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Bulk Direct Band Gap MoS_2 by Plasma Induced Layer Decoupling ROHAN DHALL, University of Southern California, MAHESH NEUPANE, DARSHANA WICKRAMARATNE, University of California-Riverside, MATTHEW MECKLENBURG, ZHEN LI, University of Southern California, CAMERON MOORE, XEI Scientific, ROGER LAKE, University of California-Riverside, STEPHEN CRONIN, University of Southern California — We report a robust method for engineering the optoelectronic properties of few layer MoS_2 using low energy oxygen plasma treatment. Gas phase treatment of MoS_2 with an upstream N_2-O_2 plasma is shown to enhance the photoluminescence (PL) of few layer MoS_2 flakes by up to 20 times, without reducing the layer thickness. A blue shift in the photoluminescence spectra and narrowing of linewidth is consistent with a transition of MoS_2 from indirect to direct band gap material. Atomic force microscopy and Raman spectra reveal that the flake thickness actually increases as a result of the plasma treatment, indicating an increase in the interlayer separation in MoS_2. Ab-initio calculations reveal that the increased interlayer separation is sufficient to decouple the electronic states in individual layers, leading to a transition from an indirect to direct gap semiconductor. With optimized plasma treatment parameters, we observed enhanced PL signals for 32 out of 35 few layer MoS_2 flakes tested, indicating this method is robust and scalable. Monolayer MoS_2, while direct band gap, has a small optical density, which limits its potential use in practical devices. The results presented here provide a material with the direct band gap of monolayer MoS_2, without reducing sample thickness, and hence optical density.

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