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Neutron Depth Profiling: A challenging new method to in situ monitor Lithium in solid-state Li-ion batteries

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Planar thin-film lithium ion batteries nowadays reveal excellent reversible electrochemical performance1. To increase the energy density of these thin-film batteries, novel approaches have been proposed. One of the new concepts is based on the etching of deep 3D-structures into a silicon substrate, increasing the effective surface area significantly. In combination with advanced materials new opportunities are obtained to increase the energy density further1,2.
Silicon and Germanium turned out to be excellent candidates for Li-storage electrode materials. About 4 Lithium atoms can be stored per Si/Ge atom. The volume expansion is, however, tremendous inducing material deterioration. In order to cope with this various approaches has been adopted. Nano-wires were found to be too mechanically sensitive to be applied in all-solid-state battery stacks. Honeycomb structure has recently also been proposed3. Striking reversible materials deformation has been reported upon (de)lithiation4.
An elegant new in situ method has been proposed, denoted as Neutron Depth Profiling (NDP)5, which is based on low-energy neutron irradiation of 6Li present at various locations inside solid-state Li-ion batteries, leading to the formation of α- and tritons particles. By measuring the energy loss of these particles that reach the NDP-detector, the depth at which these were formed can be deduced. In this presentation the basic principles of this new in situ technique will be highlighted together with some experimental results obtained with all-solid-state batteries.

References

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