Nanostructured Materials Based on Si Nanowires, Carbon Nanotubes and MoS_2 for Li-ion Battery Anodes

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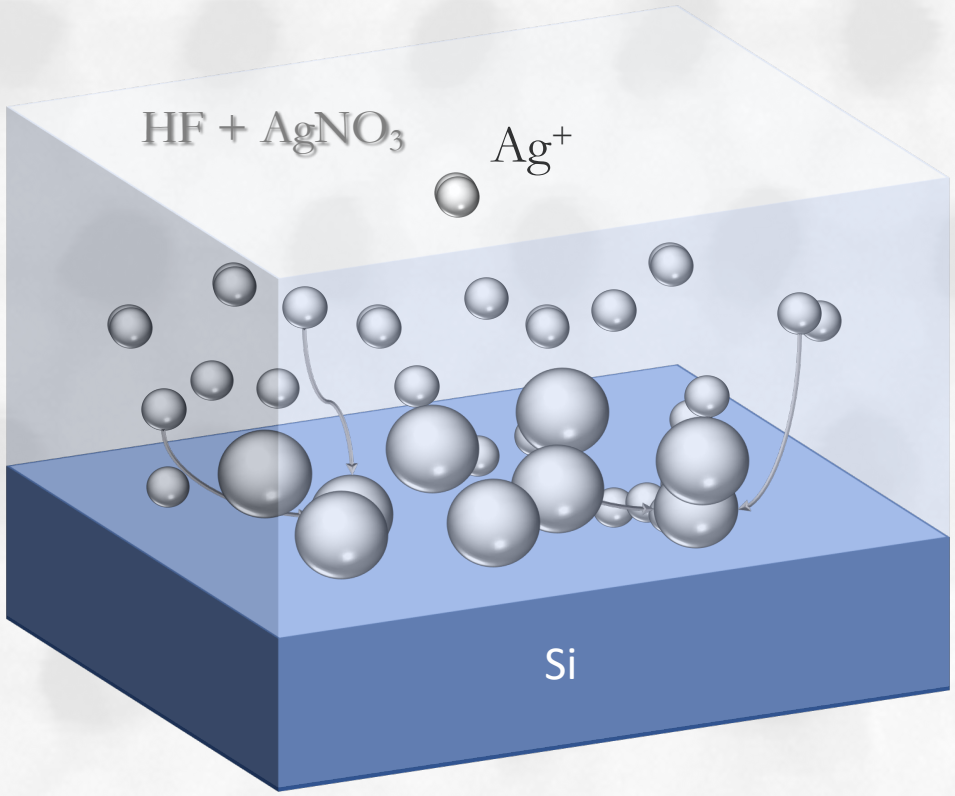
How to obtain SiNWs?

Metal Assisted Chemical Etching (MACE)

Localized etching of silicon in the presence of a catalyst, which can be any noble metal such as Au, Ag, Pt or Pd.

Step 1: Catalyst deposition

Electroless deposition method



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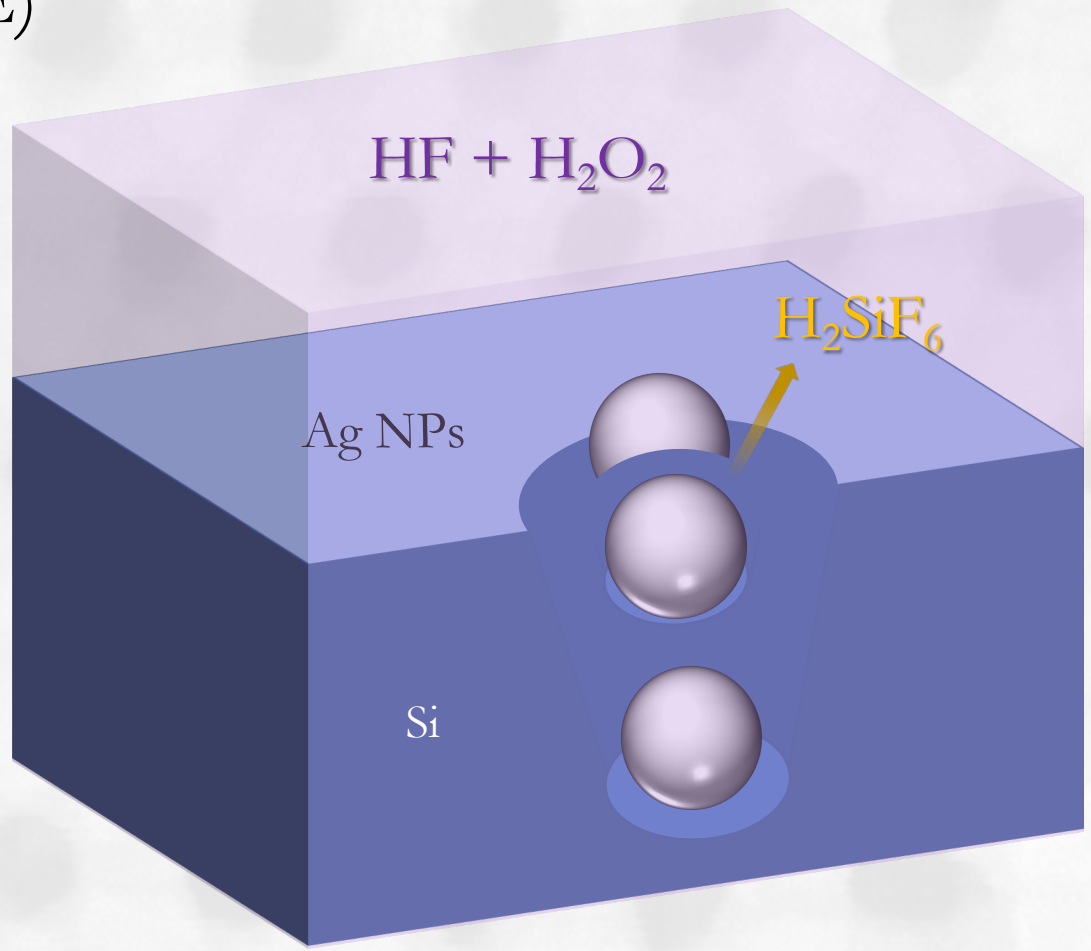
Step 2: Etching



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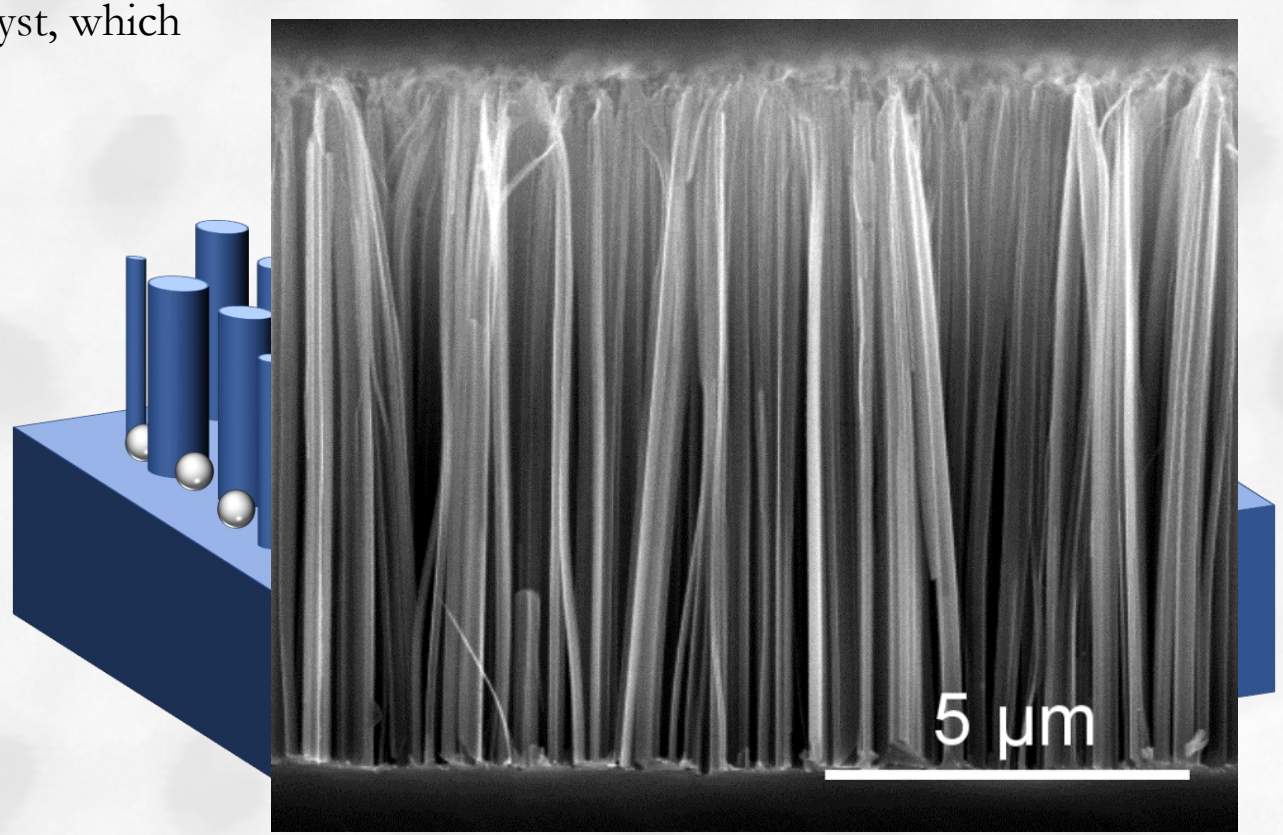
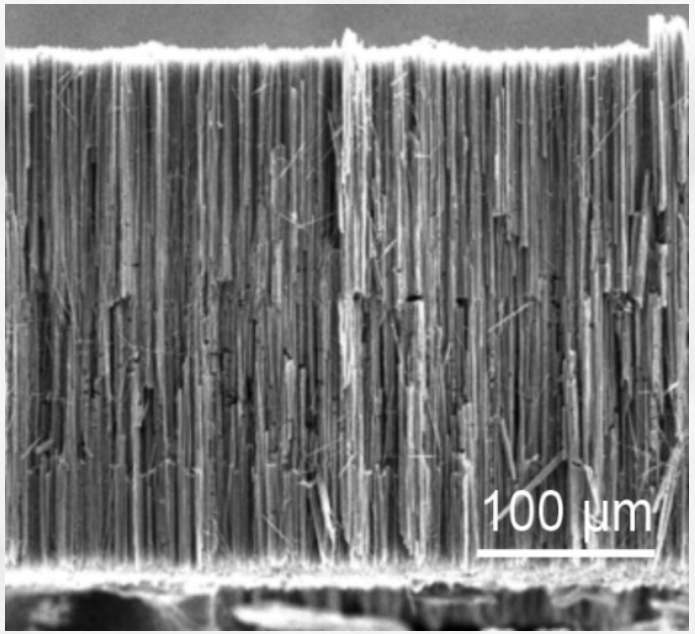
Step 2: Etching

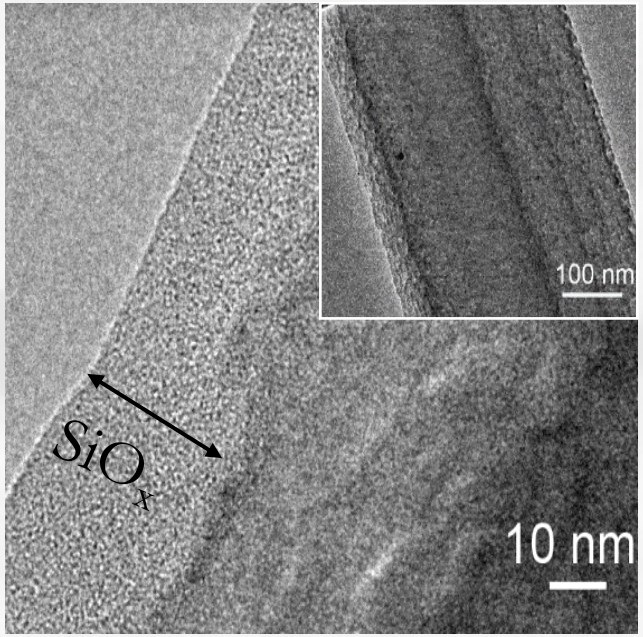
End

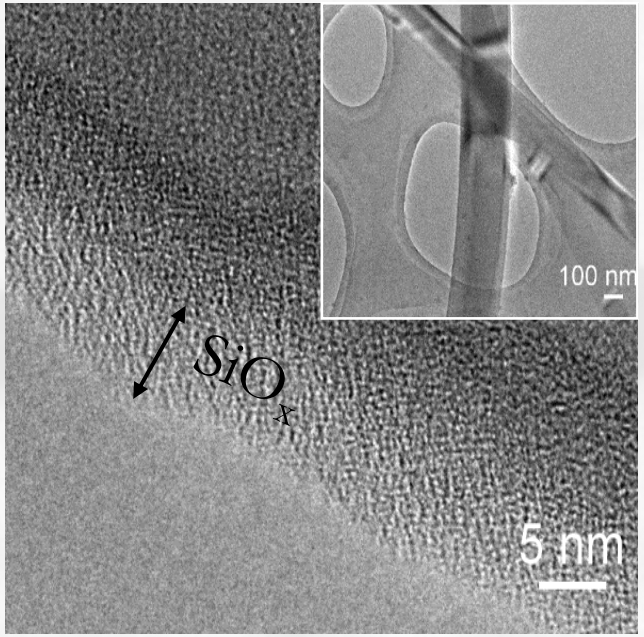


c-SiNWs (MACE) for Li-ion batteries

As-synthesized SiNWs

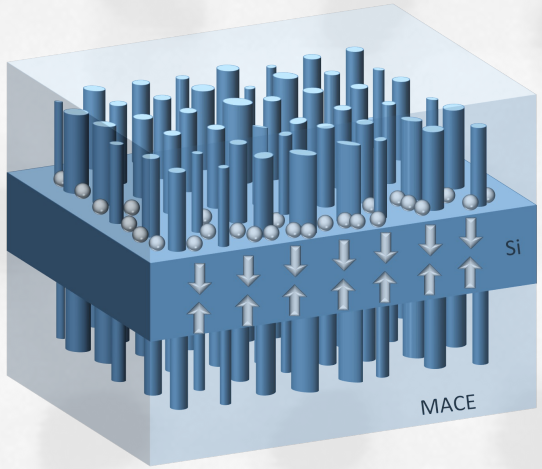




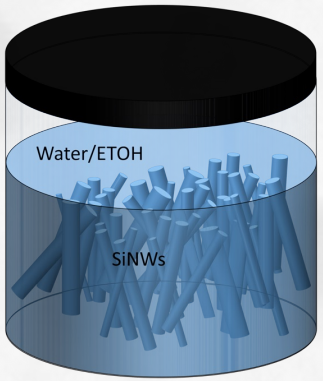


c-SiNWs (MACE) for Li-ion batteries

1.- Full-wafer etching

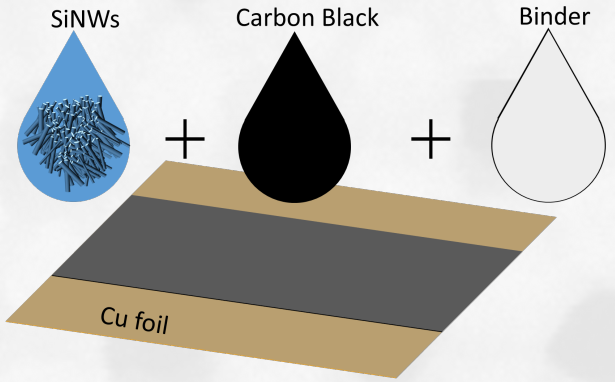


2.- Dispersed SiNWs

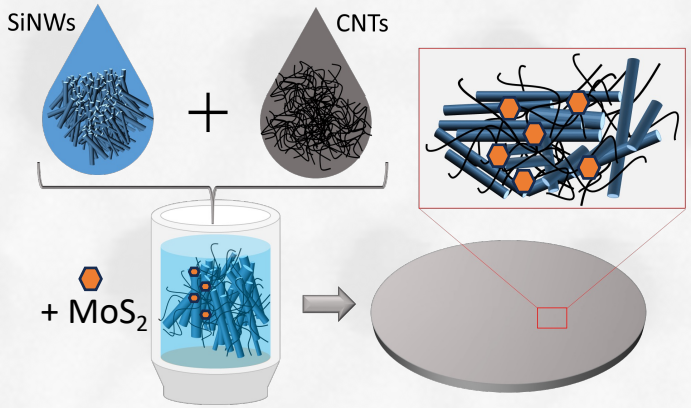


3.- Electrode fabrication

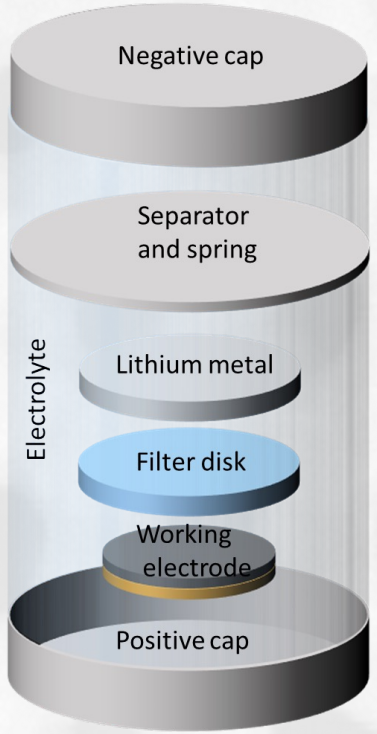
a) On-foil electrodes



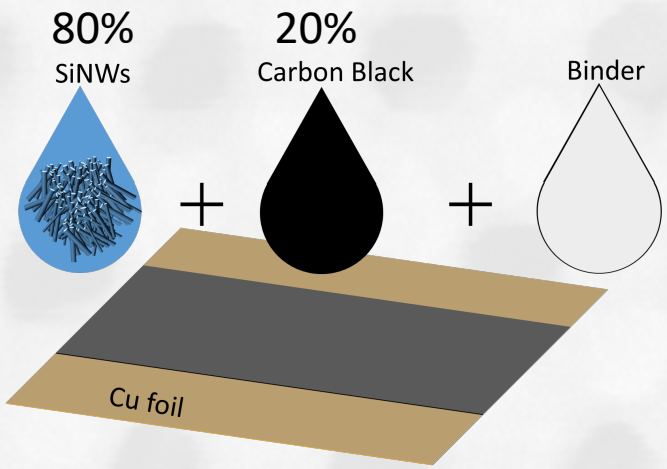
b) Free standing electrodes

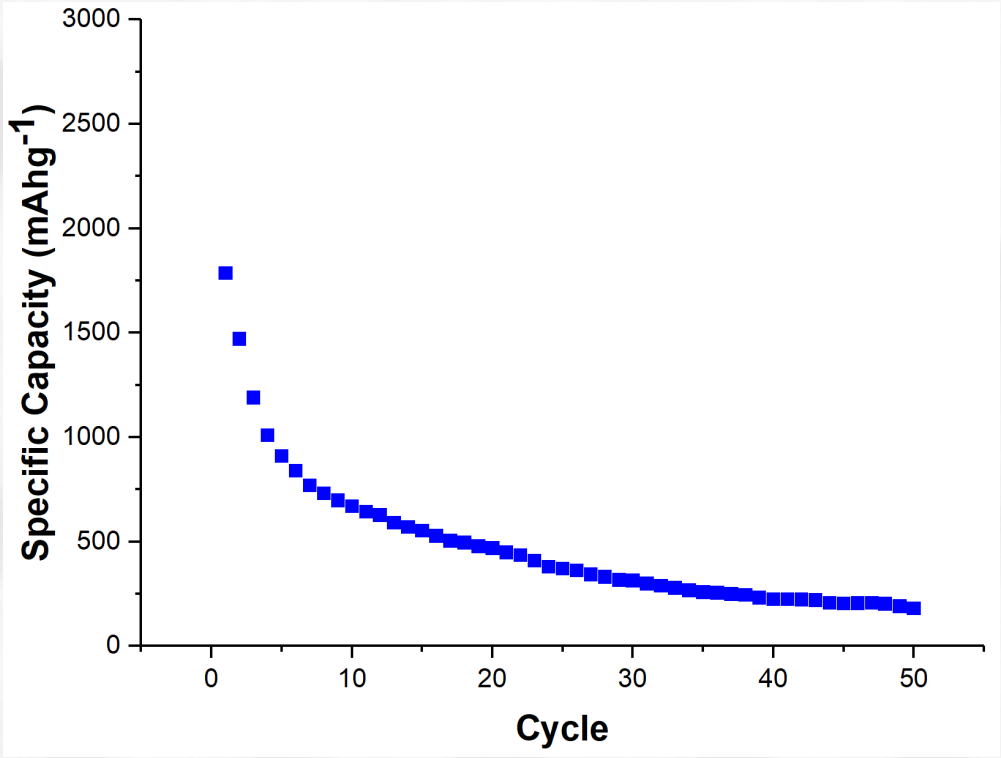


4.- Battery assembly



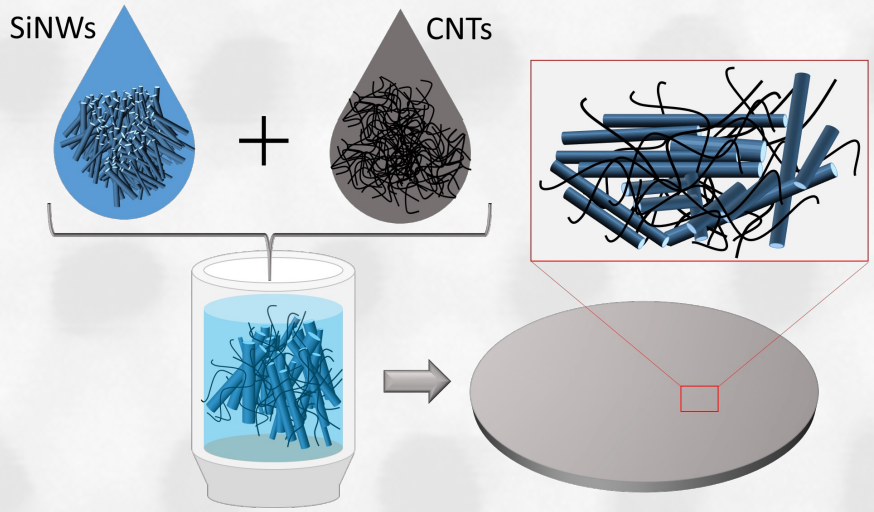
c-SiNWs/Carbon Black for Li-ion batteries—On-foil electrodes

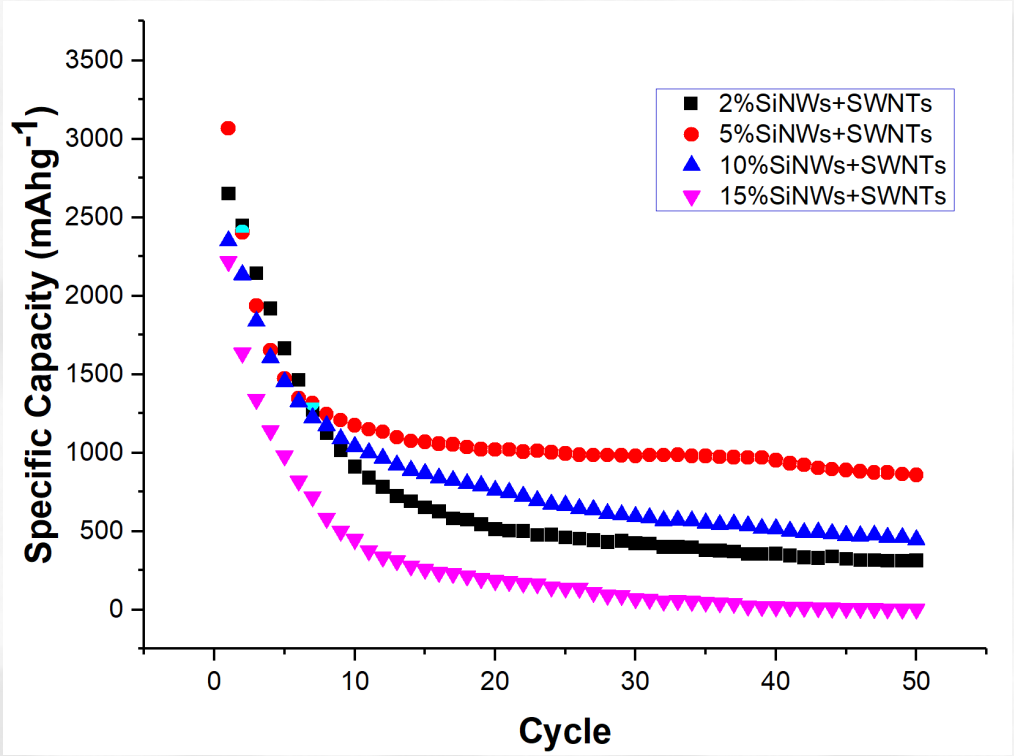




Anodes primarily based on SiNWs exhibit poor performance.

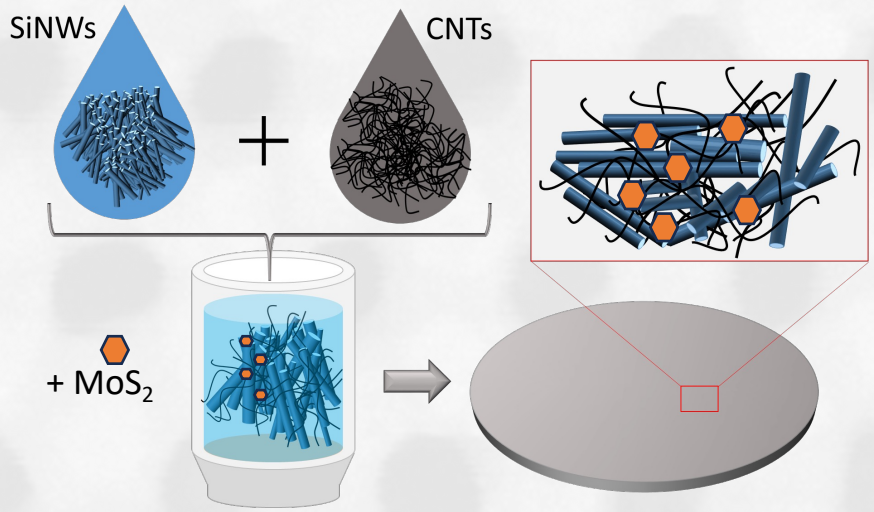
c-SiNWs/CNTs for Li-ion batteries—Free standing electrodes

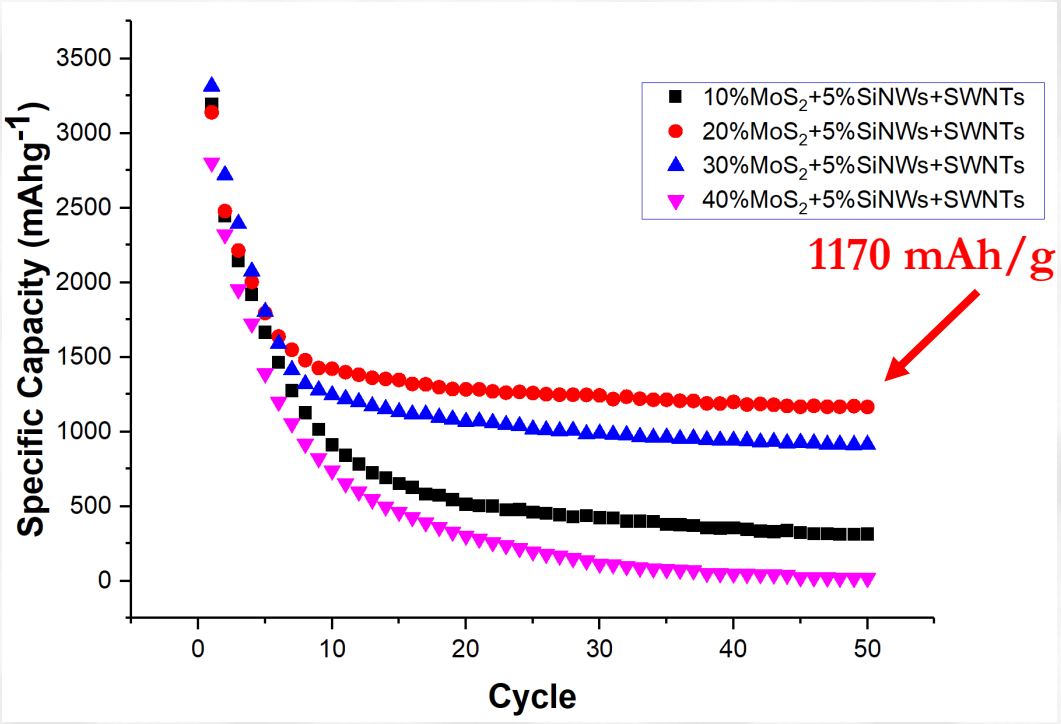




The highest capacity is observed with anodes based on 5% SiNWs + 95% SWNTs

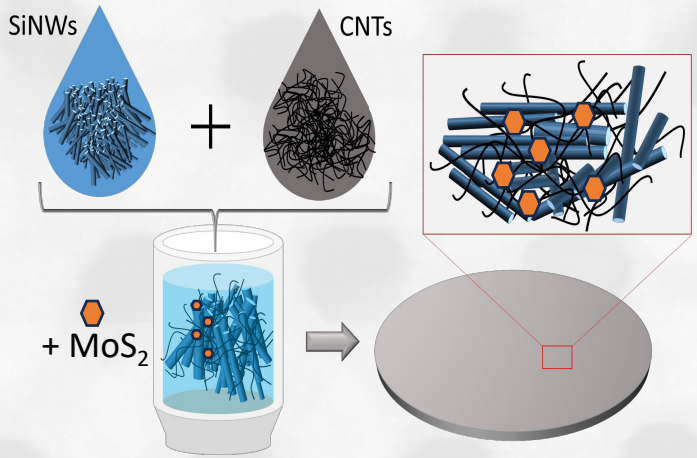
c-SiNWs/CNTs/MoS_2 for Li-ion batteries—Free standing electrodes

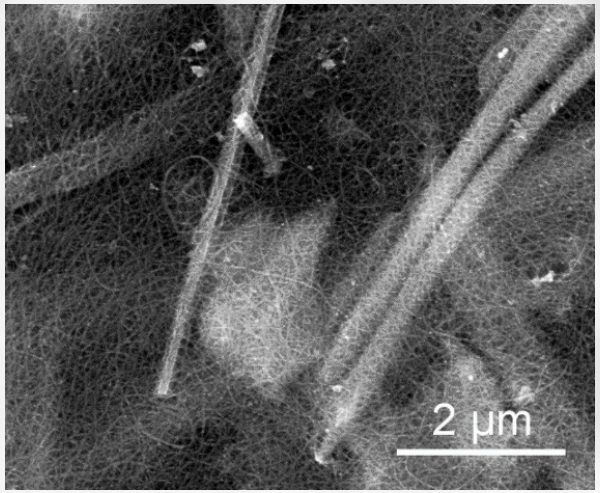


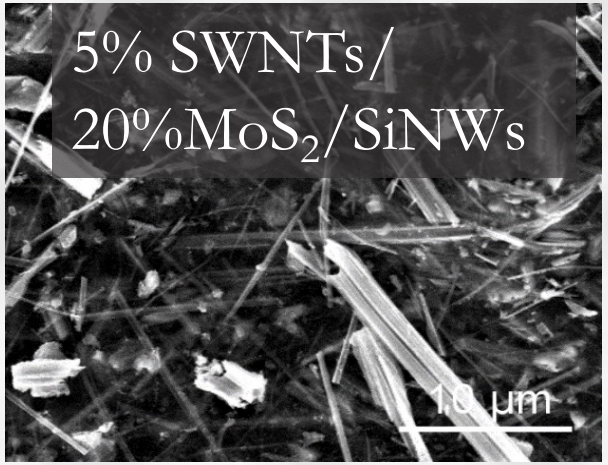


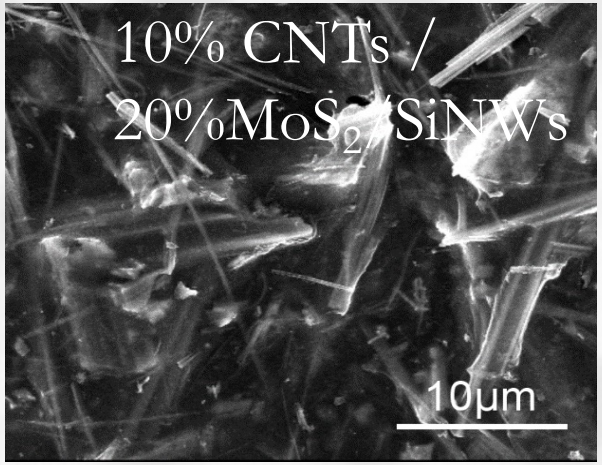
- Higher capacity with 20%MoS_2 (**1170 mAh/g** after 50 cycles)
- Better cycling performance

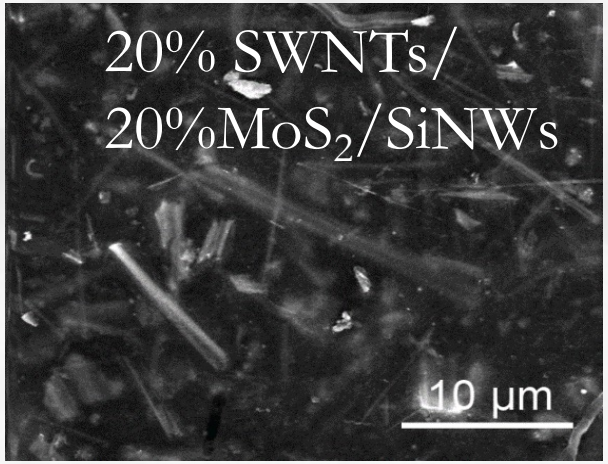
c-SiNWs/CNTs/MoS_2 for Li-ion batteries—Free-standing electrodes

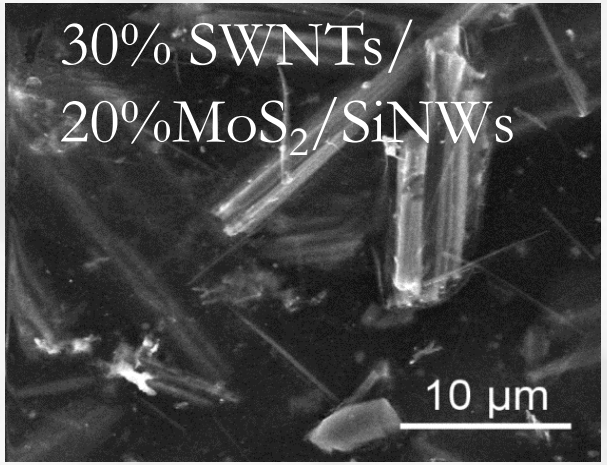




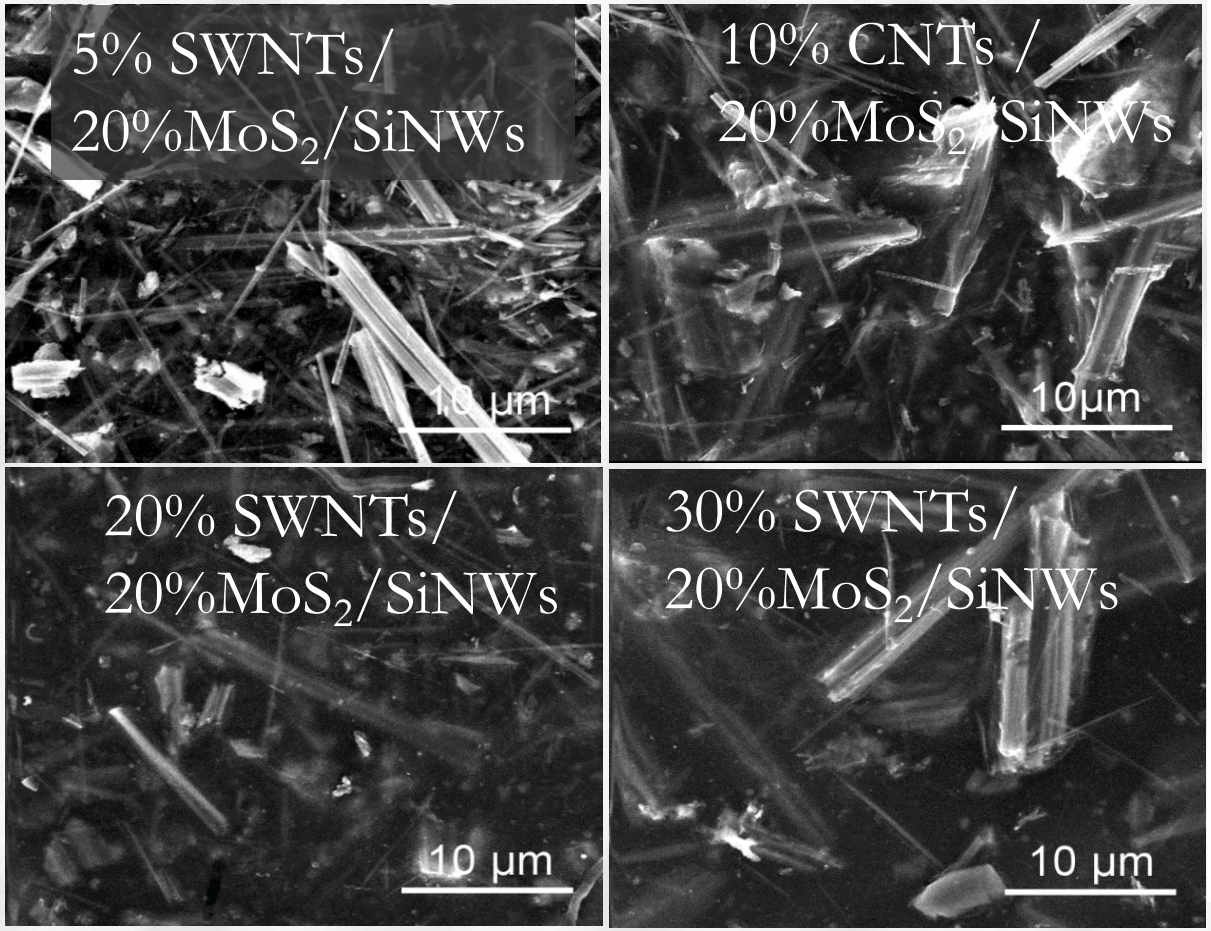


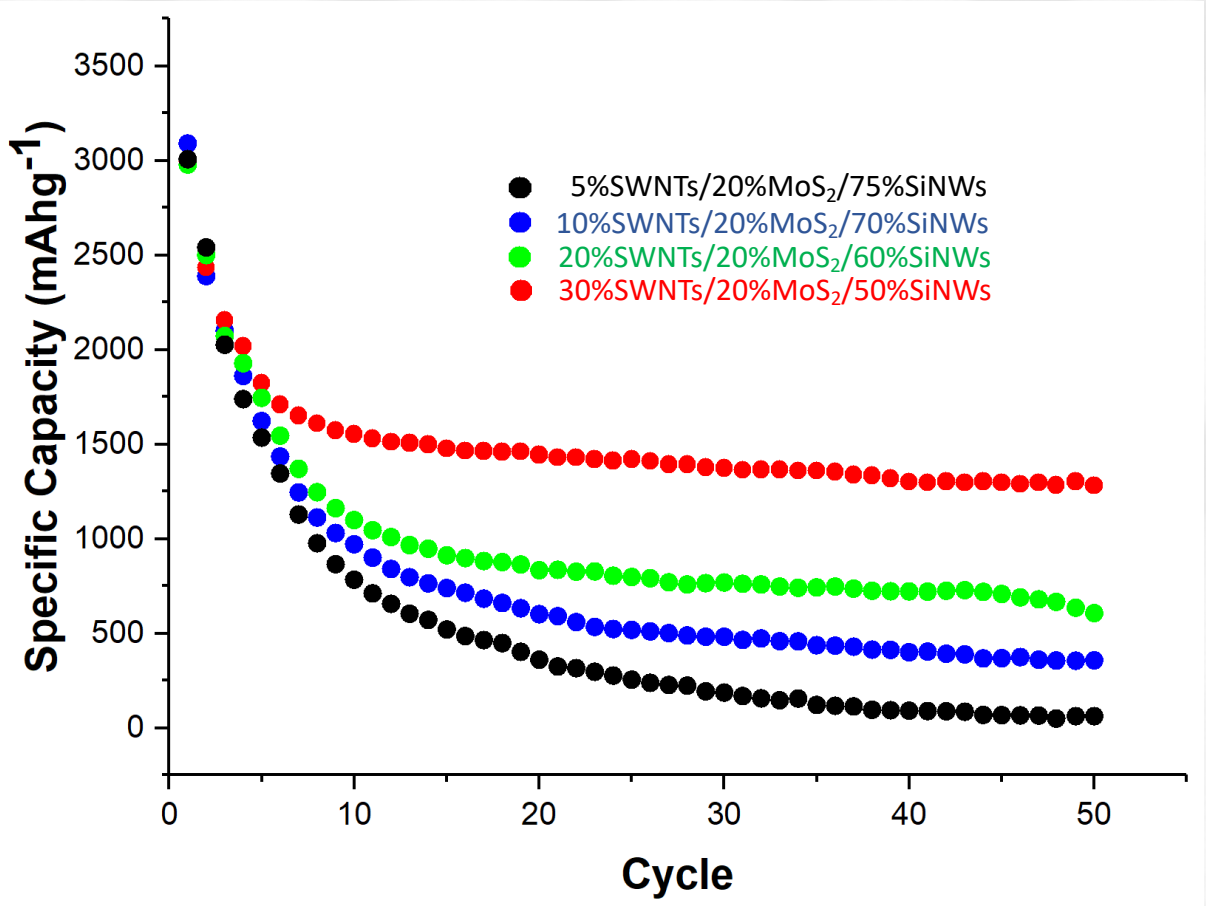






c-SiNWs/CNTs/MoS_2 for Li-ion batteries—Free-standing electrodes





Conclusions

The results obtained in this research have led to the following conclusions:

1.- Crystalline Si nanowires obtained through the MACE method substantially enhance battery efficiency.

2.- The incorporation of MoS_2 seemingly improves the conductive properties of the anode, resulting in increased battery capacity and cyclability. However, when the proportion of this component is too high, a decline in efficiency is observed, potentially due to issues with the electrical conductivity of the adduct.

3.- The inclusion of carbon nanotubes is known to significantly enhance the overall performance, justified by an improvement in the electrical conductivity of the system. The nanotubes form a network that captures silicon nanowires and MoS_2 nanosheets, thus improving the conductive properties of the anode.

Future Prospects

Currently, a combinatorial chemistry-based study is being conducted to establish the optimal preparation conditions for anodes based on MoS_2, SWNTs, and SiNWs. Additionally, the delamination processes of MoS_2 are being improved through chemical methods and ultrasound-assisted exfoliation. The role of SiNWs is also crucial, and new procedures are being developed to enhance synthesis processes, particularly by mitigating or reducing silver contamination occurring in the MACE method. Lastly, the incorporation of graphitic carbon nitride as an additional additive to those already considered in this research is being evaluated.

Acknowledments

Thanks