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Negative differential resistance observed from vertical p^+-n^+ junction device with two-dimensional black phosphorous[1] DAEYEONG LEE, YOUNG DAE JANG, JAEHWAN KWEON, JUNGJIN RYU, EUYHEON HWANG, WON JONG YOO[2], Sungkyunkwan Univ. (SKKU), SAMSUNG-SKKU GRAPHENE/2D CENTER (SSGC) COLLABORATION — A vertical p^+-n^+ homojunction was fabricated by using black phosphorus (BP) as a van der Waals two-dimensional (2D) material. The top and bottom layers of the materials were doped by chemical dopants of gold chloride ($AuCl_3$) for p-type doping and benzyl viologen (BV) for n-type doping. The negative differential resistance (NDR) effect was clearly observed from the output curves of the fabricated BP vertical devices. The thickness range of the 2D material showing NDR and the peak to valley current ratio of NDR are found to be strongly dependent on doping condition, gate voltage, and BP's degradation level. Furthermore, the carrier transport of the p^+-n^+ junction was simulated by using density functional theory (DFT) and non-equilibrium Green's function (NEGF). Both the experimental and simulation results confirmed that the NDR is attributed to the band-to-band tunneling (BTBT) across the 2D BP p^+-n^+ junction, and further quantitative details on the carrier transport in the vertical p^+-n^+ junction devices were explored, according to the analyses of the measured transfer curves and the DFT simulation results.

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