

## Phase Engineering of Nanomaterials (PEN)

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### Abstract

In this talk, I will summarize the recent research on phase engineering of nanomaterials (PEN) in my group, particularly focusing on the rational design and synthesis of novel nanomaterials with unconventional phases for various promising applications. For example, by using wet-chemical methods, for the first time, we have successfully prepared novel Au nanostructures (*e.g.*, the hexagonal-close packed (*hcp*) 2H-Au nanosheets, 4H-Au nanoribbons, and 4H/*fcc* and *fcc*/2H/*fcc* heterophase Au nanorods), epitaxially grown metal nanostructures on the aforementioned unconventional Au nanostructures and 2H-Pd nanoparticles, and amorphous/crystalline heterophase Pd, PdCu, Rh and Rh alloy nanosheets. By using gas-solid reactions, metastable 1T'-phase group VI transition metal dichalcogenides (TMDs), *e.g.*, WS<sub>2</sub>, WSe<sub>2</sub>, MoS<sub>2</sub>, MoSe<sub>2</sub>, WS<sub>2-x</sub>Se<sub>2(1-x)</sub> and MoS<sub>2-x</sub>Se<sub>2(1-x)</sub>, have been prepared. Impressively, the 1T'-MoS<sub>2</sub>-supported single-atomically dispersed Pt (s-Pt) atoms with Pt loading up to 10 wt% exhibit superior performance in hydrogen evolution reaction. Importantly, 1T'-TMD monolayers can be stabilized on 4H-Au nanowires, which have been used for ultrasensitive SERS detection. Moreover, the salt-assisted 2H-to-1T' phase transformation of TMDs have been achieved, and the phase transformation of TMDs during our developed electrochemical Li-intercalation process has been observed. Impressively, the lithiation-induced amorphization of Pd<sub>3</sub>P<sub>2</sub>S<sub>8</sub> has been achieved. Currently, my group focuses on the investigation of (crystal) phase-dependent physicochemical properties, functions and applications in catalysis, (opto-)electronic devices, clean energy, chemical and biosensors, surface enhanced Raman scattering, photothermal therapy, *etc.*, which we believe are quite unique and very important not only in fundamental studies, but also in future practical applications. Importantly, the concepts of phase engineering of nanomaterials (PEN), crystal-phase heterostructures, and heterophase materials are proposed.

**Keywords:** Phase engineering of nanomaterials (PEN); Noble metal nanomaterials; Transition metal dichalcogenides; Crystal phases; Unconventional phases; Amorphous phase; Crystal-phase heterostructures; Heterophase nanomaterials

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