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Supporting Information

Spatially isolated neutral excitons via clusters on trilayer MoS_2

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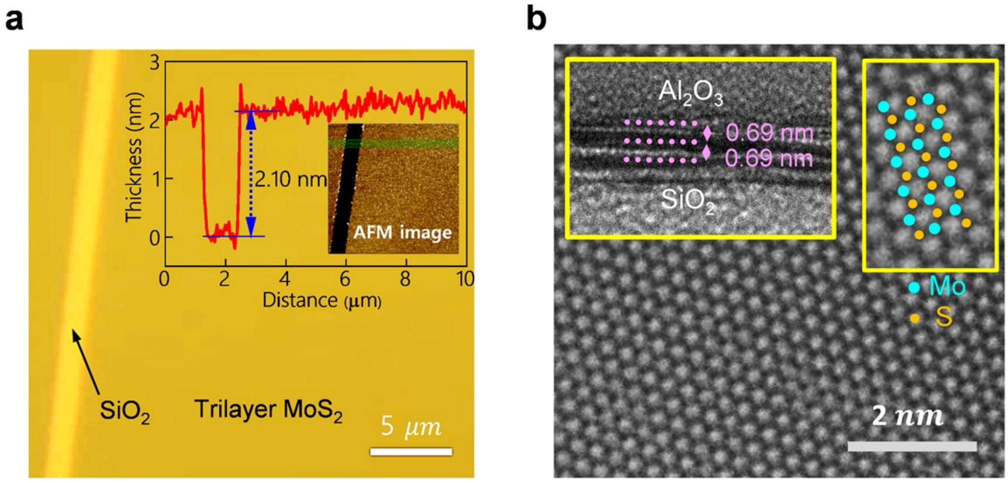

Fig. S1 (a) Optical image of MOCVD grown trilayer MoS_2 on the SiO_2/Si substrate. An inset shows AFM image with one dimensional thickness data. (b) Top view of HRTEM image. Cross sectional view present trilayed MoS_2 (left inset). Atomic positions of MoS_2 in the hexagonal structure of top view (right inset). The atoms corresponds to dark region in the hexagonal structure and the white dots is holes.

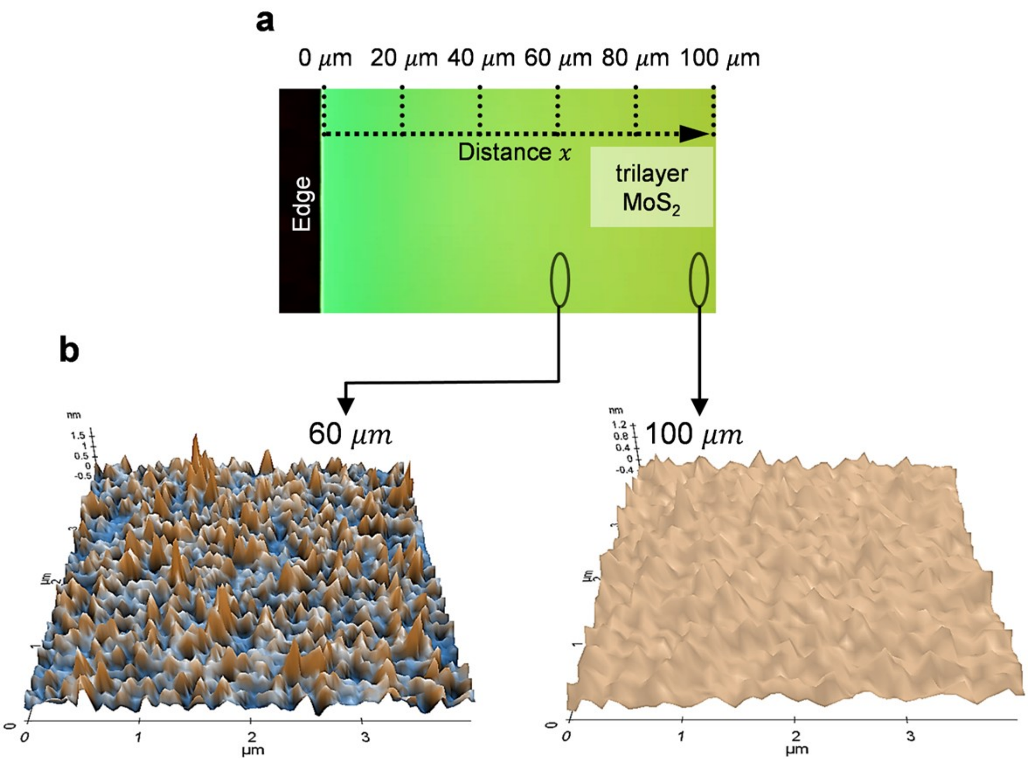

Fig. S2 (a) Optical image of MOCVD-grown multilayered MoS_2 in the near edge of substrate, where the color varied from 0 to 100 µm. (b) The surface morphology at 60 µm and 100 µm, observed by AFM. While a lot of the protruding bumps over 0.6 nm in height were found at 60 µm, corresponding to the thickness of monolayer MoS_2, the protruding bumps over 0.5 nm in height was rarely observed at 100 µm.

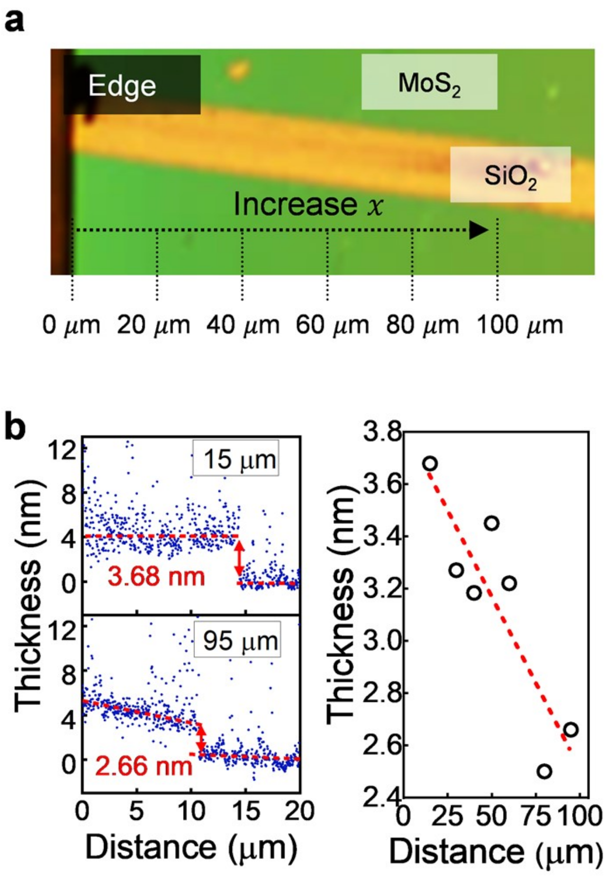

Fig. S3 (a) Optical image of MOCVD-grown multilayered MoS_2 in the near edge of substrate. To measure thickness according to the distance, we made a long scratch. (b) The thickness of multilayer MoS_2 as a function of distance. Left graph shows one dimensional thickness data at 15 µm and 95 µm. Right graph present thickness information according to the distance, which is almost corresponding with Raman data.

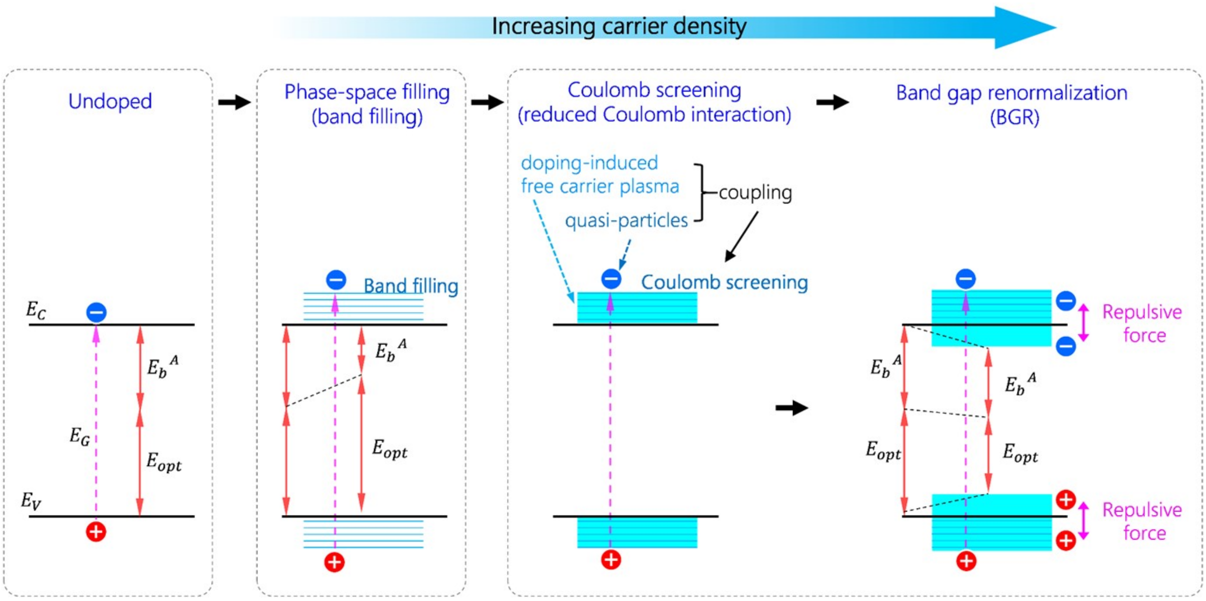

Fig. S4 (a) Nonlinearity of carrier behavior according to carrier density in low-dimensional materials. Low-dimensional materials exhibiting low density of states (DOSs) reveals well the nonlinearity properties. The excited carrier can easily occupy the low DOSs, which is a phase-space filling (or simply, band filling), inducing the change of absorbance and emission spectra. With high carrier density, Coulomb screening and band gap renormalization (BGR) occur almost simultaneously because the Coulomb screening itself include the repulsive force between excited carries, which eventually results in the band gap reduction by BGR.