Interface-Controlled Strain Engineering in MoS_2 Devices via ALD Dielectric Encapsulation for Enhanced Carrier Mobility

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Abstract

Two-dimensional transition metal dichalcogenides (TMDCs), such as MoS_2, are promising candidates for next-generation electronics. However, limited carrier mobility remains a critical bottleneck limiting device performance.[1] While strain engineering is an effective approach to modulate the electronic properties of TMDCs, conventional methods typically rely on external mechanical deformation, which is difficult to integrate into scalable device processes.[1] In this work, we investigate a scalable, process-induced strain engineering strategy for MoS_2 based on atomic layer deposition (ALD) dielectric encapsulation. The in-plane E_2g Raman mode exhibits a systematic redshift with increasing top dielectric thickness, consistent with process-induced tensile strain in the MoS_2 channel.[1] However, the overall strain transfer efficiency is significantly limited by interfacial slip between the MoS_2 and the conventional SiO_2 substrate.[2,3] To overcome this limitation, we introduce ALD-grown HfO_2 bottom dielectric layer. Photoluminescence and Raman spectroscopy reveal that the bottom dielectric layer significantly improves strain transfer to the MoS_2 channel. This enhancement is attributed to improved interface-mediated strain transfer enabled by the engineered bottom dielectric interface and top dielectric encapsulation.[2,3] By employing this dual-sided dielectric encapsulation structure, the interfacial slip is effectively suppressed, and the process-induced tensile strain in MoS_2 is maximized. Electrical characterization further shows improved carrier mobility, suggesting that interface-controlled strain engineering provides a practical route for optimizing 2D semiconductor devices without relying on complex external strain apparatus.[1]

References

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Figures

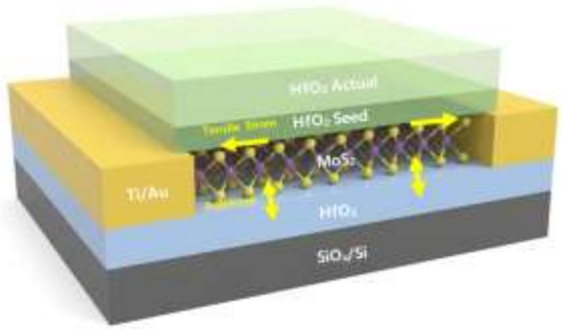

Figure 1: Schematic view of the MoS_2 device with dual-sided HfO_2 encapsulation.