High-power energy storage enabled by 2D layered materials

Minghao Yu, Xinliang Feng
Center for Advancing Electronics Dresden (cfaed) & Faculty of Chemistry and Food Chemistry, Technische Universität Dresden, Mommsenstrasse 4, Dresden, Germany
minghao.yu@tu-dresden.de

Electrochemical energy storage technologies have been brought into the spotlight as they provide elegant and efficient approaches to store, transport, and deliver energy harvested from sustainable energy resources.[1, 2] Typically, supercapacitors and batteries differ in electrochemical mechanisms, hence featuring almost opposite energy and power characteristics. However, the demand for power and energy supply is equally imperative in actual use and is keen to expand in the future. Thus it is highly desirable to design new electrode materials or rationally re-construct the recognized electrode materials for energy storage devices to mitigate the power-energy tradeoff.

2D layered materials are a class of materials with strong atom bonding in the basal plane and weak van der Waals (vdW) interaction between layers. These materials are equipped with versatile physical, chemical, electronic properties, as well as broad structural diversity. Importantly, the weak vdW interaction between the stacked layers enables layered materials with diverse possibilities for rational structure engineering, such as exfoliation into 2D nanoflakes, interlayer expansion with guest molecules, and hybrid structure construction. These structure engineering strategies are highly desired for layered materials to tailor their intrinsic properties (*e.g.,* electronic structure, conductivity, and redox capability) and electrochemical behaviours (*e.g.,* ion desolvation energy, solid-state ion diffusion kinetics, charge-storage mechanism) for diverse energy storage devices.[3]

Here, we will present our recent efforts in exploring 2D layered organic/inorganic materials for high-power energy storage applications.[3, 4] We will show 2D redox-active carbon-rich frameworks as promising electrode alternatives for high-power energy storage devices by demonstrating 2D polyarylimide covalent organic framework (COF) as the first COF anode for Zn-ion aqueous batteries[5] and dual-redox-site 2D conjugated metal-organic framework as a high-capacitance and wide-potential-window pseudocapacitive electrode. Moreover, we have demonstrated several interlayer engineering strategies for inorganic 2D layered materials to regulate the ion transport behaviors and boost the power-energy performance of the assembled energy storage devices.[6, 7]

References

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