Thermally and Mechanochemically Induced Structural Changes in Graphite and Their Impact on Electrochemical Behaviour

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Graphite is the dominant anode material in commercial lithium-ion batteries due to its abundance, safety, low cost, and stable electrochemical performance, with a theoretical capacity of 372 mAh g^{-1} and excellent cycle life. However, increasing demand for fast-charging and high-power applications has stimulated research into strategies for improving the rate capability and interfacial stability of graphite electrodes.[1]

Thermal and mechanochemical treatments are commonly used to tailor graphite microstructure. Thermal annealing typically improves structural order by reducing microstrain, removing functional groups, and changing lattice defects, resulting in more ordered graphitic domains and enhanced cycling stability. In contrast, mechanochemical processing, such as high-energy ball milling, introduces structural disorder, reduces particle size, and disrupts graphene layer stacking, producing defect-rich turbostratic graphite.[2, 3]

While such disorder can enhance lithium transport and increase the number of electrochemically active sites, it also increases surface reactivity, which may accelerate electrolyte decomposition and promote unstable solid electrolyte interphase (SEI) formation.[4, 5]

In this work, raw, thermally treated, and mechanochemically treated graphite are systematically compared using X-ray diffraction, microstructural analysis (including line-broadening analysis from synchrotron and laboratory data), scanning electron microscopy, and electrochemical measurements. The combined structural and microstructural analysis reveals how different processing routes modify graphite crystallinity, defect density, stacking faults, and particle morphology, and how these changes influence lithium storage behaviour and electrode stability.

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