WWU MÜNSTER

ARDAVAN MAKVANDI
Arbeitsgruppe Prof. G. Wilde
Institut für Materialphysik

Topic: Analytical TEM studies of structure and chemistry of electrodes and electrode / electrolyte interfaces in Li-ion batteries

Here The Li-ion batteries have been extensity using in portable electronic devices and, recently, in hybrid-electric and electric vehicles. Many studies have been conducted to improve life cycle, energy density, safety, and cost of Li-ion batteries.1 The LiNixMnyCozO2 (NMC, x + y + z = 1) is a new generation of cathode materials that has higher reversible capacity and energy density compared to the commercial LiCoO2 electrode. However, the high concentration of Ni causes capacity fading due to the cation mixing leading to chemical and structural instability of the electrode surface. Another issue related to cathode materials is the formation and growth of solid electrolyte interface (SEI) during electrochemical cycling leading to capacity fading.2 Silicon is one of the potential candidates that can be used as an anode material as its theoretical capacity is more than 10 times higher than that of graphite (4200 mAhg-1). However, due to the large volume change during electrochemical cycling, the solid electrolyte interface forms which irreversibly consumes Li-ions and, thereby, capacity fading takes place.3

In general, interfaces determine the local Li-ion transport and finally the electrochemical cell performance. Therefore, it is necessary to study the structure and chemistry of electrodes and electrode/electrolyte interfaces. The surface engineering (e.g. coating) of electrode materials is one of approaches used to improve the electrochemical performance of Li-ion batteries.

Characterization of electrode materials is important to understand the correlation between microstructural and chemical change and the electrochemical performance in order to improve the battery performance by modifying the microstructure (e.g. coating). Analytical transmission electron microscopy (TEM) techniques are ideals tools for studying the microstructure and chemistry of electrodes and electrode-electrolyte interfaces before and after electrochemical cycle. In this work, we study the structural and chemical degradation mechanism of cycled uncoated NMC-111, NMC-622, LiCoO2, and silicon electrode materials using TEM. Moreover, the effect of coating layer on the stability of electrode surface and, thereby, the electrochemical performance is studied.

1. Nitta, N., Wu, F., Lee, J. T. & Yushin, G. Mater. Today 18, 252–264 (2015).
2. Myung, S. T. et al. ACS Energy Lett. 2, 196–223 (2017).
3. Jin, Y., Zhu, B., Lu, Z., Liu, N. & Zhu, J, Adv. Energy Mater. 7, 1–17 (2017).