The semiconductor-semimetal transition induced by potassium doping in atomically-thin black phosphorus studied through Raman spectroscopy

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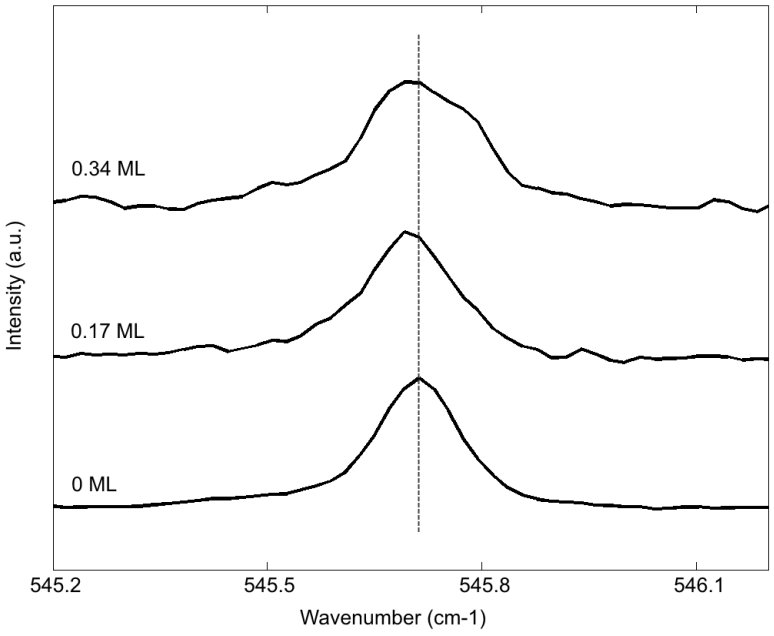
Black phosphorus is a 2D semiconductor material exhibiting a thickness-tunable direct band-gap and pronounced electrical, mechanical, and optical in-plane anisotropies resulting from its puckered structure. Exposed to the high electric field induced by adsorbed potassium atoms, the band gap of few-layer black-phosphorus shrinks and electronic band dispersions change significantly: from a quadratic to linear dispersion along the armchair direction [2]. At high doping levels, a semiconductor to semimetal transition has been observed [1]. To shed light on these mechanisms, we analyse the evolution of the Raman-allowed Ag1 and Ag2 modes as a function of potassium doping, thickness, excitation wavelength, and polarization. Raman spectra reveal a clear signature of the semiconductor to semimetal transition.

References

[1] Kim, Jimin, et al, Science, **349.6249** (2015): 723-726.
[2] Baik, Seung Su, et al, Nano letter, **15.12** (2015): 7788-7793.

Figures



The Ag2 mode shifts and increases in width as a function of doping where a monolayer of potassium (ML) is 3.46 x 10^{14} electrons. Dash line is a guide to the eye.