Advanced Applied Materials for Solid-State Batteries-2 (AdamBatt-2)

Project Partners:

The Microstructure and Electrochemical Behavior of Potassium Anode Material in All-Solid-State Sodium Batteries

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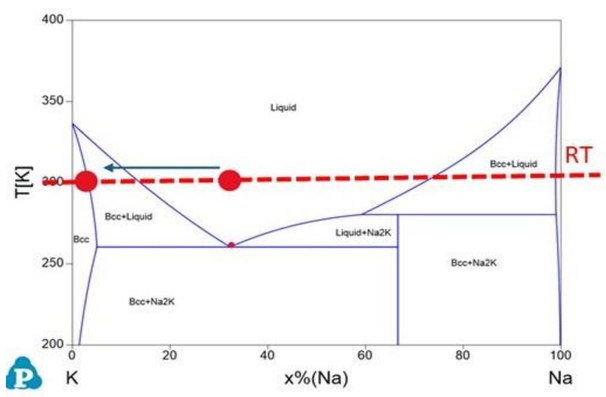
Abstract:

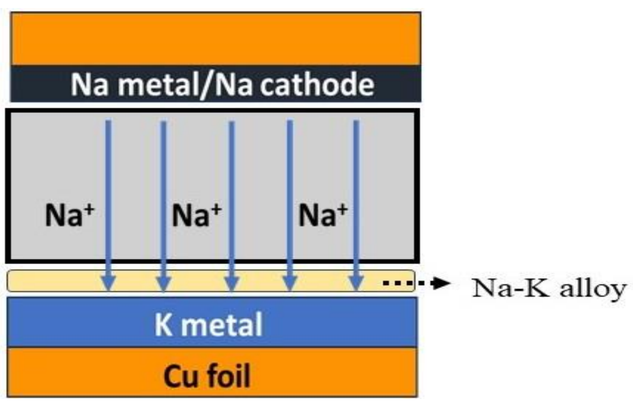
All-solid-state sodium-ion batteries face a major challenge: high interfacial contact impedance at the solid–solid interface. To address this issue, we propose leveraging the fact that sodium can react with potassium at room temperature to form a Na-K liquid alloy. Our goal is to design a battery in which the Na-K liquid alloy forms during charging and discharging, creating a solid–liquid interface that significantly reduces impedance. Our approach involves depositing potassium onto a copper foil using thermal evaporation, which can enhance the contact between copper and potassium.

Introduction

According to the Na-K binary phase diagram, a Na-K alloy can easily become liquid form at room temperature. Based on this property, we aim to design an all-solid-state sodium-ion battery using potassium (K) as the anode. During charge and discharge processes, a Na-K liquid alloy will form in situ. This liquid interface can significantly reduce interfacial impedance and alleviate the stress caused by electrode expansion during battery operation, thereby enhancing the electrochemical performance of the battery.



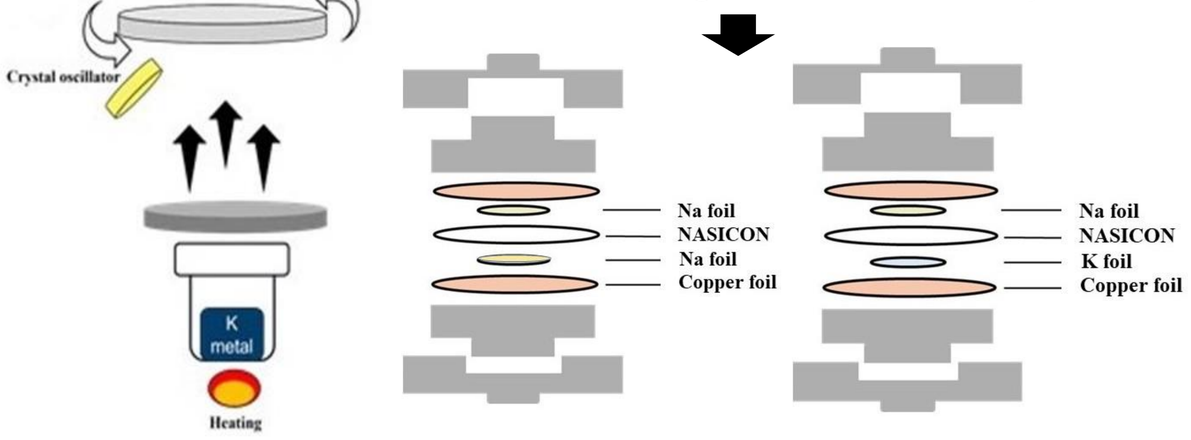
Phase Diagram of the Na-K System



Schematic Diagram of Battery Theory

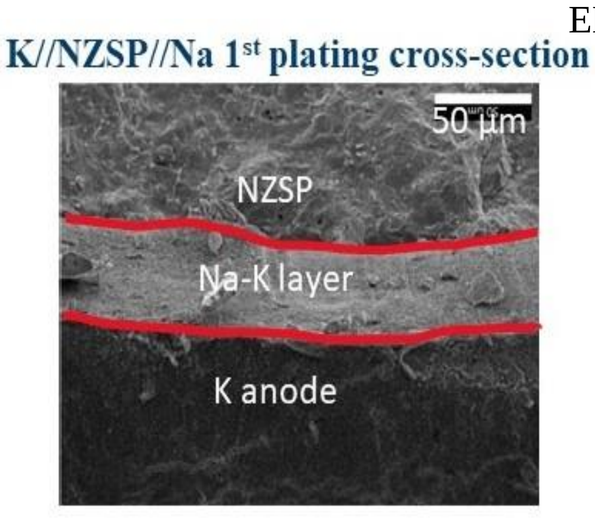
Experiment Method

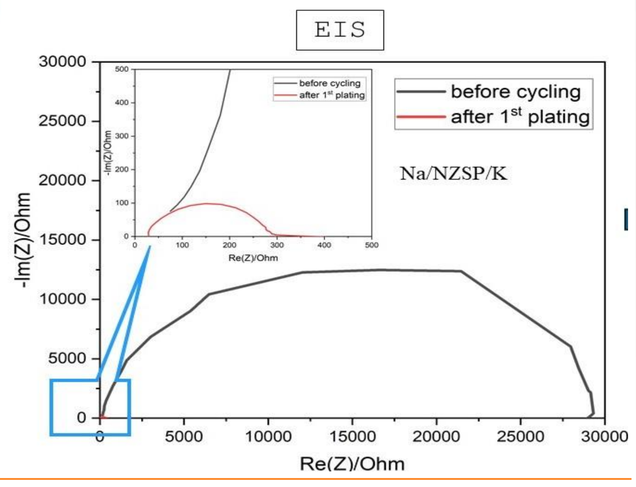
Schematic Diagram of Potassium Thermal Evaporation Configuration of the Battery



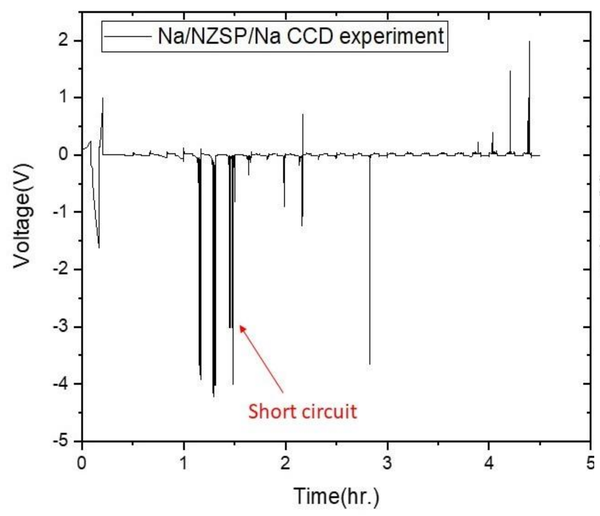
Results

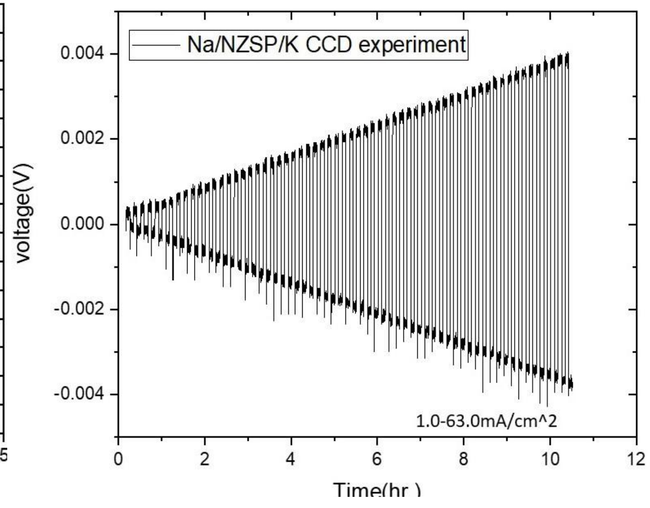
EIS Testing Before & After First Charging



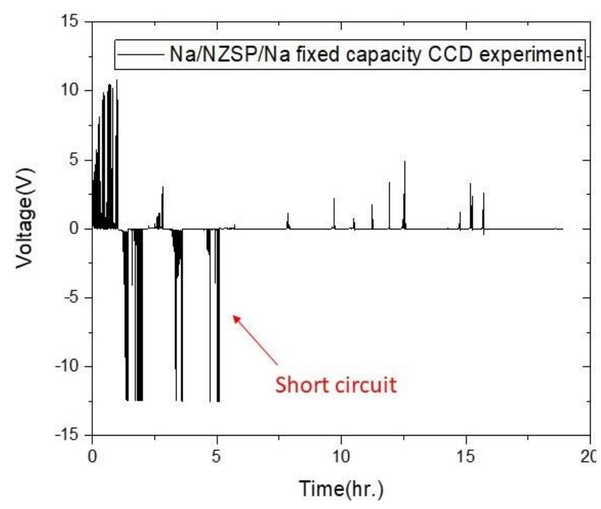


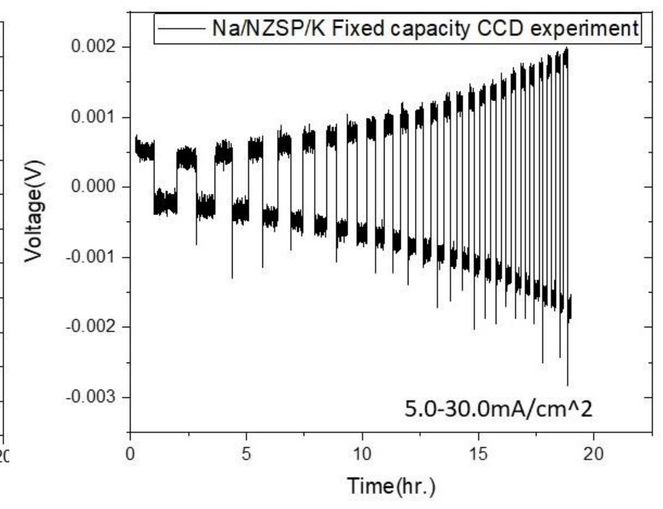
Fixed Time Critical Current Density(CCD)Experiment (5 minutes per half step)



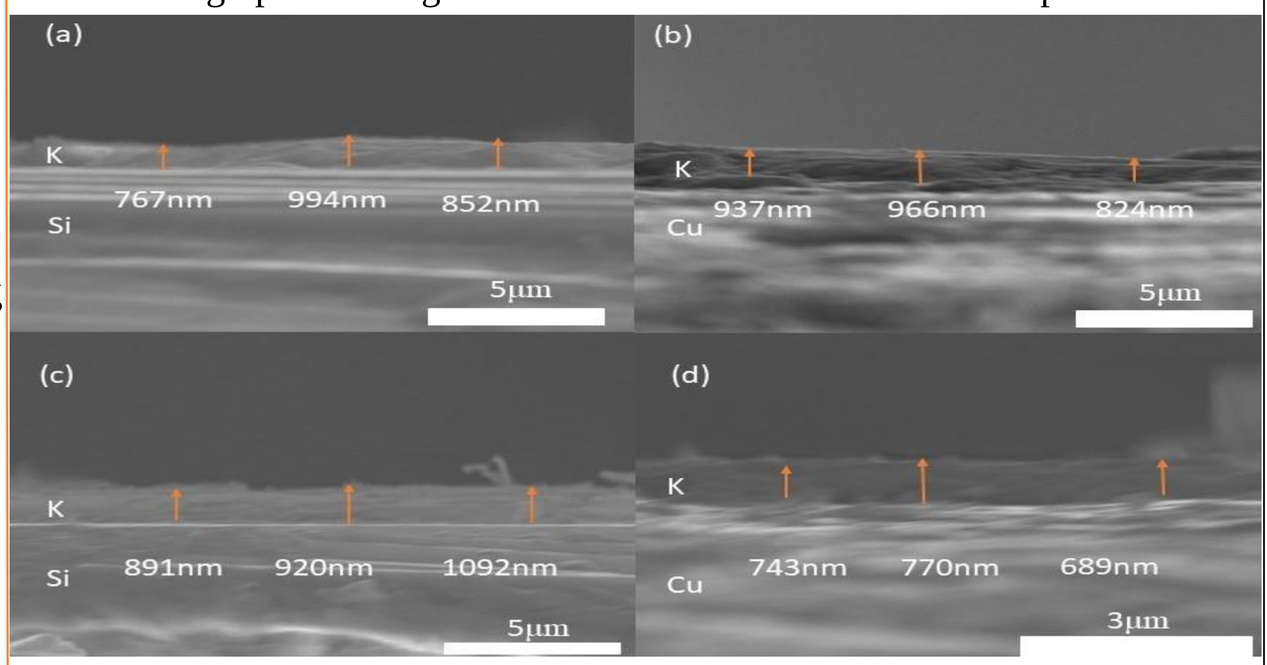


Fixed Capacity CCD Experiment (5.0 mAh per half step)





SEM Micrograph Showing Side View of Potassium Thermal Evaporation



Conclusion

According to the above CCD experiment, the presence of the K anode clearly demonstrates its potential to improve electrochemical performance. However, other key battery characteristics—such as areal capacity and performance under various temperatures—still require further investigation. Regarding the potassium thin film prepared via thermal evaporation, our ultimate goal is to utilize it in the fabrication of a volume-less battery.

References

1. *Trofimov, E., et al., Thermodynamic Reassessment of the Na-Cu and Na-K Binary Systems. Metals, 2018. 8(8).*
2. *Ma, Q.L., et al., Enhancing the Dendrite Tolerance of NaSICON Electrolytes by Suppressing Edge Growth of Na Electrode along Ceramic Surface. Advanced Energy Materials, 2022. 12(40).*
3. *Tsai, C.L., et al., Dendrite-tolerant all-solid-state sodium batteries and an important mechanism of metal self-diffusion. Journal of Power Sources, 2020. 476.*

Acknowledgements

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