

Flash Sintering-Enabled Defect Engineering of Functional Oxide Ceramics for Photocatalysis and Sodium-ion Batteries

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Flash sintering has emerged as a powerful non-equilibrium processing route for engineering defect chemistry and unlocking enhanced functional properties in oxide ceramics. In this work, I demonstrate the versatility of flash sintering in synthesizing advanced TiO₂-based functional ceramics for both photocatalysis and sodium-ion battery (SIB) applications. Through Fe–Cu co-doping and Fe hyper-doping strategies, flash sintering enables efficient dopant incorporation and the generation of a high density of non-equilibrium oxygen vacancies and Ti³⁺ species under an externally applied electric field. Compared to conventionally sintered counterparts, flash-sintered TiO₂ exhibits pronounced electronic structure modification, including bandgap narrowing, enhanced visible-light absorption, and significantly improved electronic conductivity. These defect-induced effects promote efficient charge-carrier separation for visible-light-driven photocatalysis and accelerate sodium-ion transport and charge storage in SIB anodes. Consequently, flash-sintered TiO₂ demonstrates superior photocatalytic degradation efficiency of methylene blue under white LED illumination and markedly improved rate capability and cycling stability in sodium-ion batteries. The results establish flash sintering as a unifying and scalable defect-engineering strategy for designing next-generation multifunctional ceramic materials for energy conversion and storage.

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