Scalable Substitutional Re-Doping and its Impact on the Optical and Electronic Properties of Tungsten Diselenide

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Doping is the cornerstone of semiconductor technology, enabling the success of modern digital electronics. Successful realization of wafer-scale, electronic grade, intrinsic 2D TMDCs via common deposition methods is rapidly progressing, however, advances in scalable doping still remain in the “proof-of-concept” stage, delaying the large-scale fabrication of logic circuits based on extrinsic 2D semiconductors. This work is presenting a wafer-scale synthesis of rhenium doping of WSe2 films via MOCVD at front-end-of-line (FEOL) and back-end-of-line (BEOL) compatible temperatures. By controlling the partial pressures of the precursors, doping concentrations as low as 0.0001% can be achieved. Rhenium atoms substitutionally replace W atoms in the WSe2 lattice and introduce discrete defect levels that lie close to the conduction band minima confirming the n-type nature of the dopants. However, the transport properties of field-effect transistors degrade as a function of doping concentration which is attributed to the large binding energy of electrons due to less effective dielectric screening in monolayer 2D films.