Abstract Submitted
for the MAR17 Meeting of
The American Physical Society

Giant Raman Intensity Modulation and Etching Dynamics of Exfoliated Black Phosphorus FADHEL ALSAFFAR, SARAH ALODAN, ABDULLAH ALRASHEED, ABDULRAHMAN ALHUSSAIN, NOURA ALRUBAIQ, King Abdulaziz City Sci Tech, AHMAD ABBAS, University of Southern California, MOH. R. AMER, University of Califronia Los Angeles, UNIVERISTY OF SOUTHERN CALIFORNIA TEAM, UNIVERSITY OF CALIFORNIA LOS ANGELES TEAM — Newly discovered 2D materials have demonstrated exceptional optical, mechanical, and electrical properties. Layered black phosphorus, recently discovered in the past few years, exhibit a tunable band gap, high electron mobility, and highly anisotropic, making it an attractive candidate for various electronic applications. However, black phosphorus is unstable in ambient environment, due to high reactivity with oxygen and water. Here, we spatially Raman map black phosphorus multilayers using fast-scanning Raman spectroscopy in order to capture the full picture of black phosphorus degradation mechanism. We find a giant intensity modulation in all black phosphorus vibrational modes as a function of degradation time. This Raman intensity modulation is found to be caused by optical interference due to multiple Raman scattering events inside black phosphorus layers, along with multiple reflections of the incident laser beam. Our results show that black phosphorus exhibit two different degradation mechanism, edge degradation and surface degradation. For thin film flakes, edge degradation dominates the degradation process, evident by a significant Raman intensity change at the edge of the flakes. However, for few layers flakes, surface degradation dominates the degradation process. Finally, we show that for the first time this giant Raman intensity modulation is caused by non-uniform etching of layers in ambient environment. We also estimate the etching rate at different sites on the surface of the flake which can give us insights into the degradation mechanism of black phosphorus.

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Date submitted: 11 Nov 2016 Electronic form version 1.4