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Structural and Compositional Engineered Electrochemical Materials for Energy Storage and Catalysis

This talk will discuss our recent development of structural and compositional engineered electrochemical materials for energy storage and catalysis. I will discuss how to combine the conventional materials/chemical synthesis with 3D printing techniques to develop architected materials for supercapacitors and electrocatalysis. For example, we have developed some hierarchical porous carbons containing different scales of pores interconnected and assembled in hierarchical patterns through a combination of freeze-drying, template, chemical etching, and 3D printing techniques. These porous carbons can be used as electric double layer materials that enable ultrafast charging/discharging even at low temperature (-70 ℃) and as current collectors to support ultrahigh mass loading of pseudo-capacitive materials. The findings pave the way for improving the rate capability of supercapacitors and their capacitances at ultrahigh current densities and mass loadings, which are long-standing challenges for SCs. We also extended this design concept to electrocatalytic materials for water splitting. For example, water electrolysis at high current densities is plagued by gas bubble generation and trapping in stochastic porous electrodes, which causes a significant reduction in the number of electrolyte-accessible catalyst active sites. We demonstrated that 3D printed Ni electrodes with highly controlled, periodic structures can suppress gas bubble coalescence, jamming, and trapping and result in rapid bubble release. These electrodes decorated with carbon-doped NiO achieved a high current density of 1000 mA cm−2 in 1.0 m KOH electrolyte at low overpotentials. This work demonstrates a new approach to the deterministic design of 3D electrodes to facilitate rapid bubble transport and release to enhance the total electrode catalytic activity at commercially relevant current densities.

Topic

Energy Materials

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