TEM Study of a $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$ Cathode from a Li-ion Cell with 70% Capacity Fade

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The $LiNi_{0.8}Co_{0.15}Al_{0.05}O_2$ (LNCO) electrode is a prime candidate for Li-ion batteries being developed for electric and hybrid electric vehicles [1]. Power fade in cells with LNCO is often attributed to the formation of a SEI-layer on the cathode particle surfaces; however, clear identification of this layer remains inconclusive. In this work, a LNCO cathode cycled in a Li-ion cell between 4.1 and 3V at constant current was studied by transmission electron microscopy (TEM) at the lattice dimension level. The purpose of this study was to look for the microstructual features responsible for performance loss.

A 12-cm^2 pouch cell was constructed from LNCO and graphite electrodes received from Quallion Corp. and LP40 electrolyte[2]. This cell showed 70% capacity fade after 1000 C/2 cycles at 25C°. The cell was disassembled and samples of the cathode were prepared for TEM measurements under inert conditions.

TEM observations indicated that a SEI layer formed on the LNCO particles, and lattice expansion and defect disorder accompanied cell cycling and capacity fading. Figure 1 shows an SEI layer about 5 nm thick on a LNCO grain surface. The lattice fringes of 0.24 nm represent the (006) crystal plane. An EDX spectrum (visible at the upper left of the figure) of the entire image area indicated the absence of significant impurities in the SEI layer. Many defects, stresses, and dislocations were directly observed in LNCO grains as shown in Fig. 2. This kind of edge dislocation (circled) involves the removal of one-half of a (104) lattice plane of atoms from the crystal. Some small lattice disorder was found in LNCO grain as shown in Fig. 3. The position marked with an arrow shows a lattice-disordered island about 4 nm in diameter surrounded by well-ordered (003) lattice fringes. The lattice expansion was also demonstrated by the TEM lattice images in Fig. 3. Some (003) lattice planes were expanded to 5 Å. Compared to the original fresh LNCO crystal, the (003) lattice plane was expanded by 6% due to cell cycling. It is believed that all of the above-described SEI layer, dislocation, lattice disorder, and lattice expansion are related to cell power fade.

References

1. X. Zhang et al. J. Electrochem. Soc. **148** (2001) A463.
2. J. Shim et al. J Power Sources, **112** (2002) 222.

Acknowledgements

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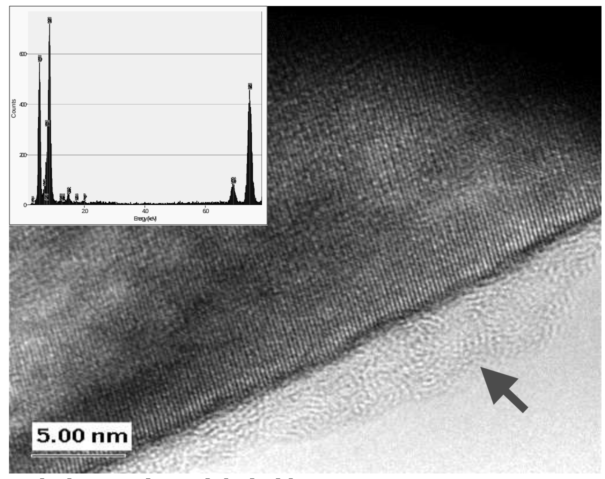

Fig.1 Lattice image & EDX spectrum of a LNCO grain with the SEI layer labeled by an arrow.

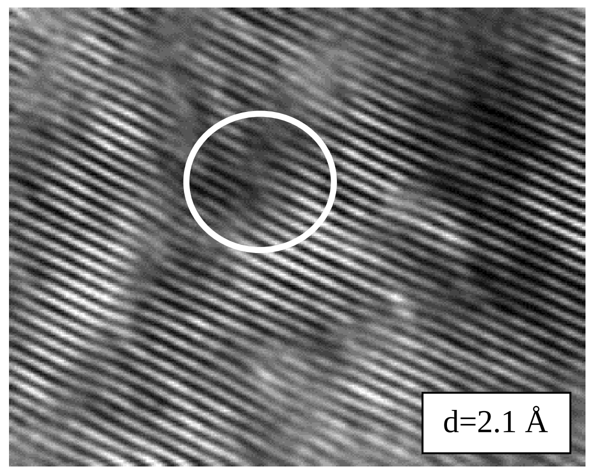

Fig.2 Lattice image of the dislocation in a LNCO grain after cell cycling and power fade.

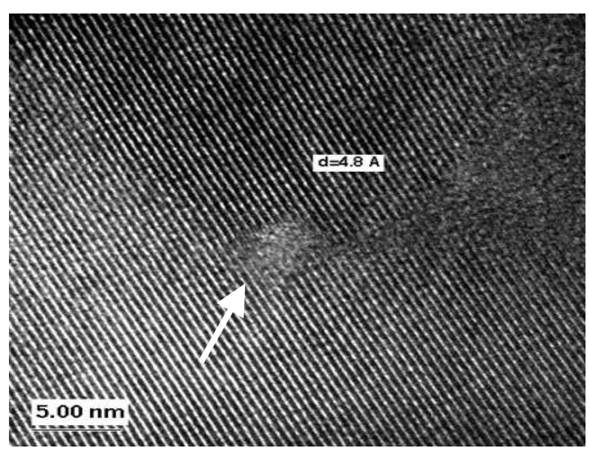

Fig.3 Lattice image of small disordered area (marked by and arrow) & lattice expansion in a LNCO grain.