NANOTECHNOLOGIES

High Performance Asymmetrical Supercapacitors Based on Bi-Metallic Transition Metal Phosphide Nanocrystals

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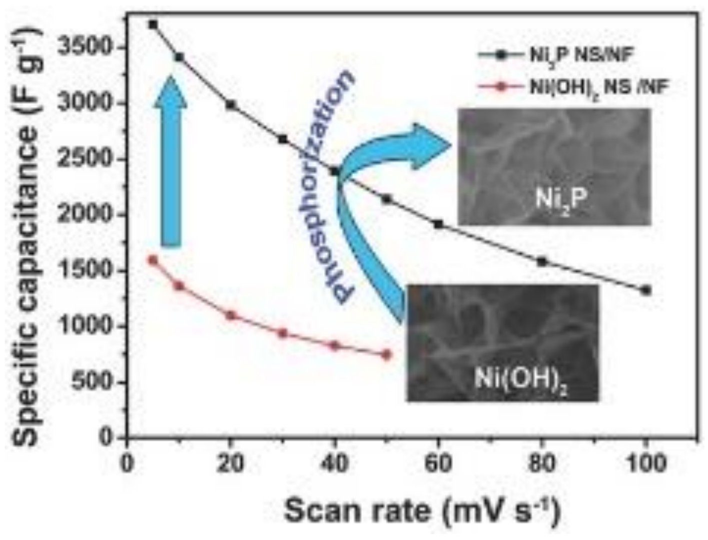
Background

Transition metal phosphides (TMPs), as an important class of functional materials, are attracting great interest for use as electrode materials in supercapacitors (SCs) due to their metalloid characteristics and high conductivity. However, the TMP-based electrodes by far suffer from unsatisfactory specific capacitance and poor cycling stability, impeding their practical use in supercapacitors. Fine-tuning the composition of bi-metallic TMPs may further improve the charge storage capacity of the supercapacitor electrodes, but how the ratio of two metal components affects the capacitive properties and where the synergy originates from have been rarely explored both experimentally and theoretically.



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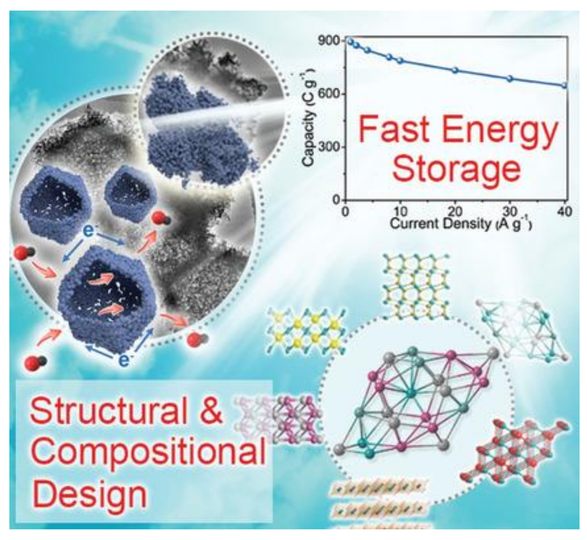

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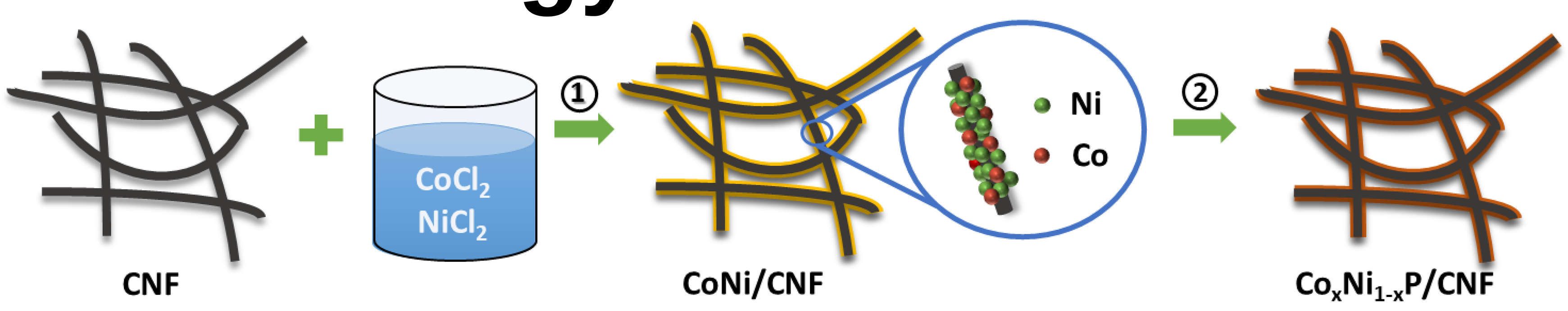
Methodology



① Reduction via $NaBH_4$ in ethylene glycol (EG) solution
② Phosphorization in the presence of NaH_2PO_2 at 300 ℃

Figure 1. Schematic of preparing $Co_xNi_{1-x}P$/CNF electrode

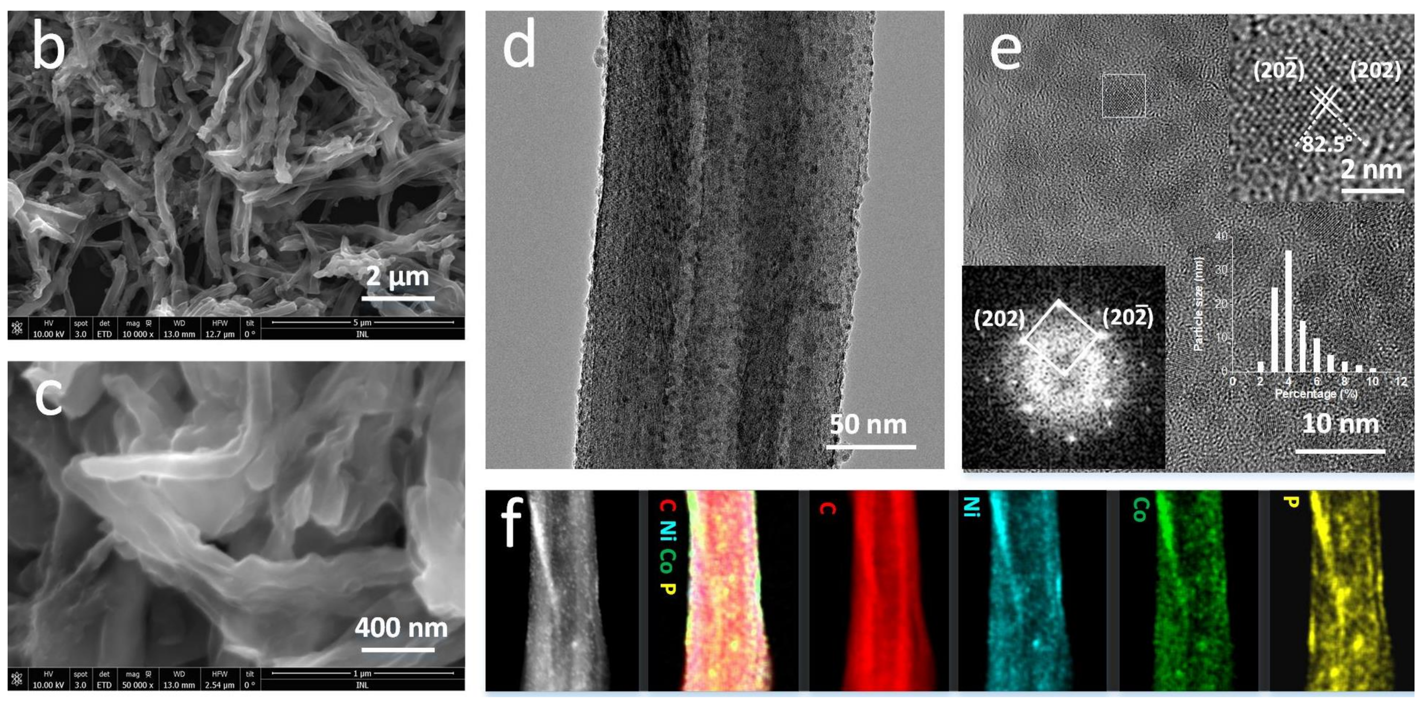


Figure 2. SEM and HR-TEM images of $Co_{0.1}Ni_{0.9}P$/CNF

Results

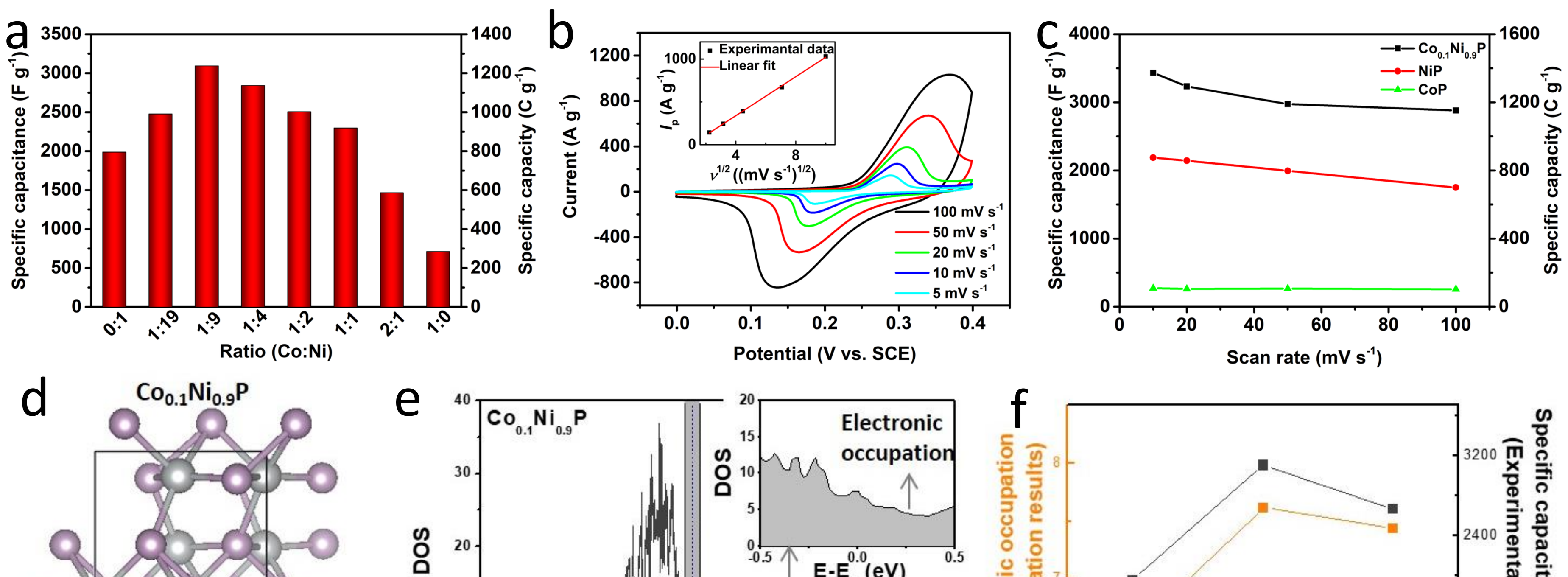


Figure 3. Electrochemical properties and DFT calculation of $Co_xNi_{1-x}P$. The specific capacitance of the as-fabricated bi-metal TMP ($Co_xNi_{1-x}P$) can be significantly enhanced, which may result from the synergistic effect of transition metal species.

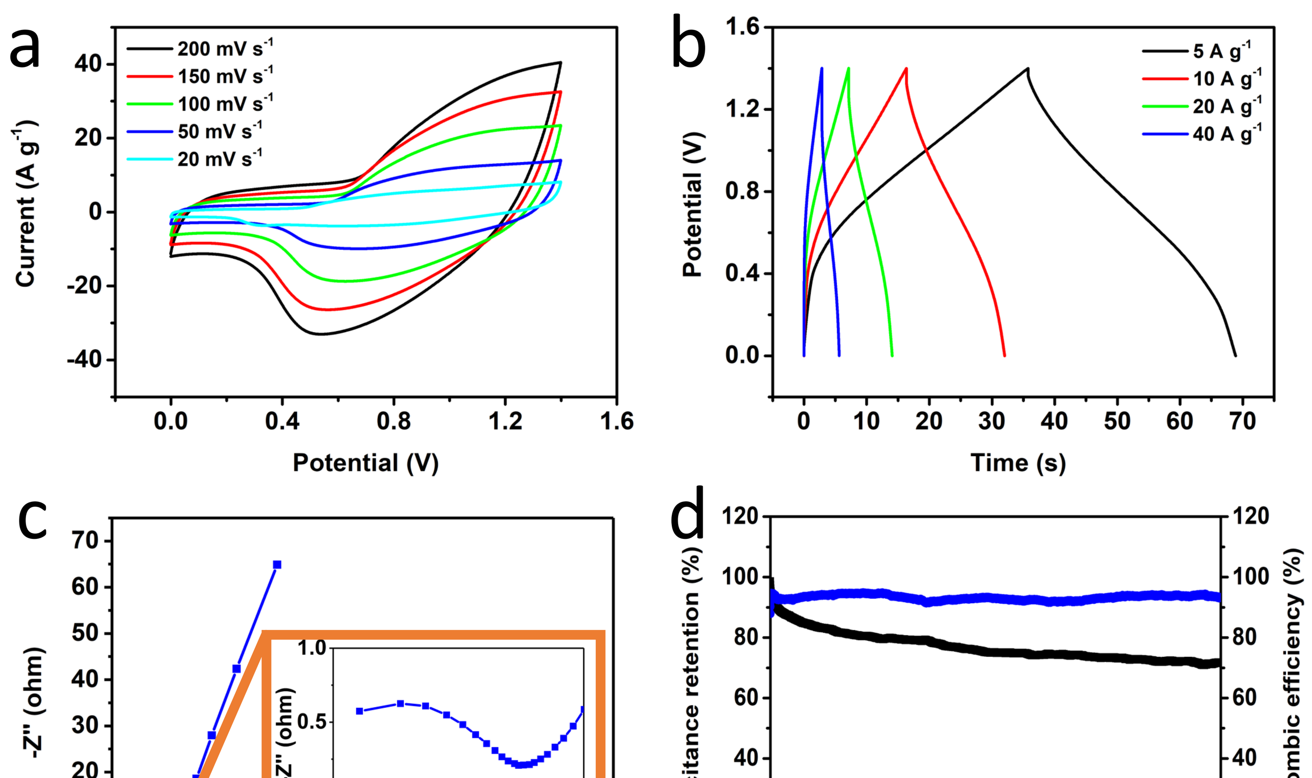


Figure 4. Performance of $Co_{0.1}Ni_{0.9}P$/CNF/CC // AC/CC asymmetric supercapacitor. The device shows not only high specific capacitance but also good cycle stability.

Conclusions

By fine-tuning the Co:Ni ratio, an extraordinary specific capacitance/capacity of 3514 F g^{-1} / 1405.6 C g^{-1} can be achieved for $Co_{0.1}Ni_{0.9}P$/CNF at 5 A g^{-1}, which is the highest value reported by far for TMP electrodes. An asymmetric supercapacitor was fabricated, showing excellent performance and good flexibility.

This work highlights the importance of composition engineering of metal phosphides in achieving high electrochemical performance for pesudocapacitive charge storage. The $Co_xNi_{1-x}P$/CNF electrode demonstrated herein would enrich the application of the TMP-based materials, and find applications in practical energy storage devices.

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