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Scaling and carrier transport properties of monolayer MoS_2 transistors AMIRHASAN NOURBAKHSH, AHMAD ZUBAIR, REDWAN SAJJAD, AMIR TAVAKKOLI, XI LING, MILDRED DRESSELHAUS , JING KONG, KARL BERGGREN, DIMITRI ANTONIADIS, TOMAS PALACIOS, Massachusetts Institute of Technology — 2D crystals of layered transition metal dichalcogenides such as MoS_2 are ideal candidates for aggressive miniaturization of field-effect transistors (FETs) to the single digit nanometer scale. This class of materials can benefit from their atomically thin body with dangling-bond-free surfaces. In particular, monolayer-MoS_2, because of its bandgap of 1.8 eV yields high I_{on}/I_{off} ratio FETs, while its atomically thin body, t $\approx$ 0.7 nm, facilitate the reduction of characteristic scaling length. In this work, we first demonstrate the fabrication and electrical characteristics of a MoS_2 FET using single-layer graphene as the source/drain contacts and a channel length of 15 nm. The MoS_2 FET had an I_{on}/I_{of} of $\approx 10^6$ with an I_{on} ~50 μA/μm and minimum subthreshold slope of 90 mV/dec. Next, by exploiting the semiconducting to metallic phase transition in MoS_2, we demonstrate a 7.5 nm transistor channel length by patterning of MoS_2 in a periodic chain of semiconducting and metallic-phase MoS_2 regions. The transistor chain shows $I_{on}/I_{off} \approx 10^5$ with $I_{off} \approx 100$ pA/μm. Modeling of the resulting characteristics reveals that the 2H/1T' MoS_2 homojunction has a resistance of 75 $\Omega.\mu$m while the 2H-MoS_2 exhibits low-field mobility of ~25 cm^2/V.s and carrier injection velocity of ~10^6 cm/s.

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