SJSU SAN JOSÉ STATE UNIVERSITY

SJSU Undergraduate Research Grants

Lithium Fluoride Coated Titanium Dioxide (Bronze) Nanowires in Lithium Ion Batteries

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Abstract

The goal of this research is to build a next generation lithium-ion battery (LIB) to meet the growing demand for energy storage devices. In this project, a metastable phase of Titanium Dioxide (TiO_2), Bronze phase (TiO_2(B)), in the form of nanowires are chosen due to their high specific capacity as well as higher surface area for lithiation in Lithium Ion Batteries, allowing for a more energy dense electrode in aqueous electrolyte LIBs.

To prevent any potential water electrolysis reaction on these nanowires, it is proposed to pair them with a LiF (lithium fluoride) coating that ideally passes lithium-ions but blocks water molecules thus creating an artificial Solid Electrolyte Interphase.

XRD Phase Identification

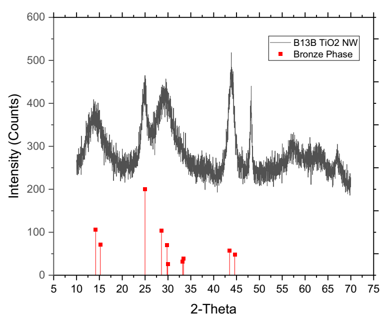


Figure 1. XRD results of TiO_2 (B) nanowires, showing full conversion to the metastable Bronze phase

LiF Coating of Nanowires

- Mix unannealed TiO_2 (B) NW with PAA to act as binding agent
- Add 1 wt% Lithium Acetate and 1 wt% Ammonium Fluoride solution to mixture to form LiF layer
- Anneal/ burn PAA binder in box furnace at 300 C for 4 hours

To verify that the PAA was being burned out in the annealing step of the nanowire synthesis, TGA was performed and showed that with 2 hours of burning at 300 C most of the PAA had been successfully removed

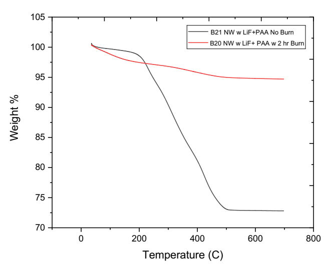
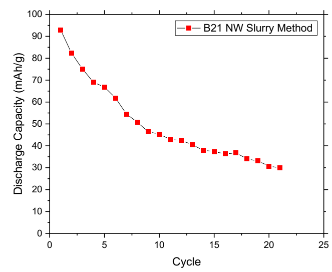


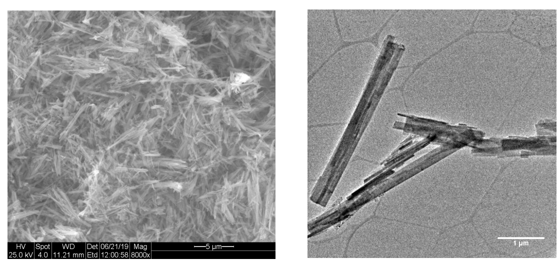
Figure 4. TGA data of B21 NW + PAA without annealing and B20 NW + PAA w annealing step completed

Project Activities and Findings

- We have successfully formulated a hydrothermal synthesis to create the metastable TiO_2(B) NW (nanowires), which have been verified through XRD, SEM, and TEM
- A slurry and doctor blading method was chosen to preserve the morphology of the NW, which has yielded promising results with initial discharge capacity over 92 mAh/g



SEM/TEM Imaging Verification



(a) (b)

Figure 2. (a) SEM images of B13-B TiO_2(B) nanowires (b) TEM images of B21 TiO_2(B) nanowires

Citations and Credits

Armstrong, A. R., Armstrong, G., Canales, J., & Bruce, P. G. (2004). TiO2-B Nanowires. *Angewandte Chemie*, *116*(17), 2336–2338. doi: 10.1002/ange.200353571

Du, Z., Peng, W., Wang, Z., Guo, H., Hu, Q., & Li, X. (2018). Improving the electrochemical performance of Li-rich Li1.2Ni0.13Co0.13Mn0.54O2 cathode material by LiF coating. *Ionics*, *24*(12), 3717–3724. doi: 10.1007/s11581-018-2556-9

Li, J., Wan, W., Zhou, H., Li, J., & Xu, D. (2011). Hydrothermal synthesis of TiO2(B) nanowires with ultrahigh surface area and their fast charging and discharging properties in Li-ion batteries. *Chemical Communications*, *47*(12), 3439. doi: 10.1039/c0cc04634e

Yang, Y., Wang, Z., Zhou, R., Guo, H., & Li, X. (2016). Effects of lithium fluoride coating on the performance of nano-silicon as anode material for lithium-ion batteries. *Materials Letters*, *184*, 65–68. doi: 10.1016/j.matlet.2016.08.006

Zhang, L., Zhang, K., Shi, Z., & Zhang, S. (2017). LiF as an Artificial SEI Layer to Enhance the High-Temperature Cycle Performance of Li4Ti5O12. *Langmuir*, *33*(42), 11164–11169. doi: 10.1021/acs.langmuir.7b02031

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