Advancing 2D Monolayer CMOS Through Contact, Channel and Interface Engineering

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Abstract
2D CMOS transistors fabricated with transition metal dichalcogenide (TMD) materials are a potential replacement for silicon transistors at sub-12 nm channel length [L_G].[1],[2],[3]. Here we present progress towards the ultimate goal and outline critical research needs. We share a design choice that theoretically beats Silicon and saves significant switching energy. We demonstrate record NMOS contacts using a high melting point metal, down to 146 Ω–μm contact resistance (R_C). We present the best PMOS performance on a grown monolayer WSe2 film with 100 μA/μm Ion and low sub-threshold swing (SS) using a Ruthenium contact metal, showing record PMOS contact resistance, RC = 2.7 kΩ-μm. We present 300 mm wafer growth options of 4 different 2D TMD films: MoS2, WS2, WSe2, MoSe2 grown at BEOL temperatures. Finally, we benchmark our results against leading TMD devices, while arguing for more directed research in the pmos device area.

References

[1] K.P. O'Brien, C.D. Dorow et al, IEDM 2021
[2] C.D. Dorow, K.P. O'Brien et al VLSI 2021
[3] K. Maxey et al VLSI 2022