# Overall performance improvement of Transition Metal Dichalcogenides (TMDs) based Field-Effect Transistors (FETs) via Chalcogen assisted channel and contact engineering

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Abstract

2-dimensional semiconductors, especially TMDs like $MoS_2$, $WS_2$, $MoSe_2$ and $WSe_2$, have great potential when it comes to realization of FETs (for logic applications) that are immune to short channel effects (SCEs), mobility degradation and poor gate control, unlike bulk semiconductors like Si. However, 2D nature of TMDs leads to poor bonding at the metal-TMD interface. This manifests as barrier at the interface for charge carriers and hence a large contact resistance that limits the maximum ON state current. Various doping techniques can be used for ON state current improvement in these devices, however, they end up degrading the performance of the transistor in other aspects like higher OFF state current and normally ON device (negative threshold voltage, $V_T$). Despite number of efforts [1], [2], [3] to develop industry scalable and selective techniques to improve performance, generic techniques that lead to overall improvement without any parametric compromise are rare. Based on first-principles atomistic simulations and analyses of various interface topologies in different TMD-metal systems, we derive an experimental method to improve overall performance of various TMD ($MoS_2$, $WS_2$, $MoSe_2$ and $WSe_2$) based FETs. Transmission efficiency across the interface, bandstructure calculations, Mulliken charge population investigations of various interfaces suggest unique chemistry which led to improved contact resistance (hence ON state current) and better OFF state performance (reduced OFF state current). Besides ON and OFF state performance improvements, subthreshold slope, gate control and mobility have improved upon following the proposed method. Being an industry compatible method, it has great potential towards 2D semiconductor technology development. Further investigations on different metal-TMD combinations is expected to unfold interesting chemistry at these interfaces.

References

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Figures

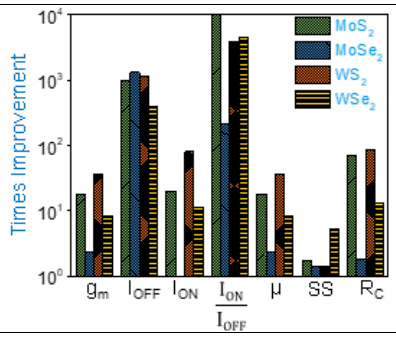


**Figure 1:** Improvement in various device metrics.