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Possible electric field induced indirect to direct band gap transition in $MoSe_2$

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Novel phenomena such as indirect to direct band gap transition, giant exciton binding energy, spin-valley-layer locking and polarization dependent valley control are attractive features of transition metal dichalcogenides (TMDs). Especially, the layer dependent indirect to direct band gap transition raised enormous interest in TMDs. There have already been many efforts to control the band gap with means other than the number of layers. Here, we report the possibility for electric field induced indirect to direct band gap transition in bulk $MoSe_2$ observed by using angle resolved photoemission spectroscopy (ARPES). In order to demonstrate the evolution of the electronic structure as a function of surface electron doping and/or surface electric field, we us in-situ alkali metal dosing on the surface of in situ cleaved $MoSe_2$. We find that the alkali metal evaporation affects the Γ and the K point electronic structure differently. The difference in binding energy between valence band maximum (VBM) at the Γ and the K points changes from 370 meV to 30 meV. Our results not only clearly show a possibility of indirect to direct band gap transition by electric field, but also show the relation between the gap size and surface electric field in this material.

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