

2D TMDs and BP Nanosheets for Electron Device Applications

(이차원켈코진반도체막과흑린나노막을적용한전자소자)

Seongil Im^{1*}

* semicon@yonsei.ac.kr

¹Institute of Physics and Applied Physics, Yonsei University, 50 Yonsei-ro, Seodaemun-gu, Seoul 120-749, Korea

ABSTRACT

Two-dimensional (2D) semiconductor materials with discrete bandgap have attracted much attention from many researchers owing to their interesting physical properties and potentials for future nanoscale electronics. Many of field effect transistors (FETs) have thus been reported. Several attempts to fabricate 2D complementary (CMOS) logic inverters have been made, too. Here, we adopted p-WSe₂ and n-MoS₂ nanosheets separately for the channels of bottom gate-patterned FETs, to fabricate 2D transition metal dichalcogenide (TMD)-based hetero-CMOS inverter on a same glass substrate by a direct printing technique. Our hetero-CMOS inverters with electrically-isolated FETs demonstrate novel and superior device performances of a maximum voltage gain as ~27, subnanowatt power consumption, almost ideal noise margin approaching to $0.5 \times V_{DD}$ (supply voltage, $V_{DD}=5$ V) with a transition voltage of 2.3 V, and ~800 μ s for switching delay. Moreover, our glass-substrate CMOS device nicely performed digital logic (NOT, OR, and AND) and push-pull circuits for organic light emitting diode switching, directly displaying the prospective of practical applications. On the one hand, we extended our 2D-CMOS studies to n-MoS₂ and p-MoTe₂ couple for faster switching of less than 60 us. Our p-channel FET with nanosheet α -MoTe₂ showed much high ON-current, since we used a properly-deep work function metal, platinum (Pt), for S/D contact. As a result, our Mo-based CMOS device with nanosheet channels demonstrated high CMOS performances in switching dynamics and electrostatic behavior; high voltage gain of ~22 in maximum, good noise margin ($NM_L \sim 0.35 V_{DD}$, $NM_H \sim 0.39 V_{DD}$), positive transition voltage of 2.5 V at 5 V V_{DD} , and 60 us switching delay at longest were displayed at a few volts. In the presentation, our recent results on dual gated BP sheet FET and MoS₂ MESFET are also introduced.

KEYWORDS

complementary inverter, MoS₂, WSe₂, α -MoTe₂, BP, glass, high gain, dichalcogenide