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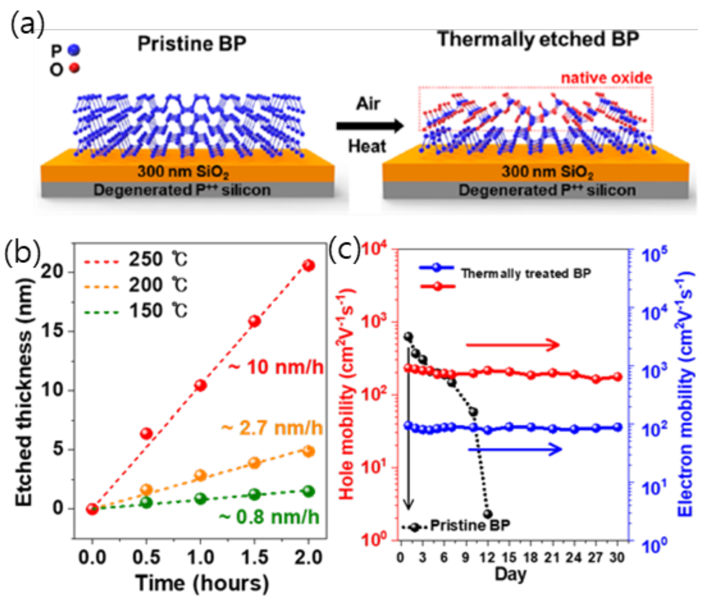
Thickness-controlled Black Phosphorus with Enhanced FET stability Under Ambient Condition

Two-dimensional layered Black phosphorus has shown great potential for next-generation electronics with tunable band gap and high carrier mobility. For the electronic applications, the thickness modulation of a BP flake is an essential due to its thickness-dependent electronic properties. However, controlling the precise thickness of few-layer BP is a challenge for the high-performance device applications. In this study, we demonstrate that thermal treatment under ambient condition precisely controls the thickness of BP flake. The thermal etching method utilizes the chemical reactivity of BP surface with oxygen and water molecules by the repeating formation and evaporation of phosphoric acid during thermal annealing. The thermally etched BP FETs shows a high hole mobility of ~576 $cm^2V^{-1}s^{-1}$ and a high on-off ratio of ~10^5. In spite of the thermal treatment under air ambient condition, the BP FETs showed long-term stability without significant degradation for one month resulting from the conservation of phosphorus layered structure under phosphorus oxide layers.

Figures



(a) Schematic illustrations explaining BP thinning mechanism by thermal treatment. (b) Thermally etched BP thickness with different temperatures of 150, 200 and 250 °C as a function of etching time. (c) Carrier mobilities of pristine BP FET and thermally etched BP FET as a function of exposure time under ambient condition.