Performance enhancement of Li-ion battery by laser structuring of thick electrode with low porosity

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Improving energy density and power density is the key issue in the development of high performance in Li-ion battery. Making electrodes thick and/or low porosity is an effective method to improve battery performance. With increased thickness and reduced porosity, however, energy density and rate capability could be deteriorated due to the increase of internal resistance and the decrease of lithium ion diffusion [1]. Recently, it was demonstrated that the wettability and performance of Li-ion battery could be improved by laser structuring of the electrode as a result of increasing electrode surface area [2].

In this study, the enhancement of performance in the $LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ (NMC532) electrode by laser structuring is reported. Grooves were structured on the electrodes with different porosity (25% and 50%) and thickness (105 μm to 215 μm) down to the aluminum foil by using a femtosecond laser (pulse width of 190 fs, wavelength of 1030 nm, repetition rate of 30 kHz and maximum laser power of 6 W). Afterward electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV) and rate capability were analyzed to confirm the improvement of battery performance by laser structuring with respect to electrode thickness and porosity. As shown in Figure 1, the laser structuring enabled the thick electrode to discharge readily. Especially, specific capacity of the laser structured electrode was higher than that of the unstructured one despite the capacity loss by laser ablation. Also, the increased capacity was achieved by the laser structuring at the low porosity as shown in Figure 2. In conclusion, laser structuring to thick and low porosity electrode is expected as a promising technology to develop the high rate capability with even high energy density in Li-ion battery.

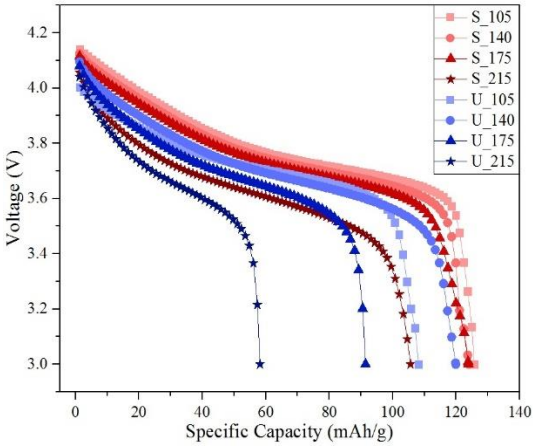

Figure 1. Discharge curve of unstructured (U) and structured (S) low porosity electrodes at 0.5C with respect to thickness.

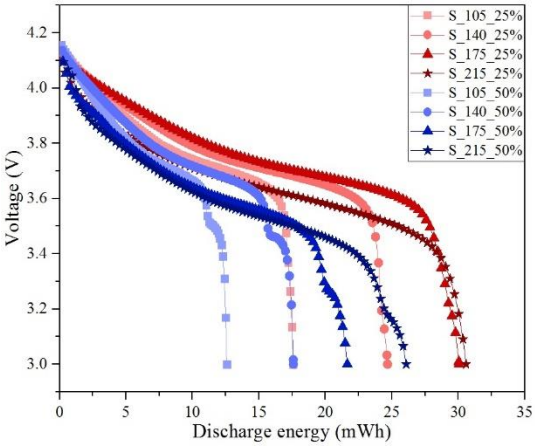

Figure 2. Discharge curve of high and low porosity electrodes at 0.5C with respect to thickness.

References:

[1] H. Zheng, J. Li, X. Song, G. Liu, V.S. Battaglia, Electrochimica Acta, 71 (2012) 258-265.
[2] W. Pflegiing and J. Proll, Journal of Materials Chemistry A, 2 (2014) 14918-14926.