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Coulomb engineering of the bandgap in 2D semiconductors

ARCHANA RAJA, Stanford University, ANDREY CHAVES, Universidade Federal do Ceará, JAEEUN YU, GHIDEWON AREFE, HEATHER HILL, ALBERT RIGOSI, Columbia University, TIMOTHY BERKELBACH, University of Chicago, PHILIPP NAGLER, CHRISTIAN SCHÜLLER, TOBIAS KORN, University of Regensburg, COLIN NUCKOLLS, JAMES HONE, LOUIS BRUS, Columbia University, TONY HEINZ, Stanford University, DAVID REICHMAN, Columbia University, ALEXEY CHERNIKOV, University of Regensburg — Here we demonstrate a novel approach for bandgap engineering in 2D semiconductors. It is based on the modification of the dielectric environment, rather than on any change in the material itself. The unique environmental sensitivity of the strong Coulomb interaction in the 2D limit makes Coulomb engineering of the bandgap particularly effective. It also preserves the favorable characteristics of the 2D layer. In our studies, we determine the bandgap of the semiconductor by measuring ground and excited exciton transitions by optical spectroscopy and extrapolating to the quasi-particle band edge. In this fashion, we have directly demonstrated tuning of the bandgap of monolayer WS_2 and WSe_2 by 100s of meV through control of the external dielectric environment. We have identified lateral jumps in the bandgap by preparing external dielectric media with abrupt boundaries. Moreover, bandgap renormalization is maximized within a 1 nm thick capping dielectric, suggesting that lateral junctions with nanoscale spatial resolution can be prepared within a homogenous 2D material.

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