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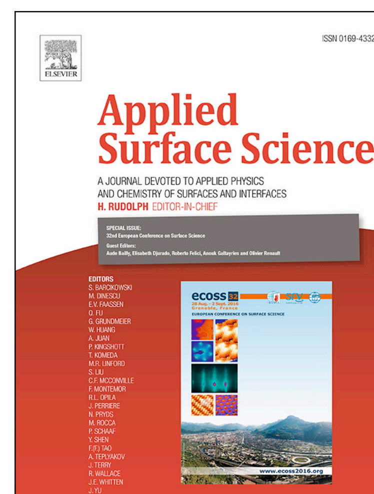

Full Length Article

Thermal annealing of black phosphorus for etching and protection

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Thermal annealing of black phosphorus for etching and protection

Sena Yang[a], Ansoon Kim[a,b], Jaesung Park[a], Hyuksang Kwon[a], Phung Thi Lanh[a,b], Songwoung Hong[a,b], Kyung Joong Kim[a,b], Jeong Won Kim[a,b,*]

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Abstract

Among 2D materials, black phosphorus (BP) with high carrier mobility and a sizable direct bandgap has recently attracted considerable attention for next generation materials. However, one of critical challenges for the applications of BP to electronic or optical devices is its air stability, because it degrades rapidly upon exposure to ambient conditions. Herein, we introduce a simple method to fabricate a stable and thin BP. Upon thermal annealing above 200°C in air, the stable protection layer of BP oxide is produced at the top of BP surface. Simultaneously, the thermal oxidation of bare BP etches the intrinsic BP layer, resulting in the decrease of BP thickness. By the thermal annealing, the field-effect transistor (FET) shows enhanced device performance of hole mobility by 10 times and on/off ratio by 50 times, compared to bare BP-based FET. The stable performance under ambient condition even without additional passivation is due to BP material stability and removal of surface scattering centres upon thermal annealing process.

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