<아주대학교 신재생에너지세미나 초록>

나노소재의 표면활성 제어를 통한 화학센서 응용

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Abstract

Momentary high-temperature annealing driven by intense pulsed light (IPL) offers a powerful route for tailoring the physicochemical and electronic properties of nanomaterials. Here, we introduce an ambient-air flash-thermal shock (FTS) technique capable of generating temperatures above 2000 K with ultrafast heating/cooling rates ($>10^4$ K s^{-1}). This process induces enhanced photothermal conversion, enabling rapid optical sintering, phase tuning, defect engineering, and in-situ catalyst formation on diverse supports including metal oxides, graphene oxide, and carbon nanofibers. The extreme thermal gradients also facilitate the uniform synthesis of high-entropy alloy nanoparticles and, through multiple FTS cycles, the transformation of catalytic nanoparticles into single atoms.

Building on these capabilities, we further explore hybrid material platforms to overcome the limitations of pristine conductive metal–organic frameworks (cMOFs) in gas sensing. Core–shell heterostructures composed of single-walled carbon nanotubes and various cMOFs synthesized through a layer-by-layer method exhibit tunable response, selectivity, and sensing kinetics via controlled film thickness, composition, and interfacial properties. Complementarily, hybrid conductors integrating cMOFs with conjugated polymers provide mixed ionic–electronic transport pathways and enhanced stability, showing accelerated desorption kinetics and improved room-temperature sensor recovery through hole-enrichment effects, supported by DFT calculations.

Together, the proposed FTS platform and cMOF-based hybridization strategies offer a generalizable framework for creating advanced catalyst-loaded and electronically engineered materials. These materials enable high-performance gas sensing with rapid response, high selectivity, and long-term operational stability, highlighting their potential for broad applications in sensors, catalysis, and next-generation electronic devices.