Motivation
• strong interest in improving the lithium ion battery performance driven by industrial and societal needs
• fundamental processes during cycling of batteries faded from the spotlight
• majority of studies focus on composite electrodes, thus properties of electrode material superposed by additives’ properties
• investigate transport properties of single NCM particles for understanding the fundamental processes as basis for improving corresponding devices

Contacting Single Secondary Particles
• particles arranged in cylindrical traps on a lithographically patterned substrate sketched cross section
• electrodeposition for fabrication of particles
• three electrode electrochemical cell for experiments on single particles

Impedance of Single Secondary Particles
• dimension of secondary particles influences impedance signal

Size Dependence in Single Particle Batteries
• half cell of a lithium-ion battery realized
• cathode consisting of single secondary particle
• diameter of secondary particle has been varied
• resonance frequency increases with increasing particle size
• ionic charge transport in secondary particles:
  • charge transfer from electrolyte to particle
  • diffusion in grains
  • diffusion along grain boundaries

Summary
• electrochemical cell designed to measure impedance of single secondary particles
• investigation of electronic and ionic charge transport in single particles
• influence of particles’ diameter on both transport processes revealed
• increase of resonance frequency observed with increasing size of particles in electronic as well as ionic charge transport
• further experiments for characterization of single particles necessary

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References
[1] LiNi0.2Co0.8Mn1.8O2 (NCM-111) secondary particles have been prepared by Dr. Joachim Binder and co-workers at Karlsruhe Institute of Technology (KIT), Institute for Applied Materials, Department for Ceramic Materials and Technologies (joachim.binder@kit.edu)
[2] SEM investigation performed by Markus Osenberg, Department of Materials Science and Technology, Technische Universität Berlin (markus.osenberg@tu-berlin.de)