High-performance monolayer MoS_2 field-effect transistors and photodetectors on SiO_2 gate dielectric passivated with cyclic olefin copolymer

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Trap states of the semiconductor/gate dielectric interface give rise to a pronounced subthreshold behavior in field-effect transistors (FETs) diminishing and masking intrinsic properties of 2D materials. To reduce the well-known detrimental effect of SiO_2 surface traps, this work spin-coated an ultrathin (≈5 nm) cyclic olefin copolymer (COC) layer onto the oxide and this hydrophobic layer acts as a surface passivator. The chemical resistance of COC allows to fabricate monolayer MoS_2 FETs on SiO_2 by standard cleanroom processes. This way, the interface trap density is lowered and stabilized almost fivefold, to around 5×10^{11} cm^{-2} eV^{-1}, which enables low-voltage FETs even on 300 nm thick SiO_2. In addition to this superior electrical performance, the photoresponsivity of the MoS_2 devices on passivated oxide is also enhanced by four orders of magnitude compared to nonpassivated MoS2 FETs. Under these conditions, negative photoconductivity and a photoresponsivity of 3×10^7 A W^{-1} is observed which is a new highest value for MoS_2. These findings indicate that the ultrathin COC passivation of the gate dielectric enables to probe exciting properties of the atomically thin 2D semiconductor, rather than interface trap dominated effects.

References

[1] S.B. Kalkan, E. Najafidehaghani et al., *Adv. Optical Mater.* 11 (2023) 2201653.

Figures

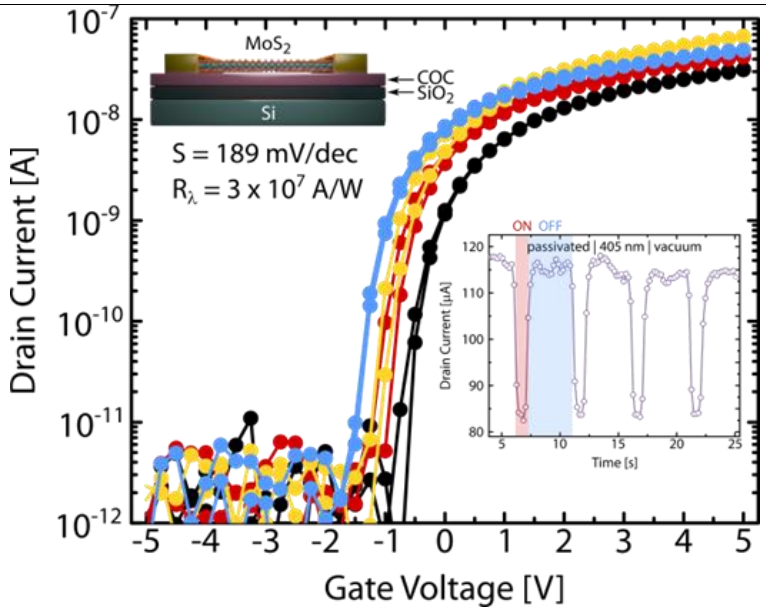

Figure 1: Performance of monolayer MoS2 based electronic and optoelectronic devices on SiO_2 gate dielectric passivated with cyclic olefin copolymer.