

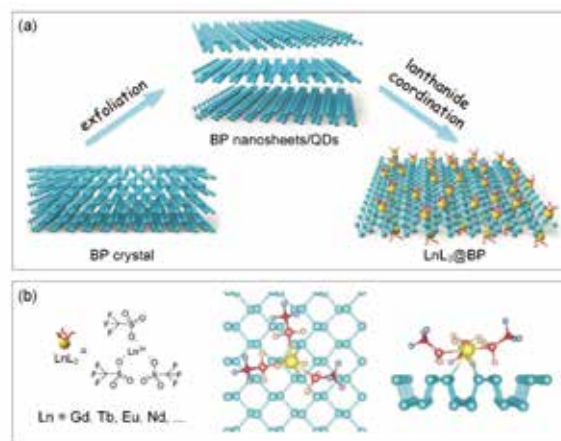
# New Method to Modulate Surface Properties of Black Phosphorus

Among various types of 2D materials, black phosphorus (BP) is a shining star thanks to its distinctive properties such as the layer-dependent band gap, active surface electronic states, good biocompatibility and excellent photothermal properties. However, due to the lone-pair electrons, BP is not stable in oxygen-water ambient condition. Besides, phosphorus is present in cells, tissues and bones, which makes it difficult to trace the BP-based nanostructures by conventional imaging techniques and conduct detailed biomedical studies *in vivo*.

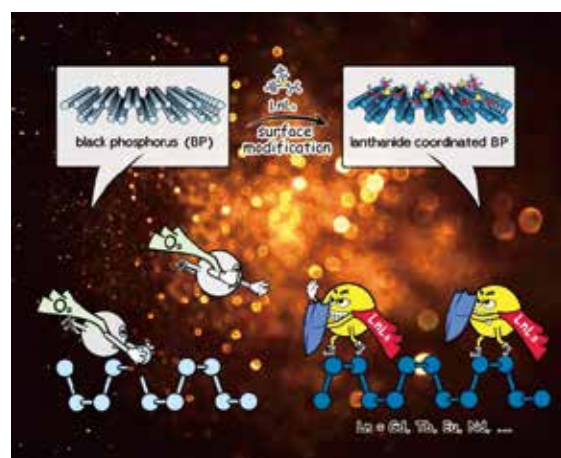
To address this challenge, a team led by YU Xuefeng at the Shenzhen Institutes of Advanced Technology (SIAT) of the Chinese Academy of Sciences has developed a series of methods to modulate the surface properties and to improve the stability performance of BP, such as organic coating, chemical coordination, covalent modification, ions doping and defects occupation.

Recently, YU and his co-workers developed a facile and efficient surface lanthanide-coordination strategy based on lanthanide (Ln) sulfonate complexes to passivate and functionalize different BP-based nanostructures. By means of Ln-P coordination, the lone-pair electrons of phosphorus were occupied, preventing the oxidation of BP, and the LnL<sub>3</sub>@BP exhibited excellent stability in both air and water. And after LnL<sub>3</sub> coordination, the original photothermal ability of BP nanostructures was retained.

“The LnL<sub>3</sub> surface passivation is an efficient method to enhance the stability of BP and can extend the application of BP to optoelectronics and biomedical engineering as well,” said YU. “We hope that the lanthanide-coordinated BP could be tracked *in vivo* to investigate the metabolic pathway of nano BP.”



(a) Schematic diagram illustrates the synthesis of lanthanide-coordinated BP nanosheets/QDs. (b) the formula of LnL<sub>3</sub> and the atomistic model of the lanthanide ligand coordinated BP surface.



Lanthanide-coordination to protect the black phosphorus from damage of oxygen (Image: YU Xuefeng).