

# Sodium vanadium phosphate electrode achieving rapid Na<sup>+</sup> migration kinetics through DBD plasma multiscale modification

Feng Liang<sup>1,2</sup>, Zhipeng Xie<sup>1,2</sup>

<sup>1</sup> Department of Metallurgical and Energy Engineering, Kunming University of Science and Technology, <sup>2</sup> National Engineering Laboratory for Vacuum Metallurgy, Kunming University of Science and Technology

e-mail (speaker): liangfeng@kust.edu.cn

Na<sub>3</sub>V<sub>2</sub>(PO<sub>4</sub>)<sub>3</sub> (NVP) with its unique sodium superionic conductor framework that provides a three-dimensional Na<sup>+</sup> diffusion pathway, has attracted considerable attention as a high-potential cathode material. However, the low electronic conductivity and poor Na<sup>+</sup> diffusion kinetics of NVP considerably hinder its high-rate and long-cycle performance.<sup>[1,2]</sup> Although considerable progress has been made in individually modifying NVP electrodes at the microscale or macroscale, the process is relatively complex and time-intensive. To enhance charge transfer kinetics and maintain structural integrity, a highly efficient method is needed to simultaneously modify the NVP electrode at the microscopic and macroscopic scales.

Low-temperature (LT) plasma technology offers an innovative solution for multiscale electrode modification through its unique non-equilibrium characteristics. Through synergistic physicochemical interactions between energetic electrons, reactive species, and material surfaces, it enables materials modification across multiple spatial scales. Therefore, LT plasma has the potential to effectively modify NVP, offering high efficiency, environmental friendliness, and in situ modification capabilities.<sup>[3-5]</sup>

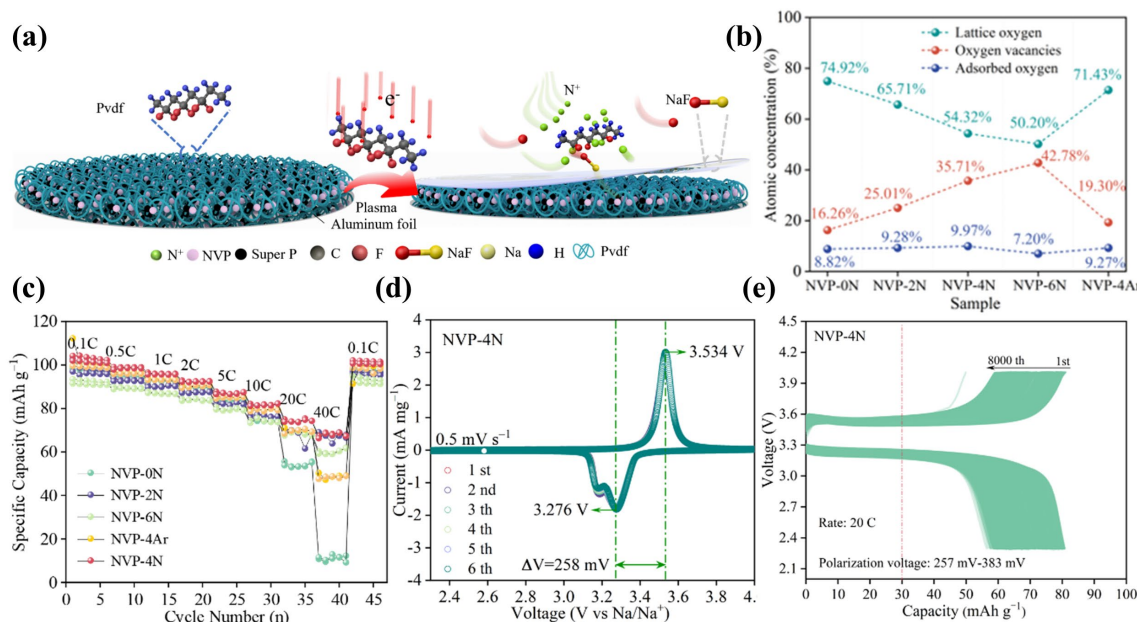
To efficient improve of NVP electrochemical property,

we develop a novel method for multiscale modification of NVP electrode plates using dielectric barrier discharge (DBD) plasma. By optimizing the LT plasma process parameters, an NaF layer is formed in situ at the macroscopic interface of the NVP electrode, while the oxygen vacancy concentration is regulated at the microscopic scale (Figure 1(a,b)), thereby improving Na<sup>+</sup> diffusion kinetics and electronic conductivity. Compared The DBD plasma modified NVP electrode plates demonstrate excellent rate performance and cycling stability (Figure 1(c-e)).

The work was financially supported by the National Natural Science Foundation of China (12175089, 12205127).

## References

- [1] Y.J. Chen *et al*, Carbon **225**, 119141 (2024)
- [2] L.W. Liang *et al*, Adv. Energy Mater **11**, 2100287 (2021)
- [3] J.F. Zhu *et al*, ACS Appl. Mater. Interfaces **11**, 17384 (2019)
- [4] Z.Y. Yao *et al*, Adv. Funct. Mater. **32**, 2111919 (2022)
- [5] Z. Wang *et al*, Energy Storage Mater. **50**, 161 (2022)



**Figure 1.** (a) Schematic of NaF formation during DBD plasma treatment, (b) XPS quantitative analysis for O-vacs signal, (c) rate performance, (d) initial six CV curves (0.5 mV s<sup>-1</sup>) of sample, and (e) charge-discharge profiles at cycle numbers ranging from the 1st to the 8000th at 20C