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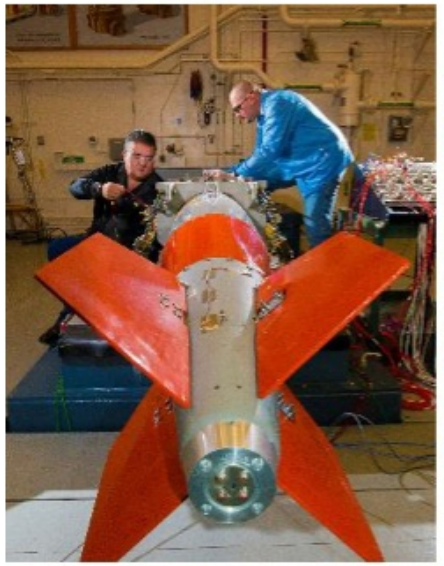

Influence of Molecular Adsorption on MoS_2 Memtransistor Switching Kinetics

John M. Cain[1], Xiaodong Yan[2], Stephanie E. Liu[2], Vinod K. Sangwan[2], Mark C. Hersam[2], Stanley S. Chou[1], Tzu-Ming Lu[1]

[1]SANDIA NATIONAL LABORATORIES, ALBUQUERQUE NM

[2]NORTHWESTERN UNIVERSITY, EVANSTON IL

October 12, 2022

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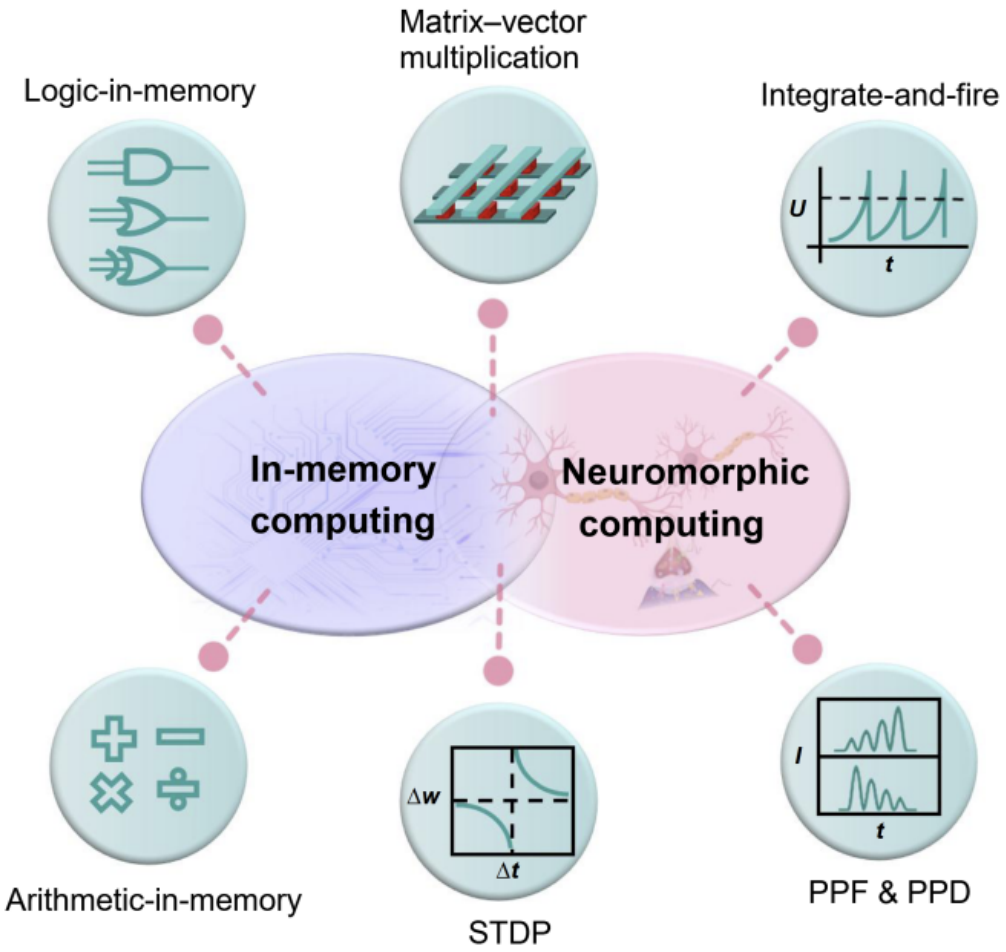
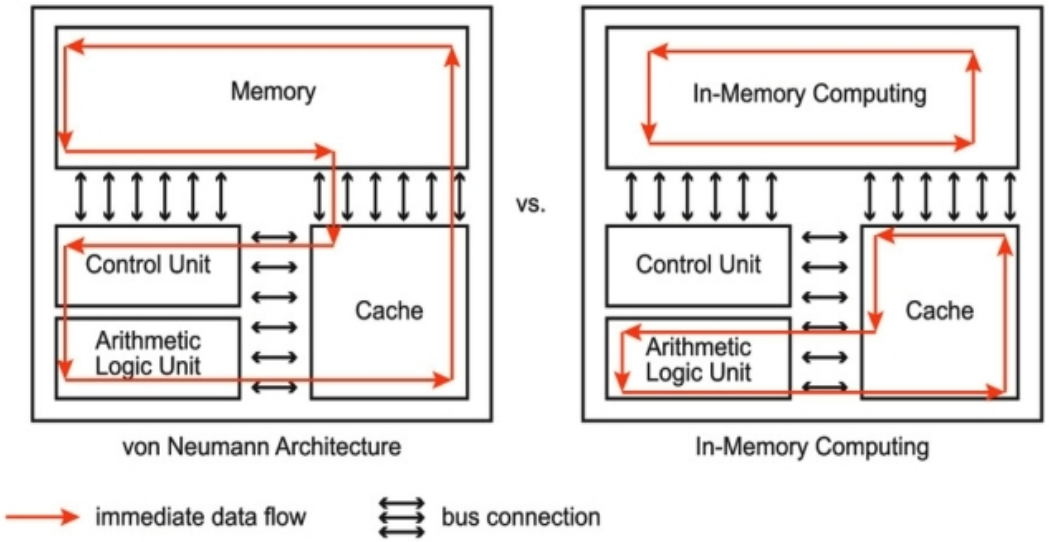
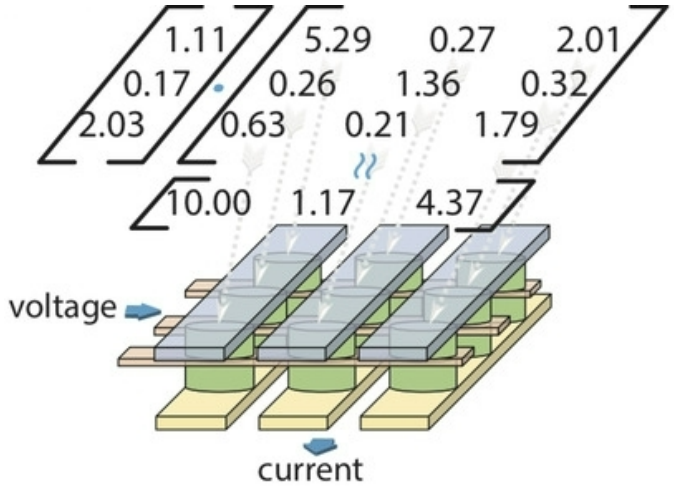
Memristive Circuits Yield More Efficient Computing



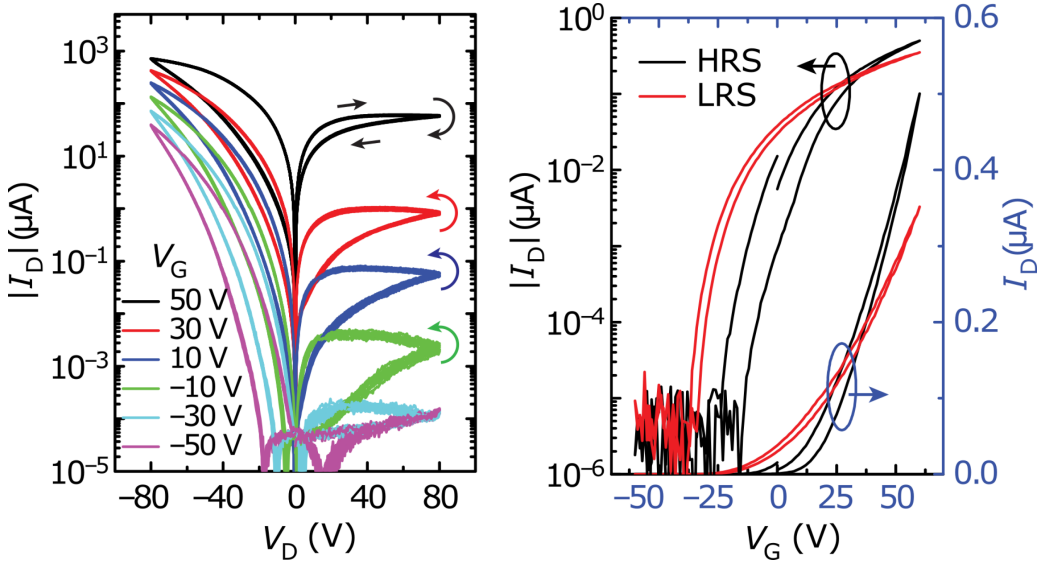


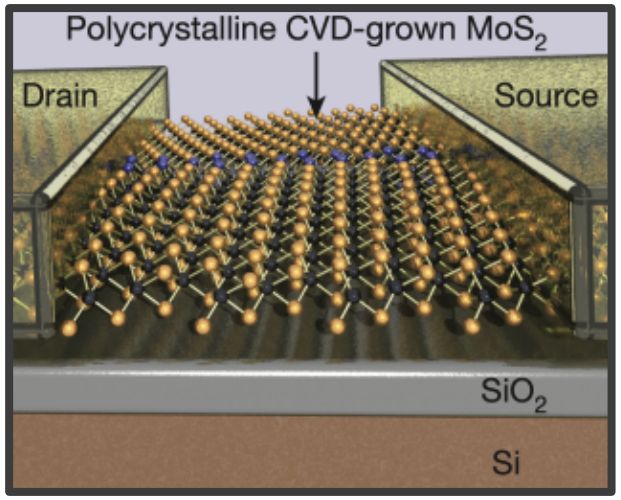


Mehonic et al. *Advanced Intelligent Systems* ***2020,*** 2000085.

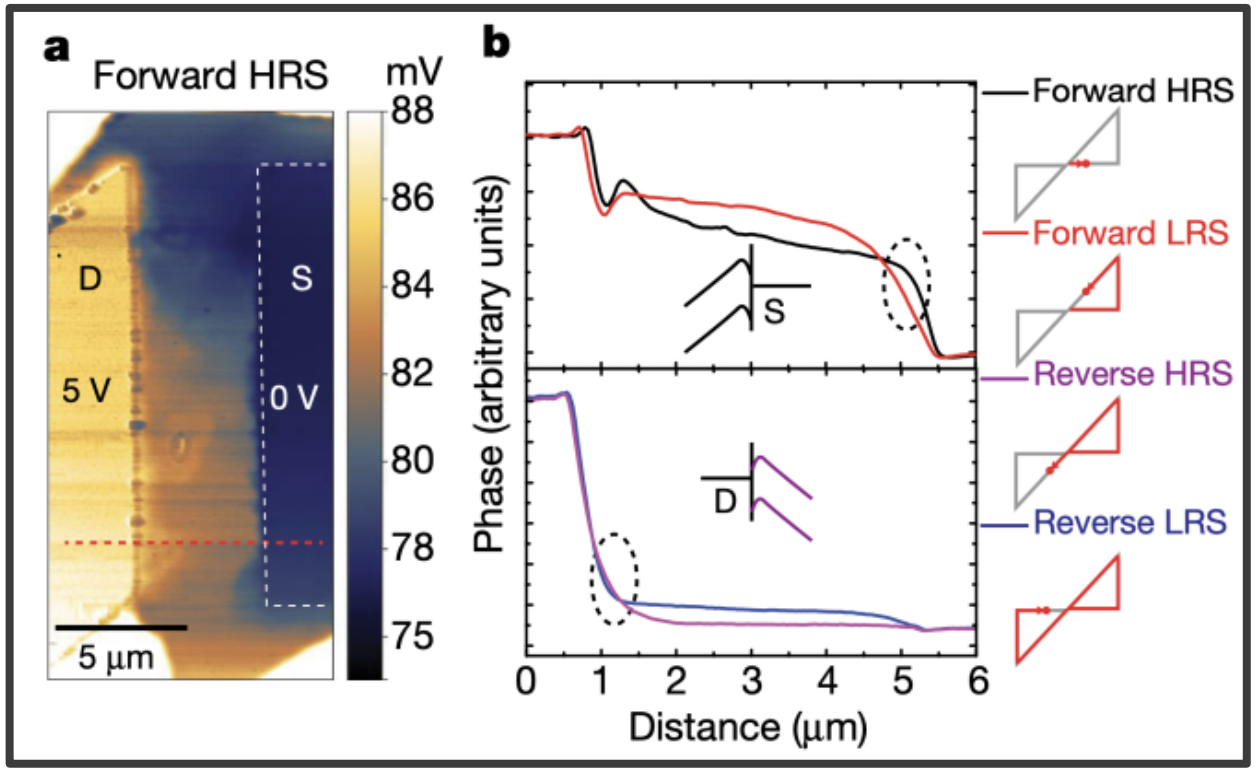
Yan et al. *Advanced Intelligent Systems* **2019**, 1900068.

MoS_2 'Memtransistors' Utilize a Hysteretic SBH





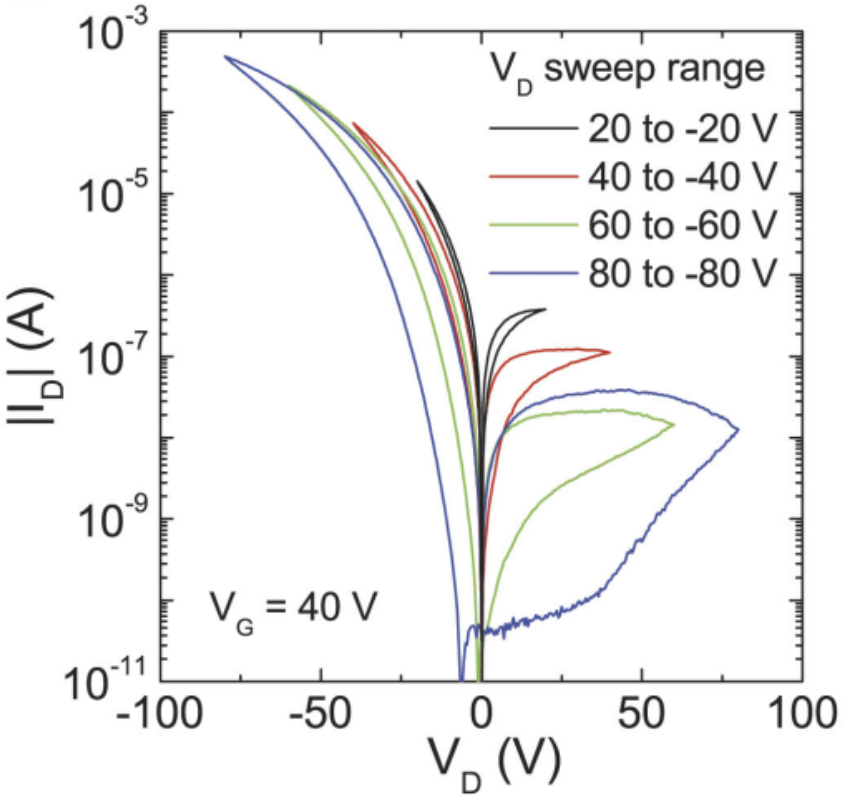
Electrostatic Force Microscopy Images of Channel



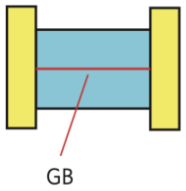
Sangwan et al. *Nature* **2018**, 500-504.

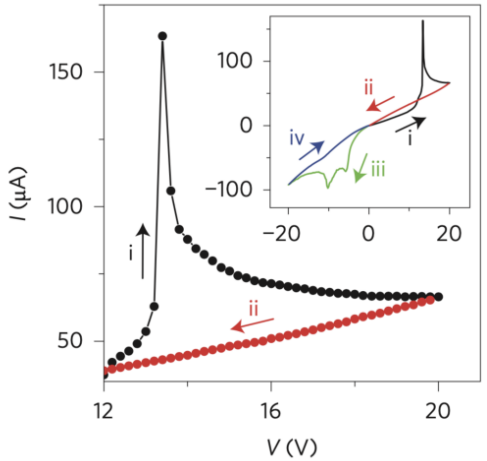
Goal: Lower Set Voltages by Modifying V_S migration kinetics

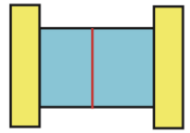
Memory Switching is Modest at V_{ds} < 50 V

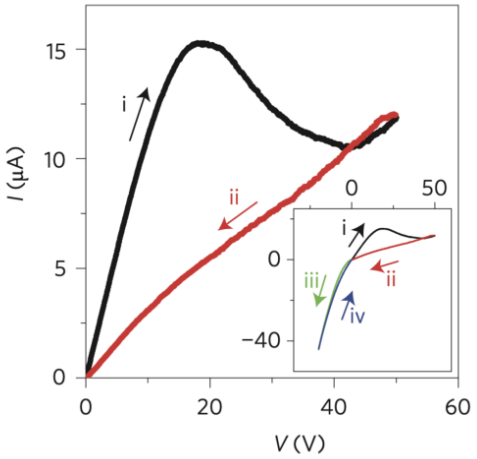


Sangwan et al. *Nature* **2018**, 500-504.

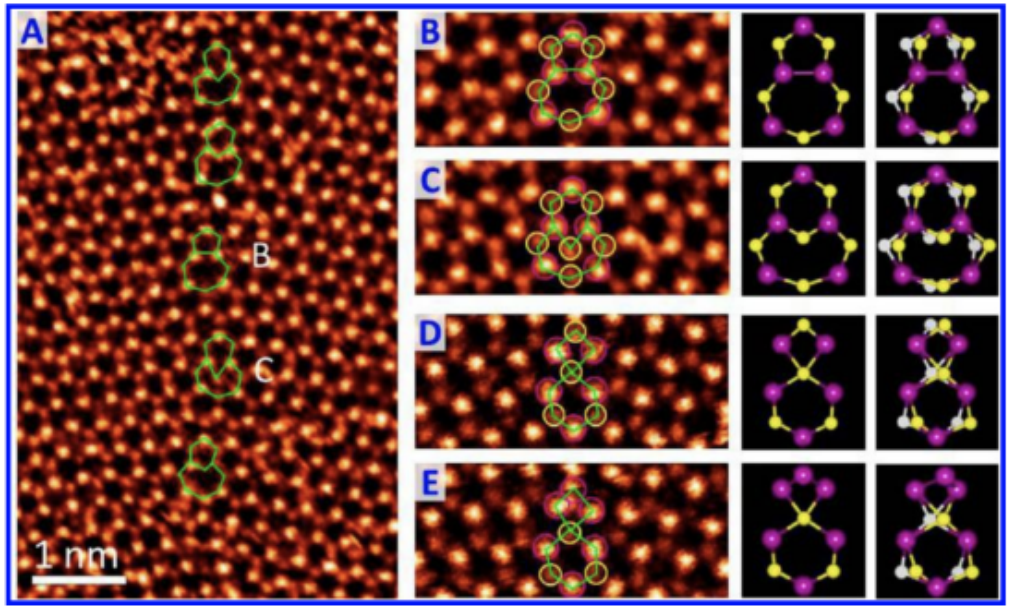








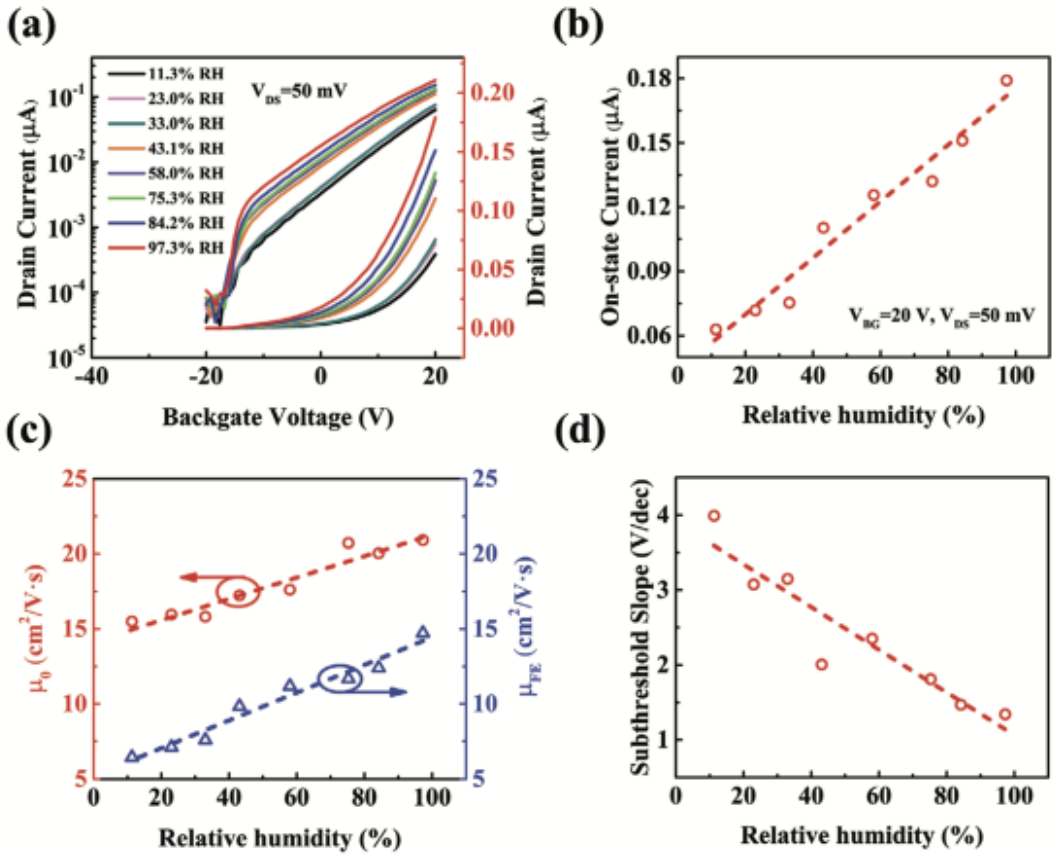
Sangwan et al. *Nat. Nanotechnol.* **2015**, 403-406.



Zhou et al. *Nano Lett.* **2013**, 2615-2622.

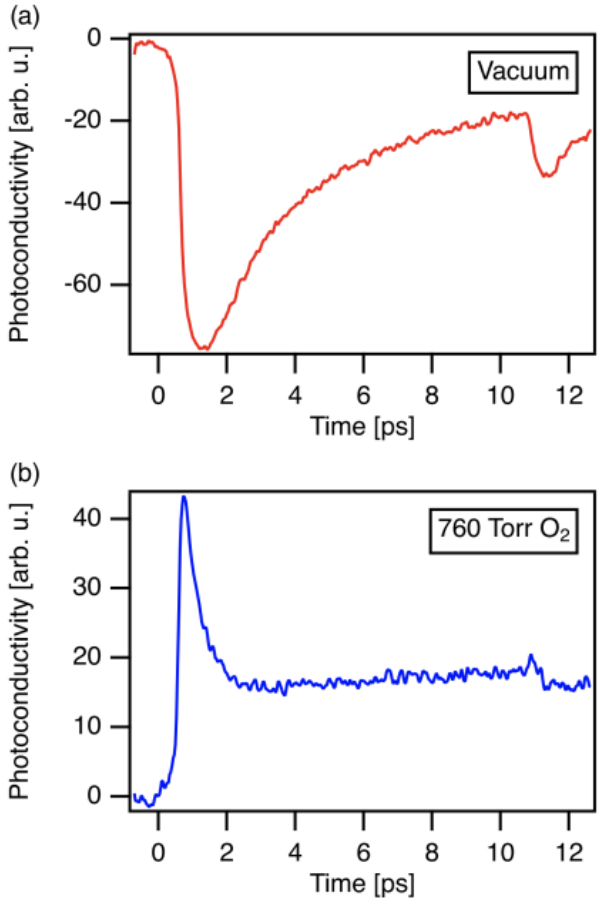
Adsorbed Molecules Alter Transport Properties in MoS_2

Adsorbed Water Dopes MoS_2 Film



Yang et al. *Advanced Electronic Materials* **2020**, 2000659.

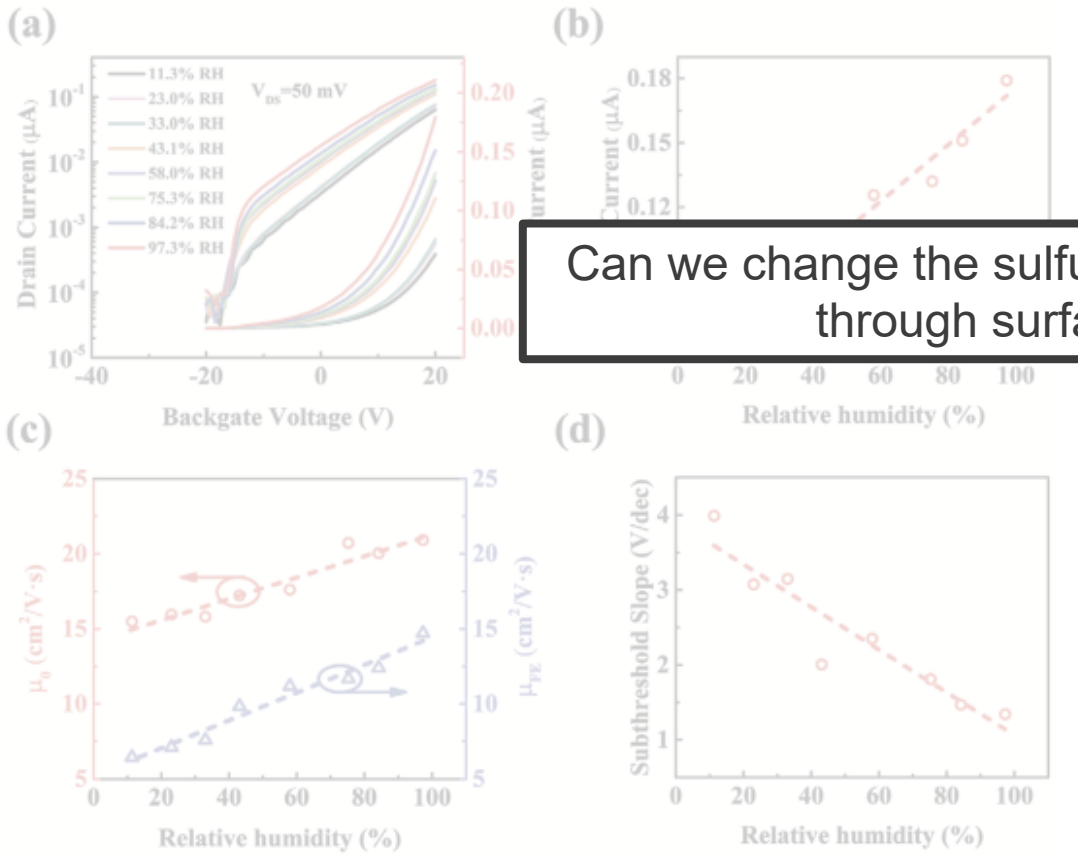
Adsorbed O_2 Changes Photoconductivity



Gustafson et al. *J. Phys. Chem. C* **2021**, 8712–8718.

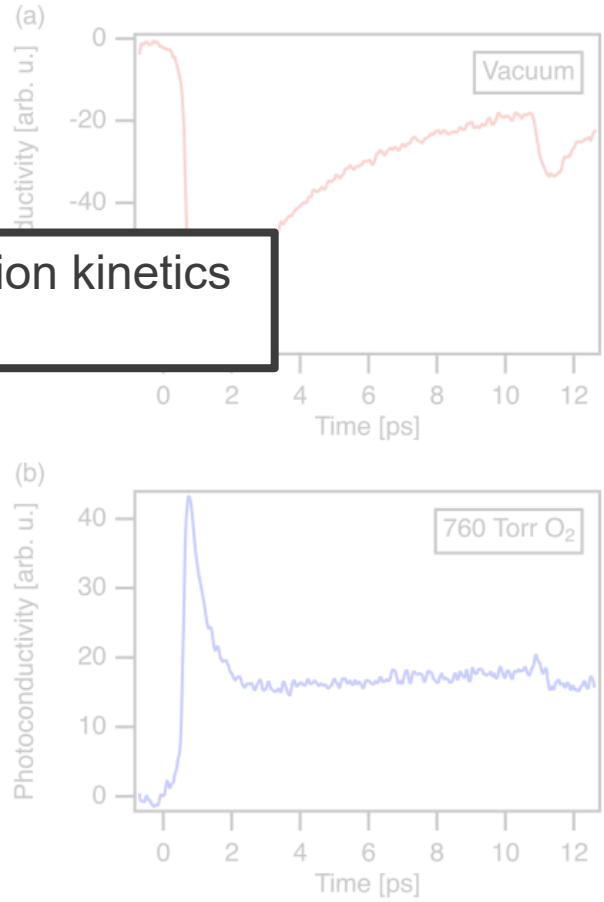
Adsorbed Molecules Alter Transport Properties in MoS_2

Adsorbed Water Dopes MoS_2 Film



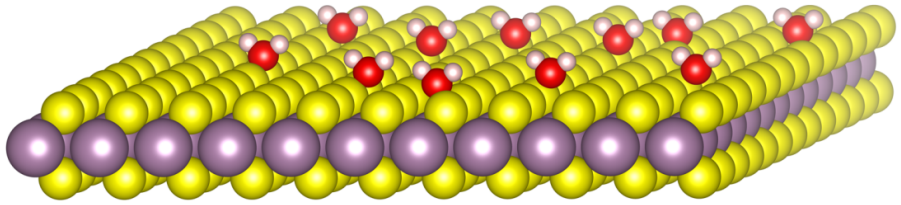
Can we change the sulfur vacancy migration kinetics through surface interactions?

Adsorbed O_2 Changes Photoconductivity



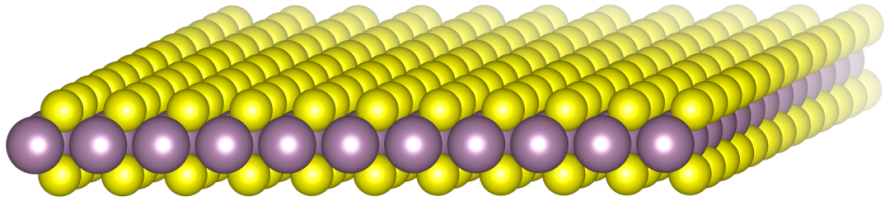
Adsorbed Molecules Suppress a Fast-Switching Process

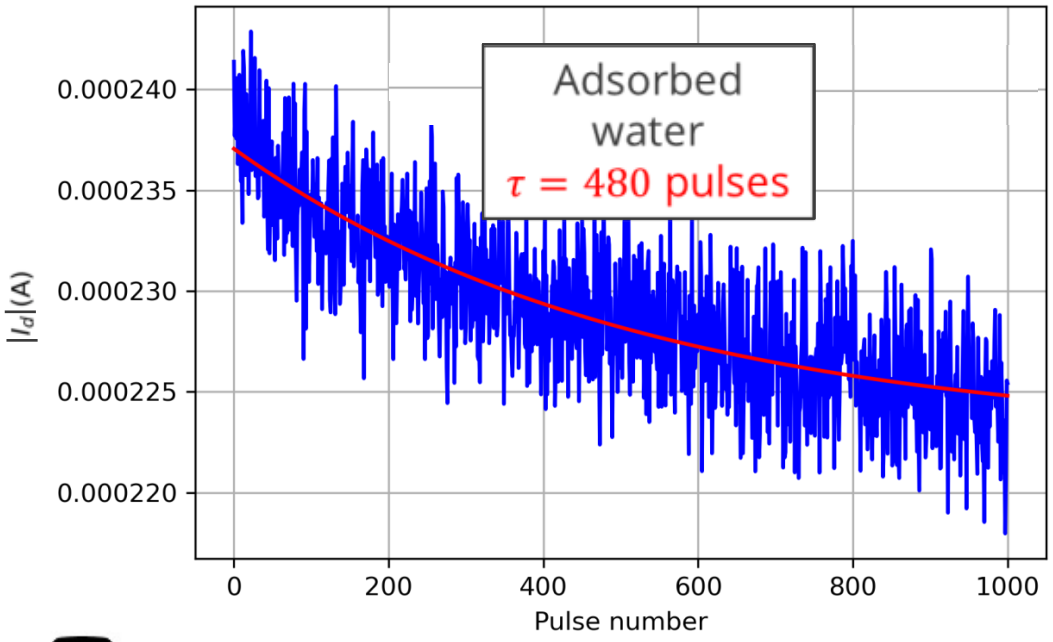
Molecules adsorbed to surface:



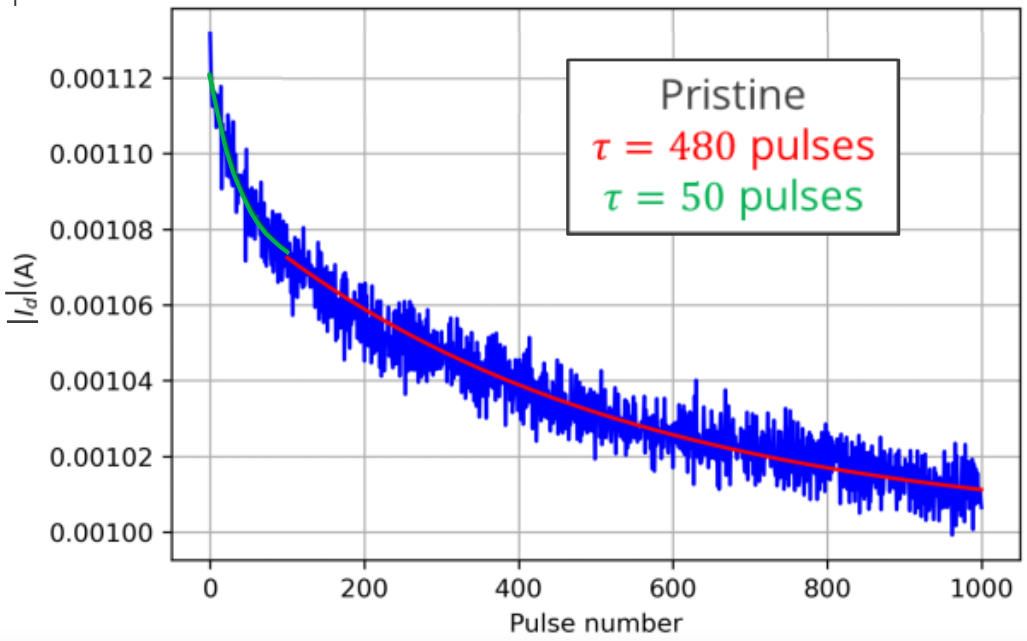
Bake out @ 100°C in vacuum for 15 min.

Pristine MoS_2 surface:

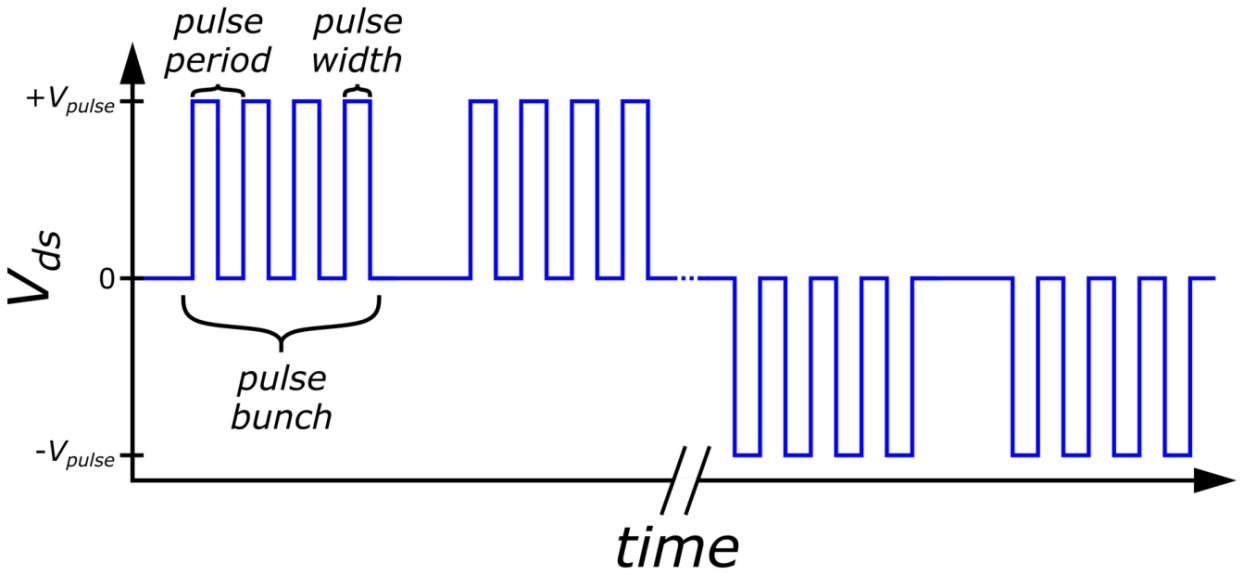


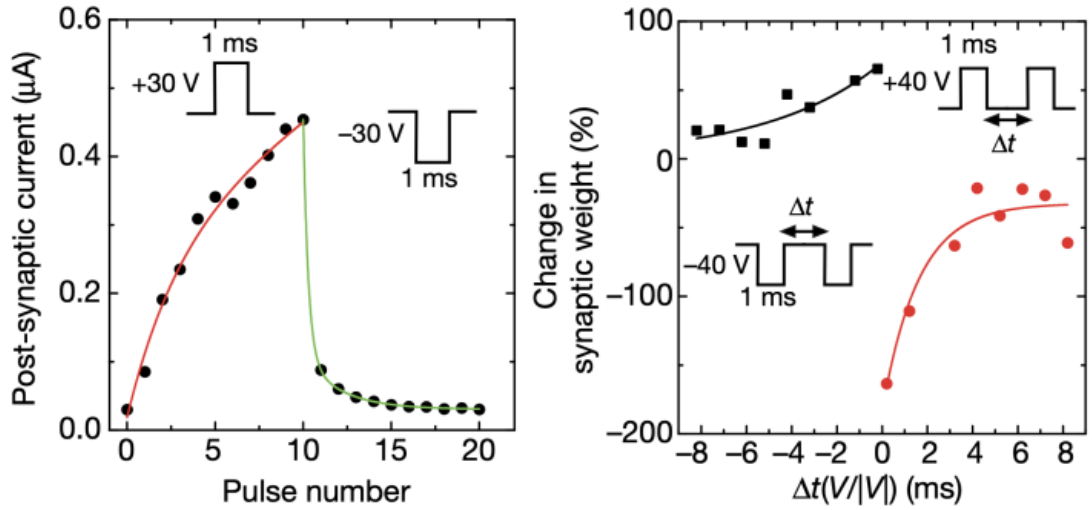


V_{ds} = -20 V
V_{gs} = 0 V
t_{pulse} = 10 ms
t_{period} = 20 ms

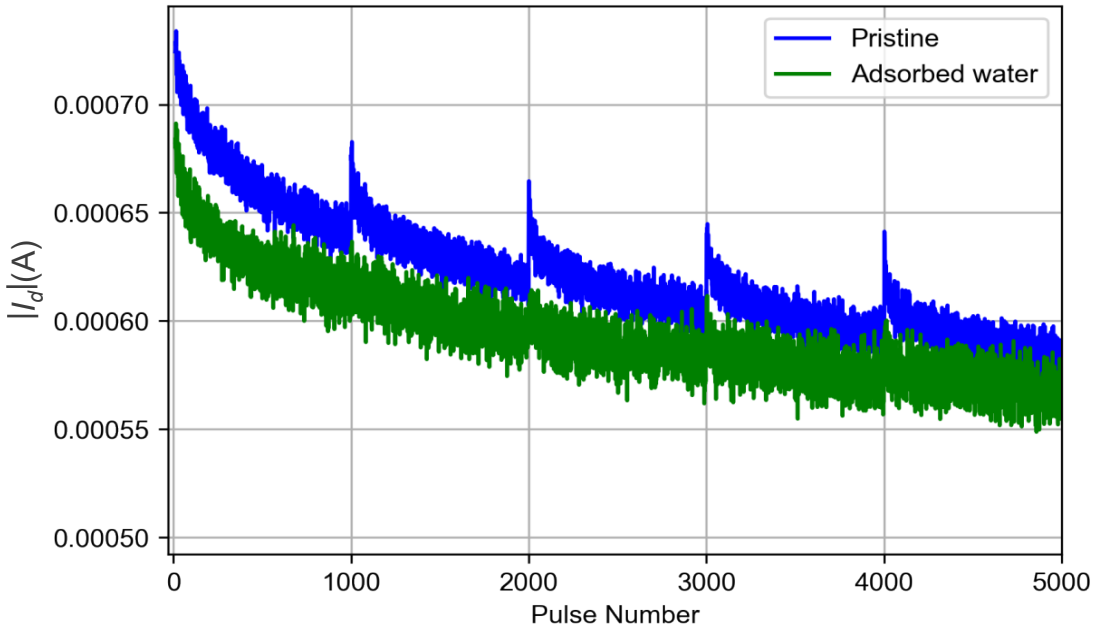


Pulse Bunching Allows Separation of Fast and Slow Processes



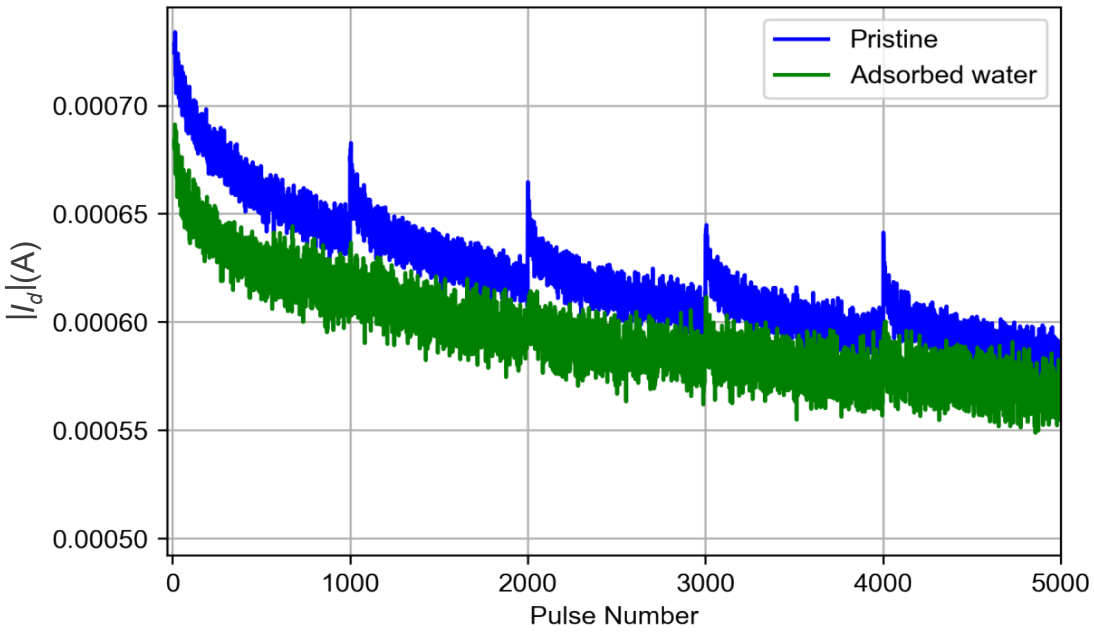


V_{ds} = - 20 V, V_{gs} = 0 V, t_{pulse} = 10 ms, n_{pulse} = 1000

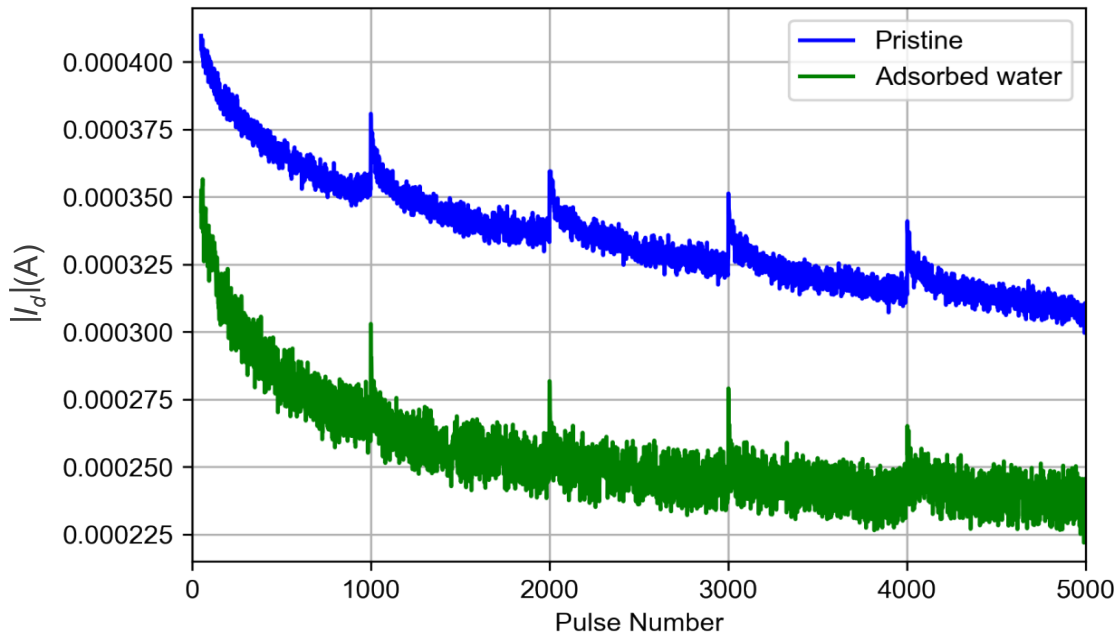


Application of V_{gs} < 0 Attenuates Transient Suppression

V_{ds} = - 20 V, V_{gs} = **0 V**, t_{pulse} = 10 ms, n_{pulse} = 1000



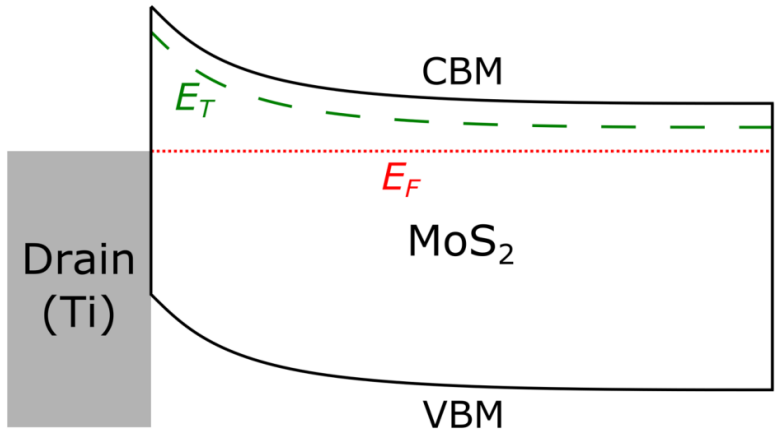
V_{ds} = - 20 V, V_{gs} = **-60 V**, t_{pulse} = 10 ms, n_{pulse} = 1000

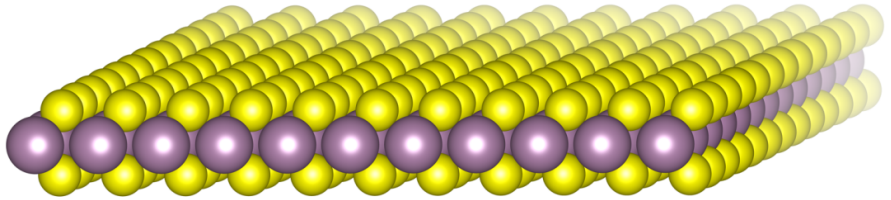


Gate-dependence Suggests Adsorption Changes Trap Energy

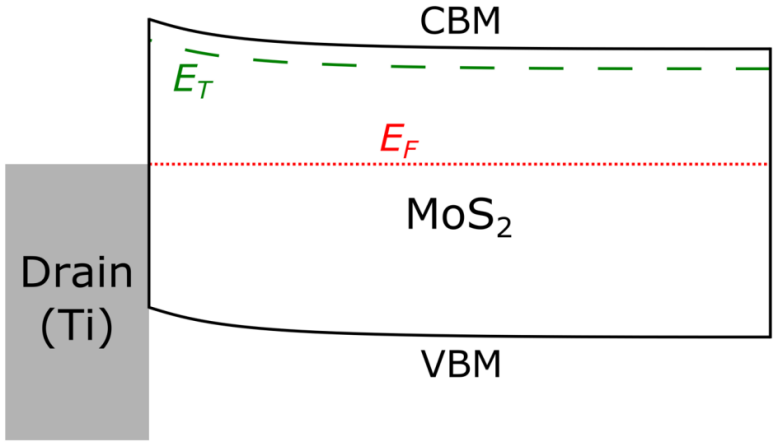
Pristine MoS_2 surface:

Gate bias = 0 V



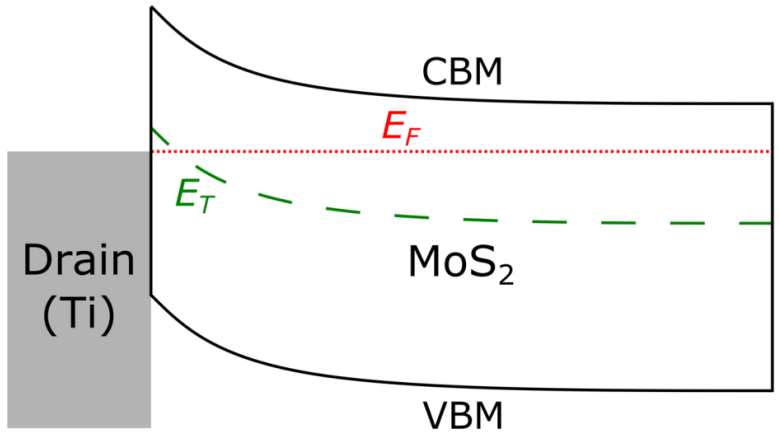


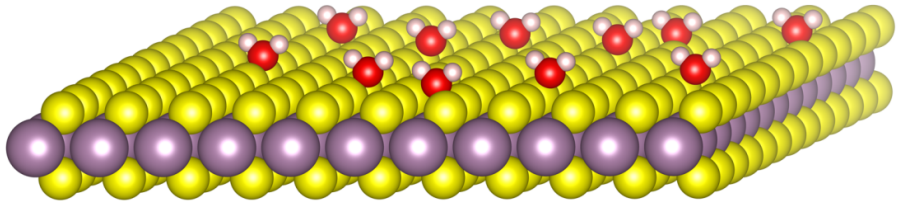
Gate bias = -60 V



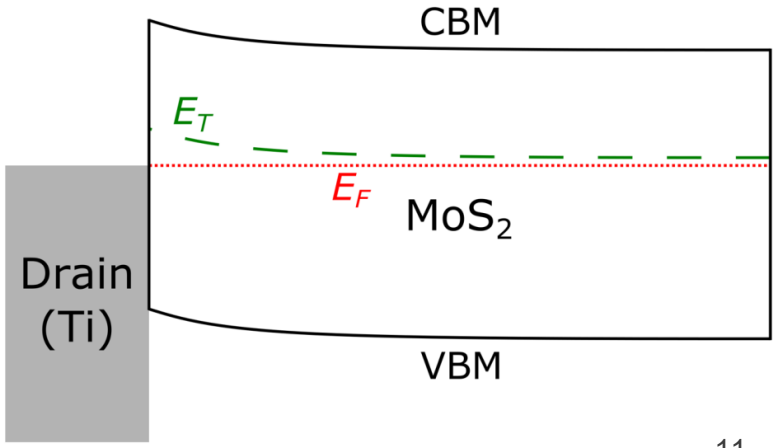
Adsorbed to surface:

Gate bias = 0 V

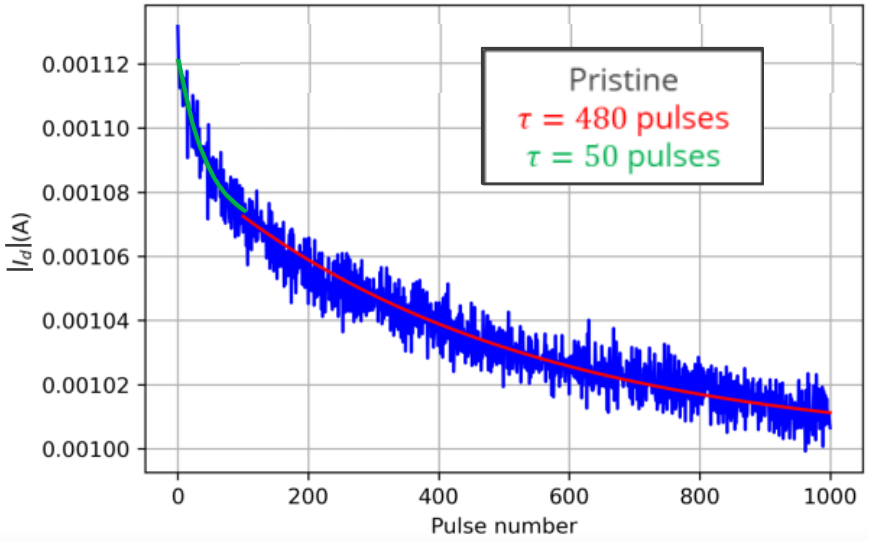


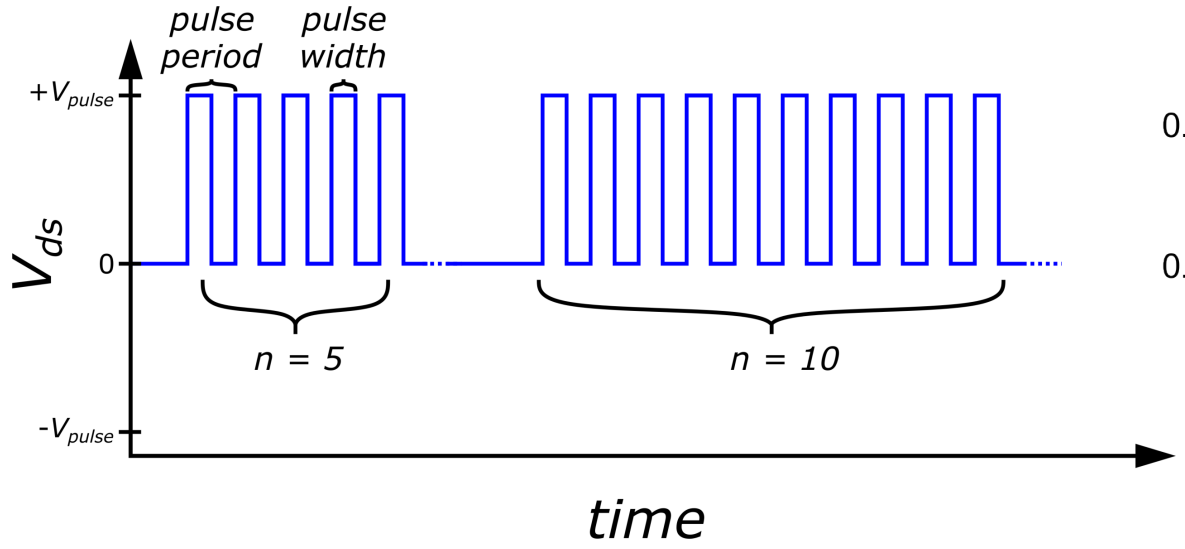


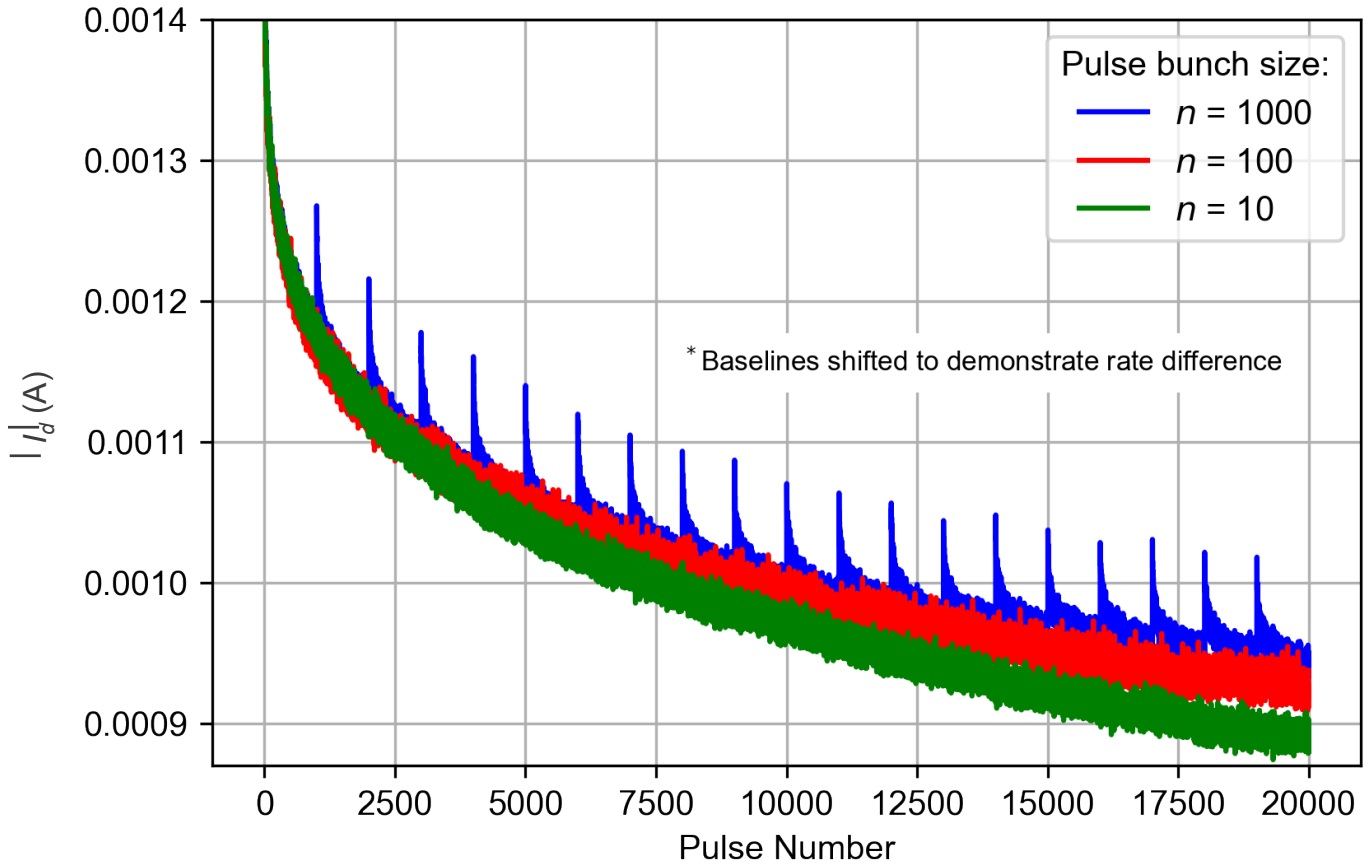
Gate bias = -60 V



Persistent Switching Rate Depends on Trap Occupation

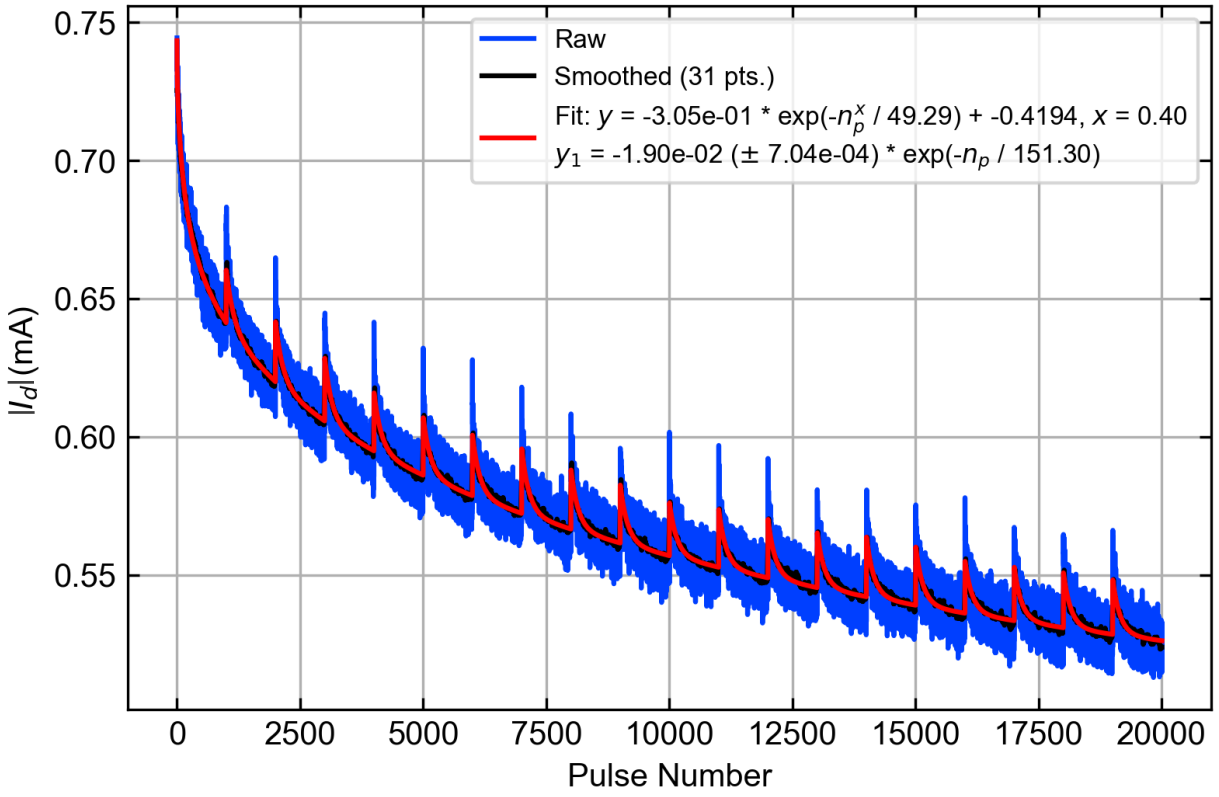




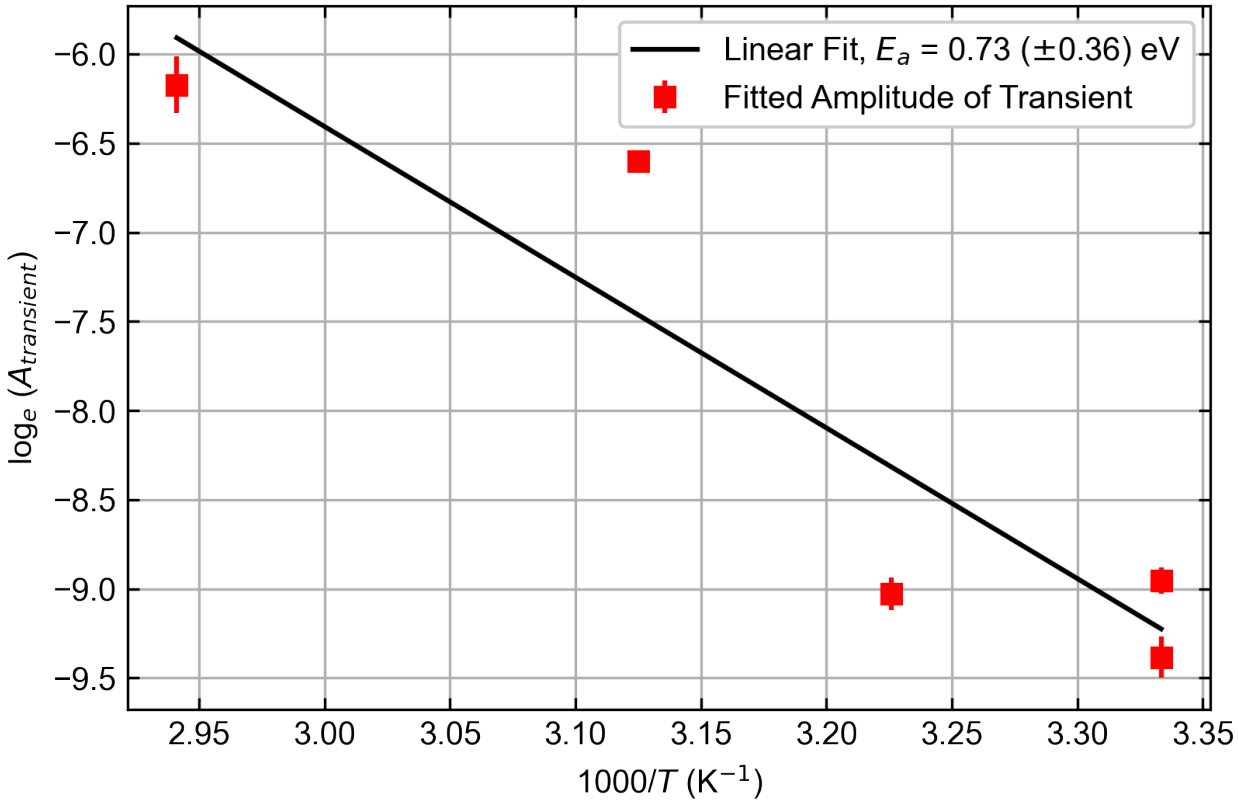


VT Pulsing Indicates Deep Level Trap Responsible

V_{ds} = - 20 V, V_{gs} = -20 V, t_{pulse} = 10 ms, n_{pulse} = 1000

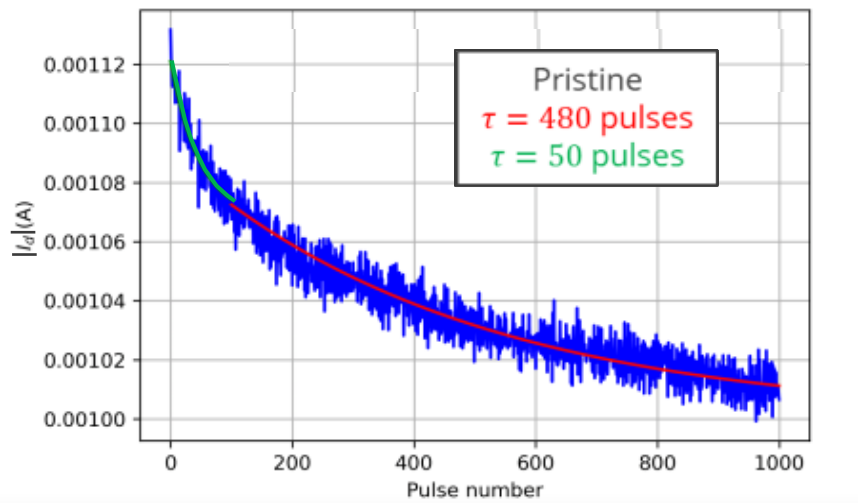


$A_{transient}$ at 300 K, 310 K, 320 K, & 340 K (pristine)

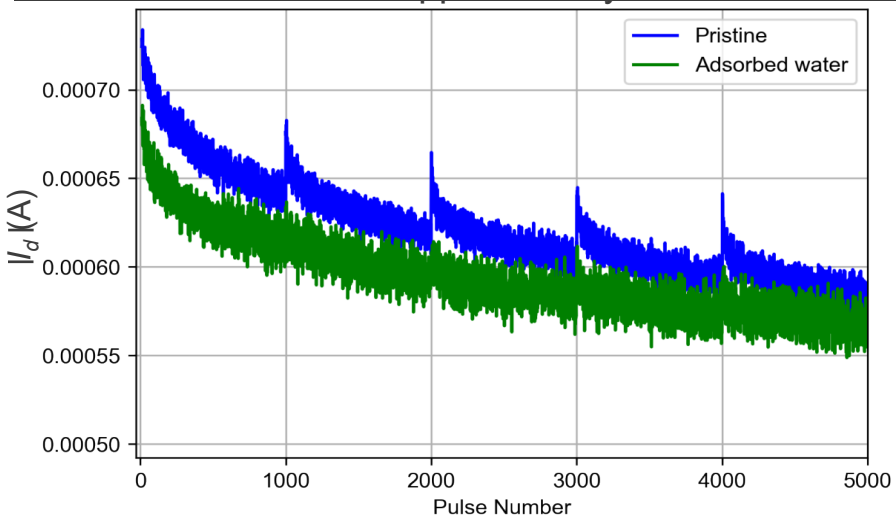


Conclusions

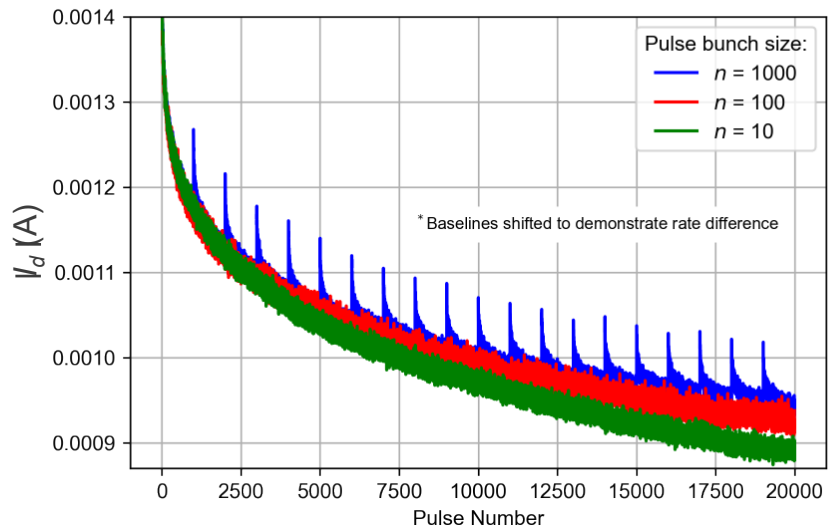
Switching Process Consists of Fast and Slow Processes



Fast Process Can be Suppressed by Adsorbed Molecules



Occupancy of Traps Changes Persistent Switching Rate



Trap State Responsible Lies Relatively Deep in Band Gap