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Nanostructured Nickel Oxide Foams as the Anode of Rechargeable Lithium Batteries

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Nickel oxides have been extensively studied as electrode materials for various functional electrochemical devices such as gas sensors, electrochromic devices, rechargeable batteries and electrochemical capacitors. In particular, they have been considered as the promising next-generation anode materials in rechargeable lithium batteries due to their high specific capacity (700 mAh/g), low cost and excellent cycling stability. However, nickel oxides result in low energy density of the battery because they react with lithium at relatively high potential (0.8~2.0V *vs.* Li/Li^+) in normal operation conditions. Moreover, the lithium oxide formed at cycling process might act as electrical insulating phase causing decreased reversible capacity and rate capability. One possible way to solve these problems is to reduce the reaction polarization by using the nano-sized nickel oxides that provide short pathway for ion and electron transport. In this regard, the syntheses of various types of nanostructured nickel oxides (e.g. nanowires, nanoflakes, nanosheets) have been reported for the application to rechargeable lithium batteries.

Nanostructured metallic foams (NMFs) are considered as one of the most promising options for electrode design in functional electrochemical devices because their large area for fast surface reaction and micro/nano hybrid pores for facile lithium ion transport might decrease the activation and concentration polarizations, respectively, during the operation of electrochemical devices. At the time of their first introduction, a couple of metallic phases of copper, tin and their alloy were reported to have NMF structure, but recently different metals including nickel have been successfully prepared in a similar form.

In this work, the branch surfaces of nanoramified nickel foams were deliberately oxidized and the resulting samples were evaluated as the anode of rechargeable lithium battery. Despite the oxidation process, the morphology of the nickel/nickel oxide foam was nearly identical to that of the as-prepared nickel foam. As the anode of rechargeable lithium battery, its reversible capacity was varied with foam thickness and oxidation conditions. In our initial results, it proved that the nickel/nickel oxide foam reacted quite reversibly with lithium and the excellent capacity retention was maintained after 100 cycles. Furthermore, it showed notable rate performance thanks to its unique structure. For instance, the reversible discharging capacity at the rate of 7.43C ($2.25mA/cm^2$) reached about 50% of the corresponding capacity at the rate of 0.25C ($0.1mA/cm^2$).

In this presentation, the change in the overall foam shape and the proportion of nickel oxide to nickel in the foam branches with oxidation conditions will be suggested. In addition, the optimal oxidation condition for enhanced reversible capacity and rate performance will be critically discussed.

References

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