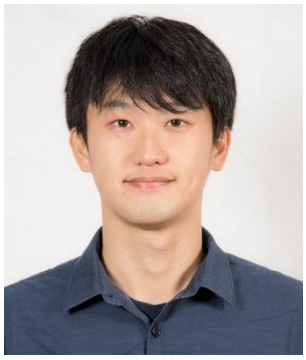

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Lithium ion battery
Electrochemical impedance
Battery algorithm

# The Origin of Impedance Rise of Ni-Rich NMC Cathodes in Lithium-Ion Batteries

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## Abstract

Ni-rich $LiNi_xMn_yCo_zO2$ (NMC) (x>y, z) electrode materials hold great promise as next-generation high-voltage, high-capacity cathodes in lithium ion battery. However, impedance rise and capacity decay of NMC electrode during prolonged cycling limits its practical application. Several research articles have attributed impedance rise to degradation mechanisms at the NMC electrode-electrolyte interface during operation. Such mechanisms include electrolyte oxidation[1], gas production[2], surface film formation[1], surface phase reconstruction[3], transition metal (TM) dissolution[1] and crack formation[4]. However, multiple degradation process used to occur in parallel, so the dominating cause of impedance rise in the NMC electrode and how they are interdependent upon one another has yet to be determined.

In the first part of the talk, near-field IR microscopy which can analyze organic compounds with high spatial resolution (~10nm) will be introduced. By this novel diagnosis techniques, we disclosed organic layers formation on binder- carbon-free thin-film NMC532 model electrode made by PLD after electrochemical cycling. Based on the structure and the chemical composition of discovered organic layers, electrolyte-NMC reaction mechanism will be discussed.

In the second part, the effect of initial property of NMC surface on organic film formation was investigated. Through comparison of film quantity and electrochemical impedance rise between pristine- and treated- NMC composite electrodes, we demonstrated the impedance contribution from organic layers.

In the end, we will introduce our impedance modeling and Nyquist plot simulation. Through comprehensively concerning all the resistance in the NMC composite electrodes, the feature in Nyquist plot and the effect of each individual interphase resistances will be discussed.

**Keywords:** NMC, solid-electrolyte interface, battery impedance, near-field IR

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