Electronic and structural properties of flat two dimensional phosphorus on Au(111)

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Among two-dimensional (2D) materials, phosphorene, a single layer of phosphorus atoms, has attracted a special attention due to its monoelemental 2D nature and natural electronic and tunable bandgap. Black phosphorus, the 3D version of phosphorene, consists in puckered layers of phorphorus held together by van der Waals interaction. Due to the non-planar structure of the phosphorus atomic layers, many allotropes have been predicted for phosphorene. However, only few of them have been realized experimentally. Notably, blue phosphorene with its honeycomb lattice was achieved through in-situ growth on Au(111) [1]. Phosphorus nanostructures have also been realized in the submonolayer regime, including nanoribbons, chains or hexagonal lattices. Blue phosphorene and other allotropes reported have in common a non-planar structure. Here, we present the growth and electronic properties of flat monolayer of hexagonal phosphorene on Au(111) (Figure 1). The growth process involves intermediate stages with the formation of chains, rings and porous network. The growth and evolution of the electronic structure has been followed by scanning tunnelling microscopy and spectroscopy and compared with ab initio calculations. The local spectroscopy reveals that the electronic spectrum of the phosphorus structures is different from blue phosphorus. Notably, the spectrum transforms from featureless in small nanostructures to the emergence of an electronic band on the 2D lattice, even including a partially flat band.

References

[1] J. L. Zhang et al., Nano Lett. 16, 4903 (2016)

Figures

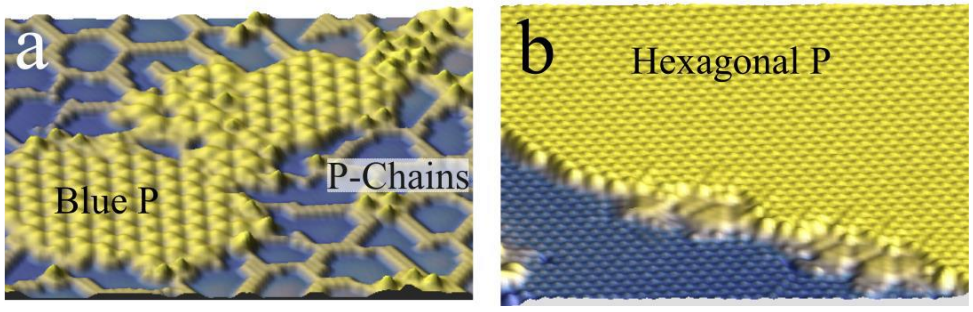

Figure 1: (a) Topography of Blue phosphorene (Blue P) and phosphorous porous network (size: 26x26 nm^2). (b) Phosphorous monolayer in hexagonal closed-packed structure (size: 17x17 nm^2).