Transfer-Free Robust n-and p-Type Graphene Field-Effect-Transistors for Digital Logic Device Applications

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Abstract

Graphene is attractive for conventional semiconductor applications because of its high mobility. However, pristine graphene does not have a bandgap, which makes it a challenging to take advantage of its extraordinary electronic properties in practical field-effect-transistors (FETs). Many studies have been focused on engineering of a bandgap of graphene for many semiconductor applications, which includes transistors. To realize predominant electrical performance of graphene-based FETs; herein, we report the fabrication of transfer-free, large-scale, and high-quality monolayer graphene with a domain size of ~ 380 μm. The graphene was synthesized directly on Ti (10 nm)-buffered 4-inch-Si (001) substrates *via* plasma assisted thermal CVD at 100 °C. Defect-free graphene-FETs exhibited an extraordinary hole mobility of ~ 40,000 and ~ 22,000 $cm^2V^{-1}s^{-1}$ in an inside the domain and a across the domain geometry, respectively, regardless of the channel lengths. Nitrogen- and Boron-doped graphene thin film transistors (TFTs) that was based on the monolayer graphene grown directly at 100 °C revealed an unchangeable mobility with decreasing the channel length at a channel width of 20 μm, and the inside the domain-TFTs recorded an excellent reproducibility of *on-off* current ratio, ~ 2×10^8, and 5×10^5; electron-mobility, ~1,500, and ~400 $cm^2V^{-1}s^{-1}$; and a subthreshold swing (*S.S.*); ~0.09 and ~0.07 $Vdec^{-1}$, respectively at a low gate voltage (4 V). They revealed a predominant stability under an annealing up to 500 °C, under an operation temperature up to 130 °C, and under various field stresses. Their results showed predominant reliability and uniformity in 4-in wafer scale. These results could pave the way for the development of the monolayer graphene-FETs, *n*- and p-type-FETs with nanometer-scale channel dimensions.

References

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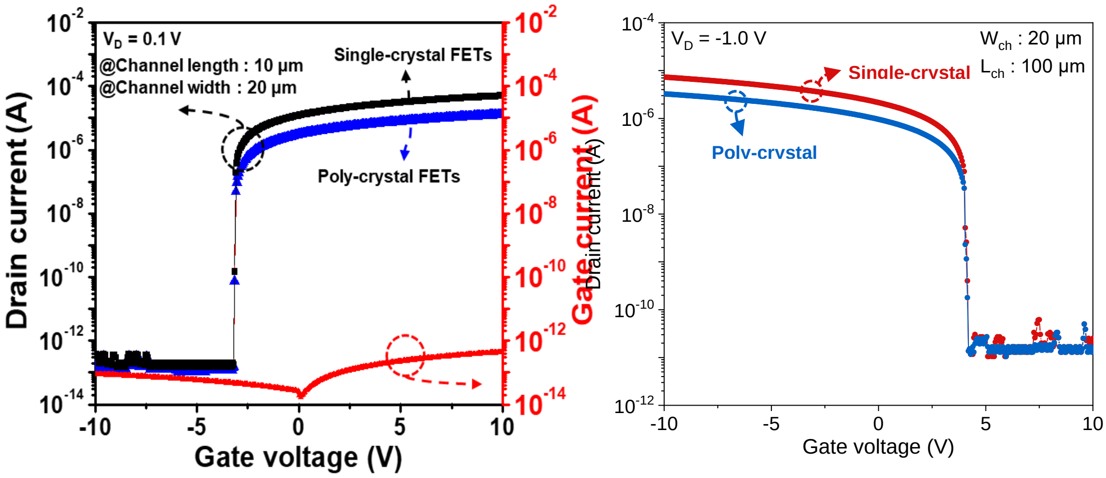

Fig. 1 (left) I-V characteristics of n-type graphene FETs. (right) I-V characteristics of p-type graphene FETs.