we demonstrate Deuterium microscopy by using the deuteron-deuteron (dd) scattering reaction at the SNAKE microprobe. The high deuteron energies are advantageous for the analysis of freestanding samples, which may be easily prepared to a thickness of several tens of micrometers, so that the scattered particles are transmitted through the sample, to the 1 mm thick Si strip detector pairs covering about 2.5 sr solid angle of detection. The cross section for the dd-elastic scattering reaction is about the same as for pp-scattering (~100 mb/sr). The main background due to nuclear reactions is outside of the relevant energy window so that ppm sensitivity is also available for Deuterium microscopy. Deuteron-proton-scattering events give an additional signal for Hydrogen atoms, so the H/D-ratio is monitored in parallel [3].

This coincidence analysis becomes a valuable tool for studies of hydrogen incorporation or dynamic processes using Deuterium marking. The background from natural hydrocarbon or water contamination is eliminated. We present our first measurements on deuterated polyethylene sheets as well as 3D deuterium microscopy of Tungsten foils.

References:
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Primary authors: Mr ROS, Linus (Lund University, Sweden); Dr REICHART, Patrick (Universitaet der Bundeswehr, Muenchen, Germany)

Co-authors: Prof. DOLLINGER, Günther (Universitaet der Bundeswehr, Muenchen, Germany); Ms PEEPER, Katrin (Universitaet der Bundeswehr, Muenchen, Germany); Mr BORYSIUK, Maciek (Lund University, Sweden); Dr MOSER, Marcus (Universitaet der Bundeswehr, Muenchen, Germany); Prof. KRISTIANSSON, Per (Lund University, Sweden)

Presenter: Dr REICHART, Patrick (Universitaet der Bundeswehr, Muenchen, Germany)

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