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Imaging inherent and air-induced defects in black phosphorus with scanning tunneling microscopy JAKE RIFFLE, CAMERON FLYNN, CHARLIE AYOTTE, CHRISTINE CAPUTO, SHAWNA HOLLEN, University of New Hampshire — Black phosphorus has received significant attention due to its large, direct bandgap and high mobility at the monolayer level (phosphorene). Because phosphorene devices so far rely on exfoliation from the bulk crystals, it is important to understand native impurities and defects in the source material. We will present the atomic structure, local density of states, and native defects of bulk and few-layer black phosphorus acquired through low-temperature, ultra-high vacuum scanning tunneling microscope (STM) experiments. We studied black phosphorus from different commercial sources, prepared in a dry nitrogen environment and cleaved in UHV. Observed defects occur in higher concentrations than can be attributed to impurities, and appear to be vacancies or self-interstitials. Multiple types of point defects are observed. Spectroscopy measurements show an asymmetric density of states, contrary to previous reports, and evidence that point defects are charged. Finally, controlled exposure to air resulted in a high concentration of defects distinct from native defects. These results indicate that vacancies and self-interstitials are prevalent in commercially-available black phosphorus and their charging behavior may explain common p-doping in black phosphorus devices.

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