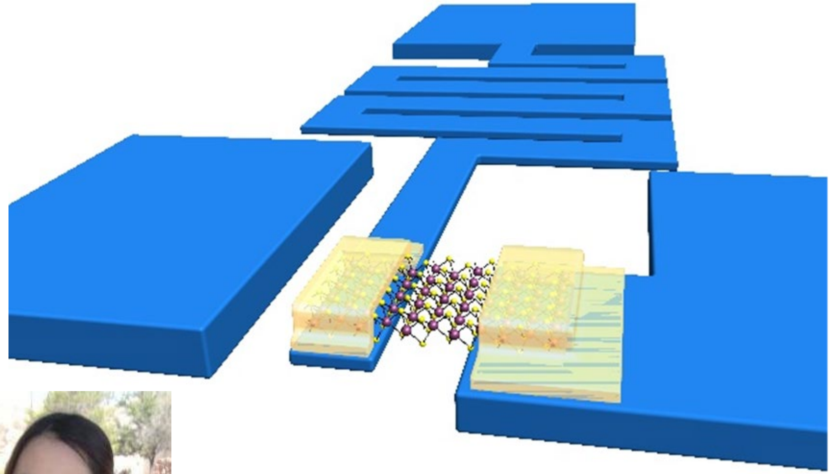
Stritch Research Update



UTEP TEAM:

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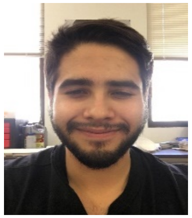

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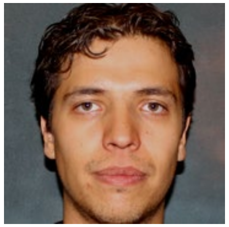

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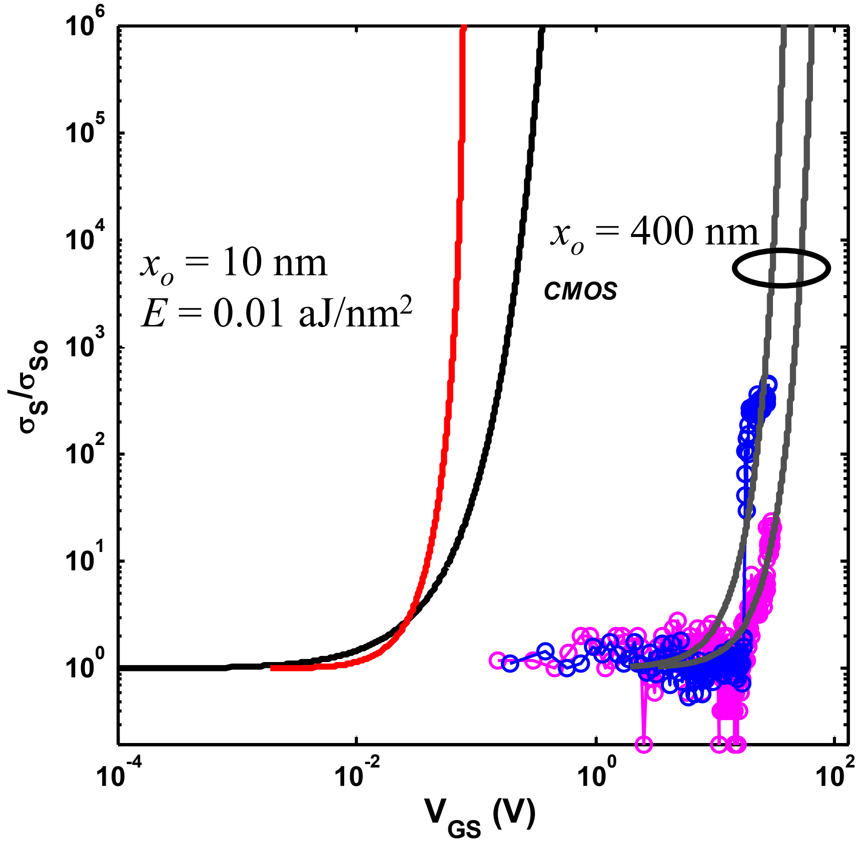
Stritch Output Characteristic



200X increase

$\varepsilon_{TMD} = 2.7\%$

- **Swing$_{\text{Stritch}}$ (17mV/dec) < Swing$_{\text{CMOS}}$ (60 mV/dec)**

Stritch Output Characteristic

- What gives rise to steep output?
- How can steep output be used?

CMOS:

$$\sigma_{CMOS}/\sigma_{CMOS_O} = \exp(V_{GS}/kT\ )$$

Stritch:

$$\sigma_S/\sigma_{S_O} = \exp\left(\left|\frac{\partial E_g}{\partial \varepsilon}\right| \varepsilon(V_{GS})/2kT\ \right)$$

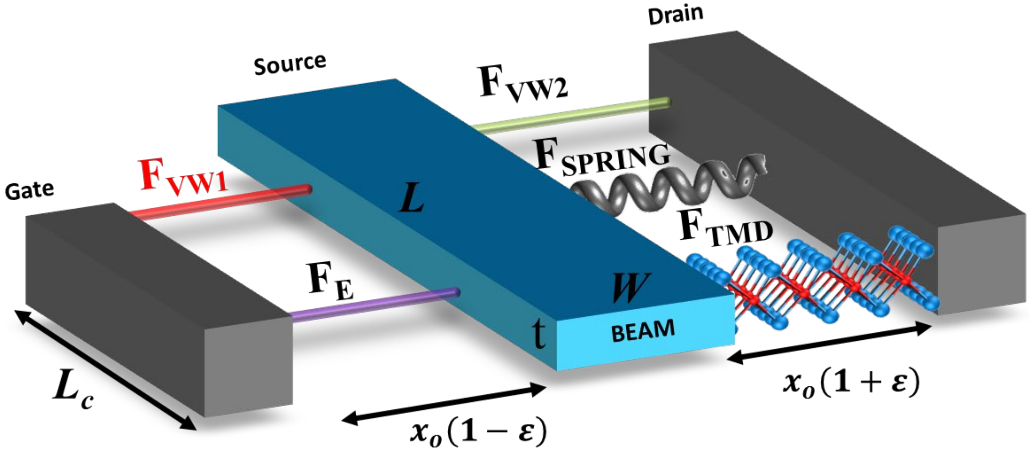
TMD deformation potential

MEMS actuation sensitivity

Stritch output is steeper than CMOS when:

$$\left|\frac{\partial E_g}{\partial \varepsilon}\right| \varepsilon(V_{GS})/2>1$$

MEMS Actuation Sensitivity

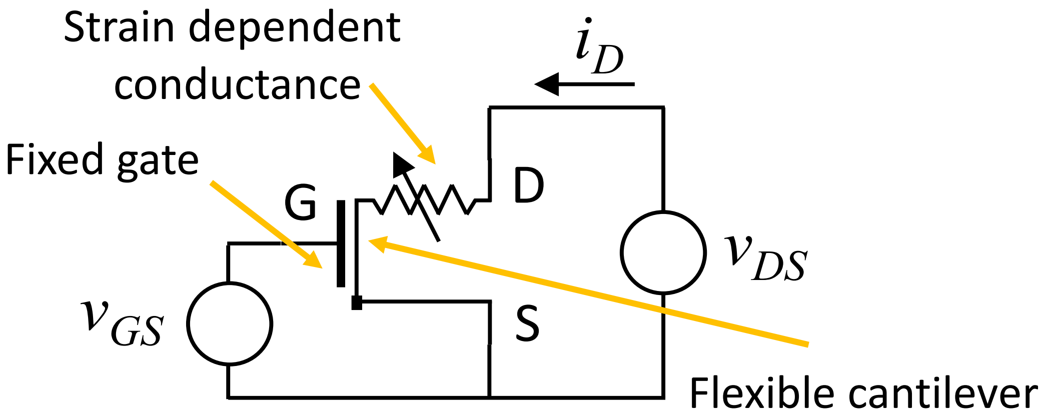


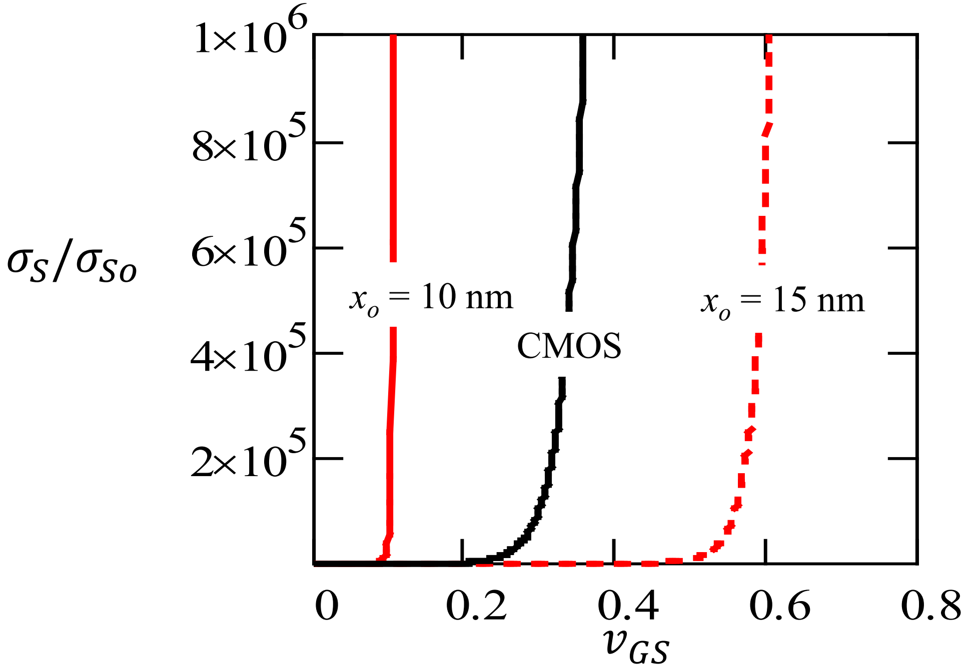
$$F_E = F_{CAN} + F_{TMD} + F_{VW_2} - F_{VW_1}$$

$$\frac{\epsilon_o A V_{GS}^2}{2x_0^2(1-\varepsilon)^2} = k_{CAN} x_o \varepsilon + k_{TMD} x_o \varepsilon + \frac{HA}{6\pi x_o^3(1+\varepsilon)^3} - \frac{HA}{6\pi x_0^3(1-\varepsilon)^3}$$

- **F_{VW1} aids F_E to strain TMD when x_o is small**
- **F_{VW1} increases actuation sensitivity $\left(\frac{\Delta\varepsilon}{\Delta V_{GS}}\right)$**

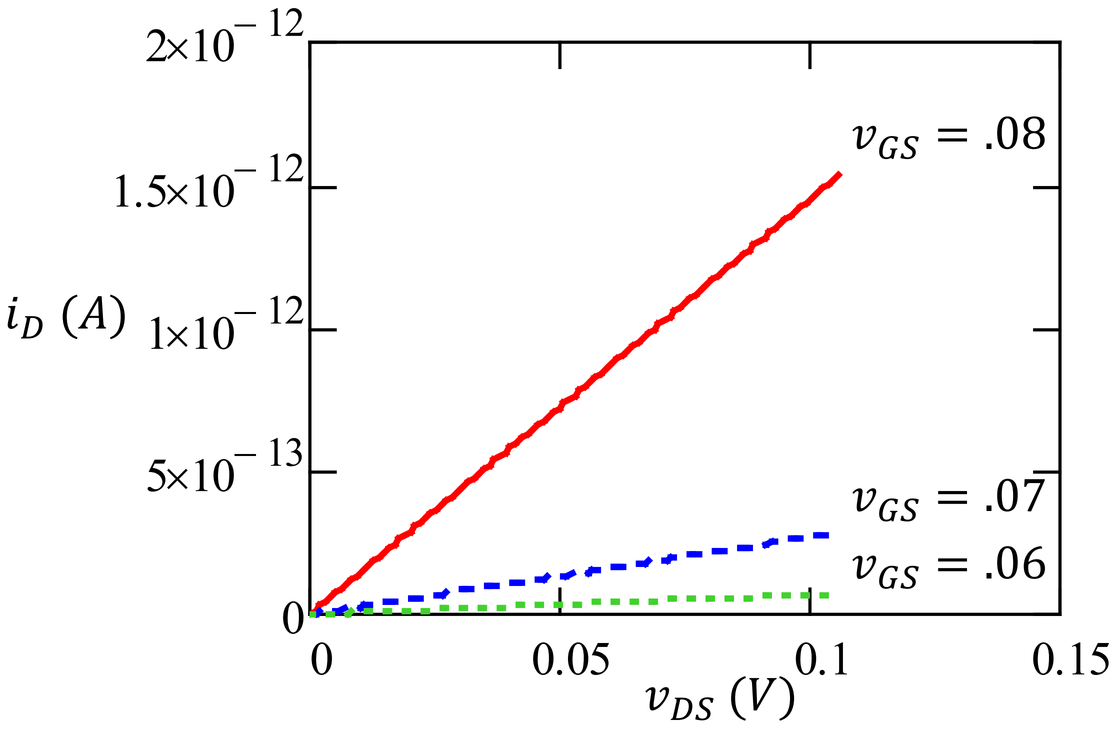
Stritch Transistor





- **Turn-on voltage is sensitive to x_o**
- **Output remains steep**

I-V Characteristic

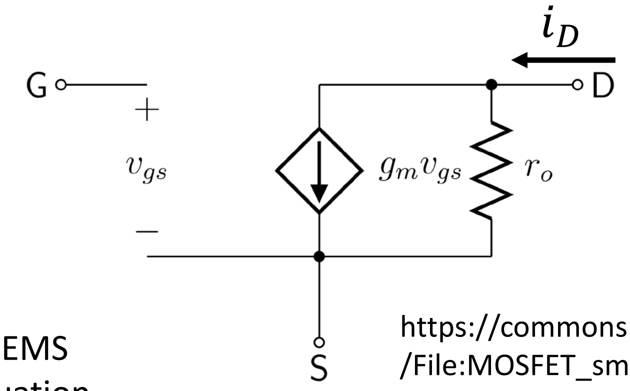


- **Similar to MOSFET in linear region**
- **However slope increases exponentially with v_{GS}**

Stritch Small Signal Model

$$v_{ds} = g_m v_{gs} r_o$$

$$i_d = g_m v_{gs} + {}^{v_{ds}}/_{r_o}$$



https://commons.wikimedia.org/wiki/File:MOSFET_small_signal.svg

TMD deformation potential

MEMS actuation sensitivity

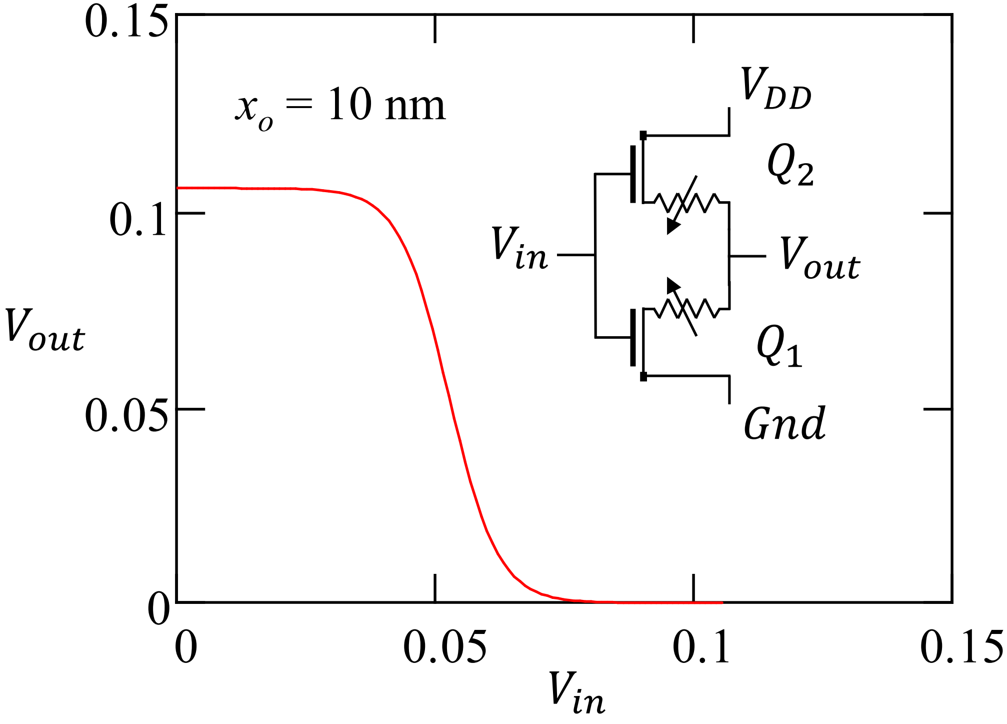
$$g_m \equiv I_{DQ}\frac{\left|\frac{\partial E_g}{\partial \varepsilon}\right|\left(\frac{\partial \varepsilon}{\partial V_{GS}}\right)}{2kT} = V_{DSQ}\sigma_{SQ}\frac{\left|\frac{\partial E_g}{\partial \varepsilon}\right|\left(\frac{\partial \varepsilon}{\partial V_{GS}}\right)}{2kT}$$

$$r_o \equiv \frac{1}{\sigma_{SQ}} = 1/\,\sigma_{S_O}\exp\left(\left|\frac{\partial E_g}{\partial \varepsilon}\right|\varepsilon(V_{GSQ})/2kT\right)$$

$$A_{Vo} = \frac{v_{ds}}{v_{gs}} = g_m r_o = V_{DSQ}\frac{\left|\frac{\partial E_g}{\partial \varepsilon}\right|\left(\frac{\partial \varepsilon}{\partial V_{GS}}\right)}{2kT}$$

Complementary Logic Configuration

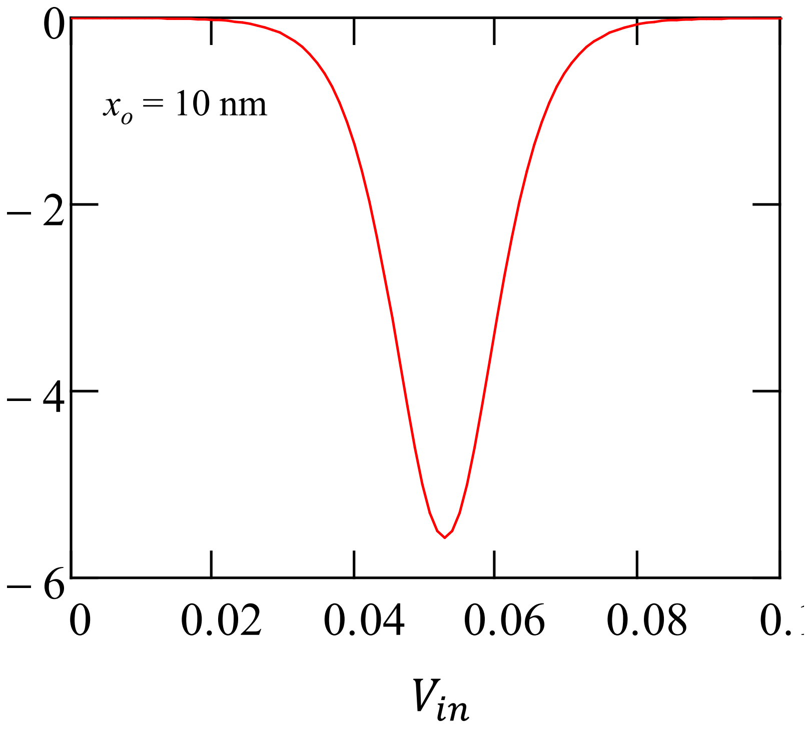
$$V_{out} = V_{DD} \frac{R_1(V_{in})}{R_1(V_{in}) + R_2(V_{DD} - V_{in})}$$



- Electrostatic force is ambipolar
  - ❑ Allows inverting and non-inverting circuitry

Voltage Gain of Complementary Circuit

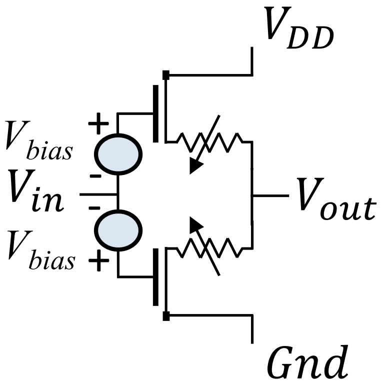
$$A_V = \frac{V_{out}}{V_{in}}$$

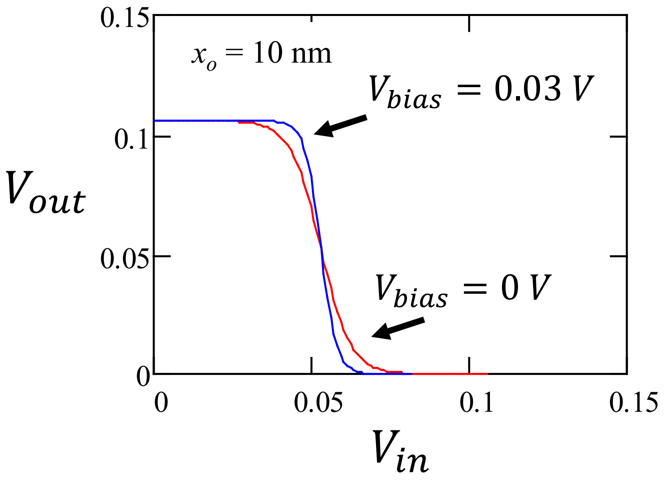


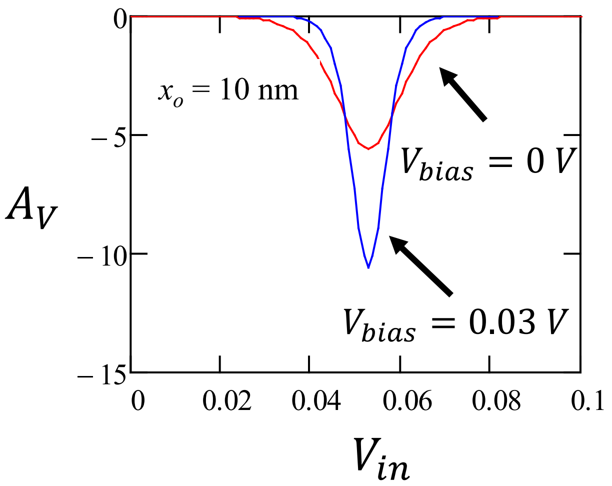
- Maximum $A_V = -5.5$

DC Bias Increases Gain

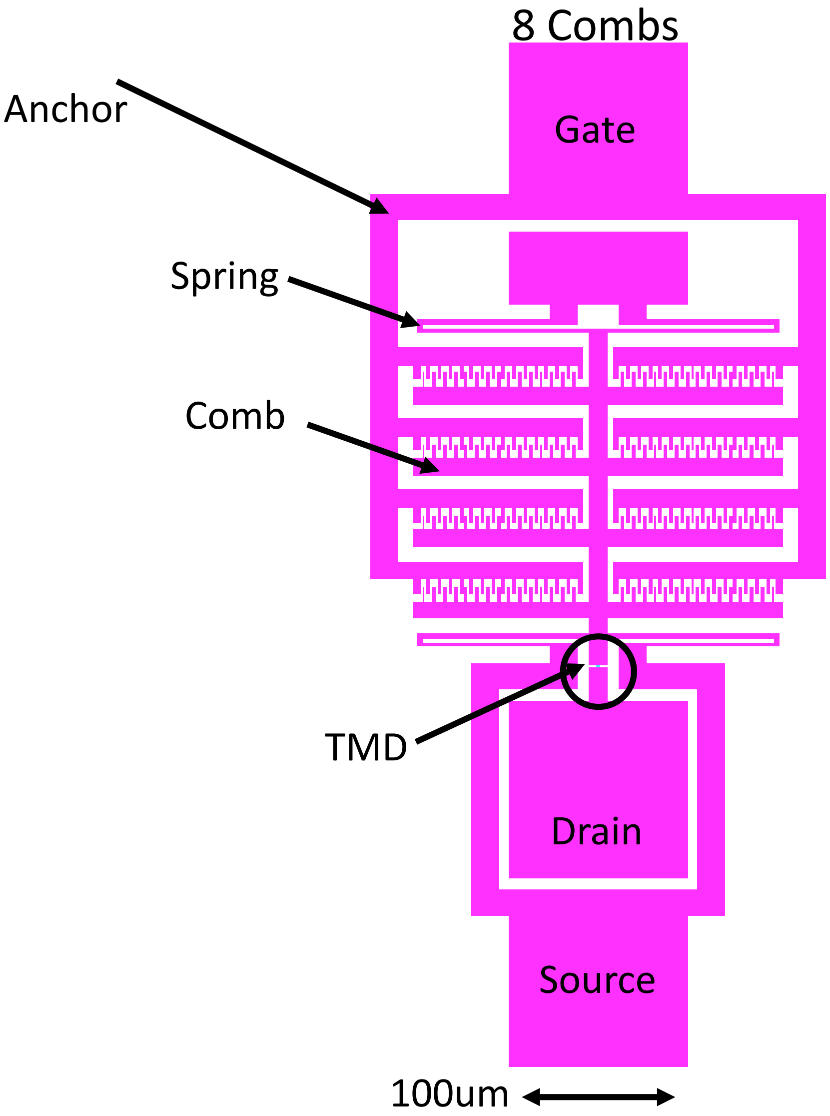
- **Bias pre-actuates MEMS**
  - **Increases actuation sensitivity**



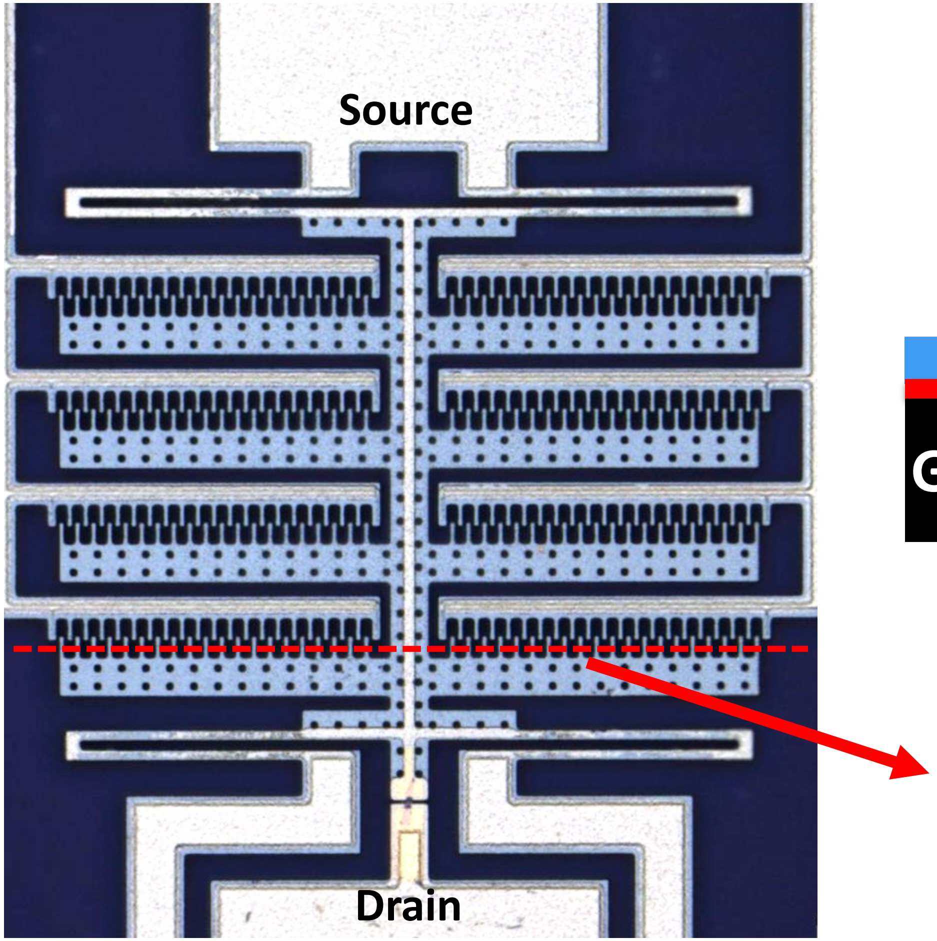




UTEP Comb-Drive Design

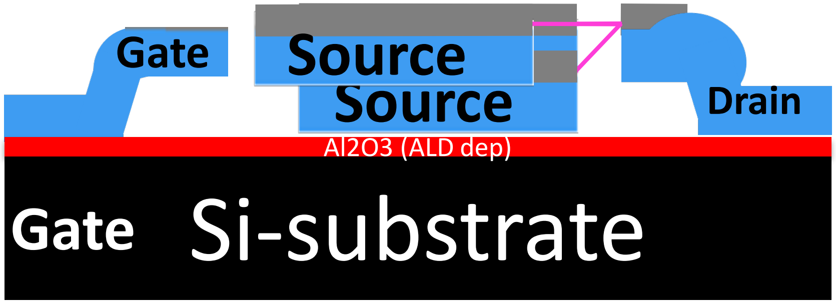


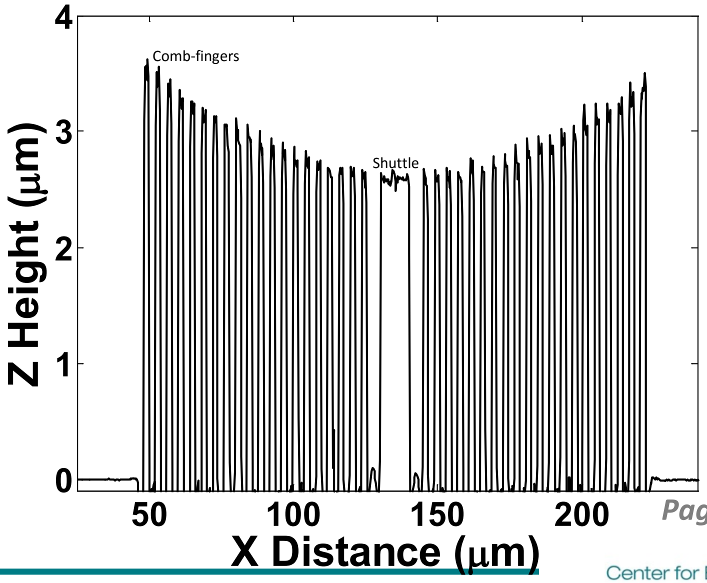
Lateral vs Vertical Actuation



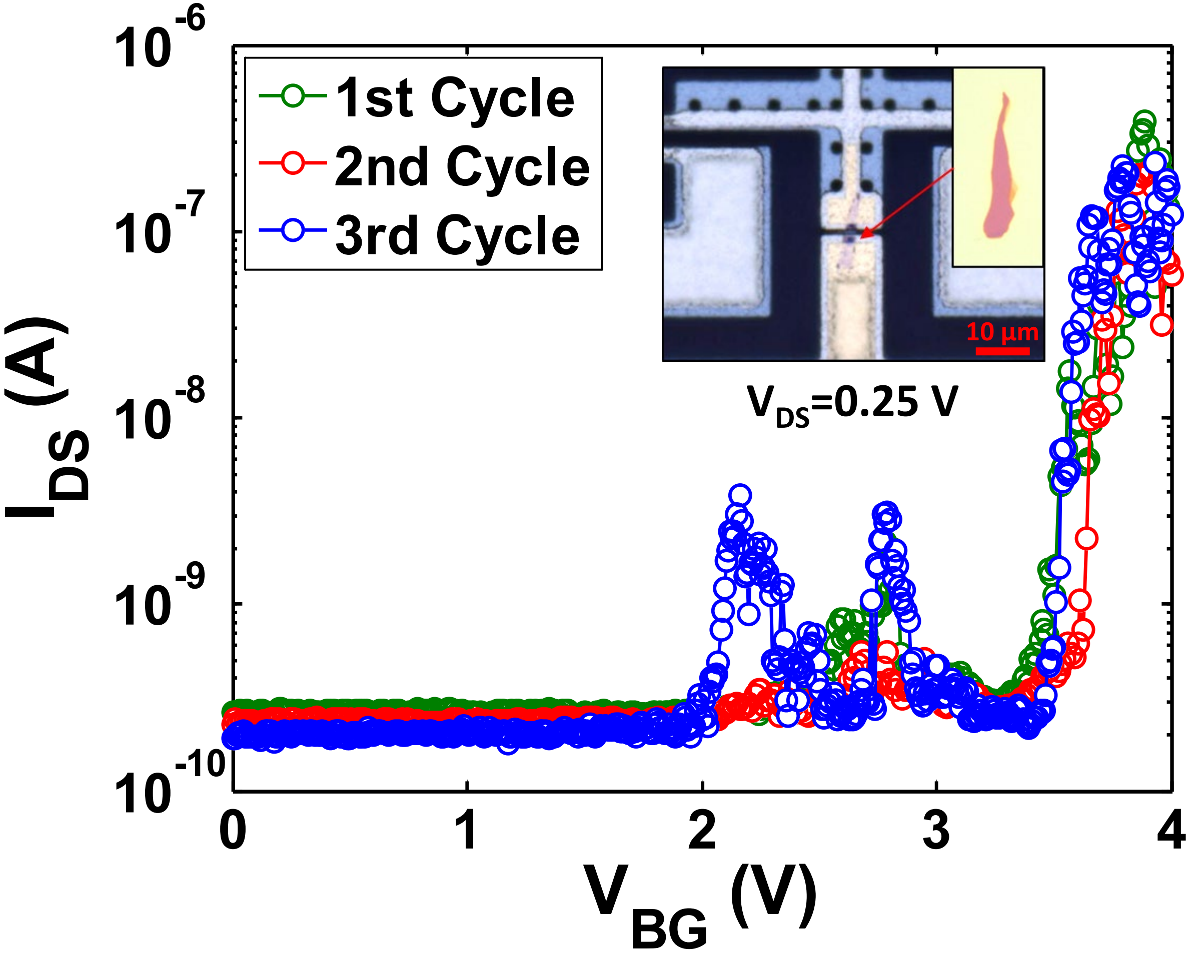
VERTICAL ACTUATION

LATERAL ACTUATION





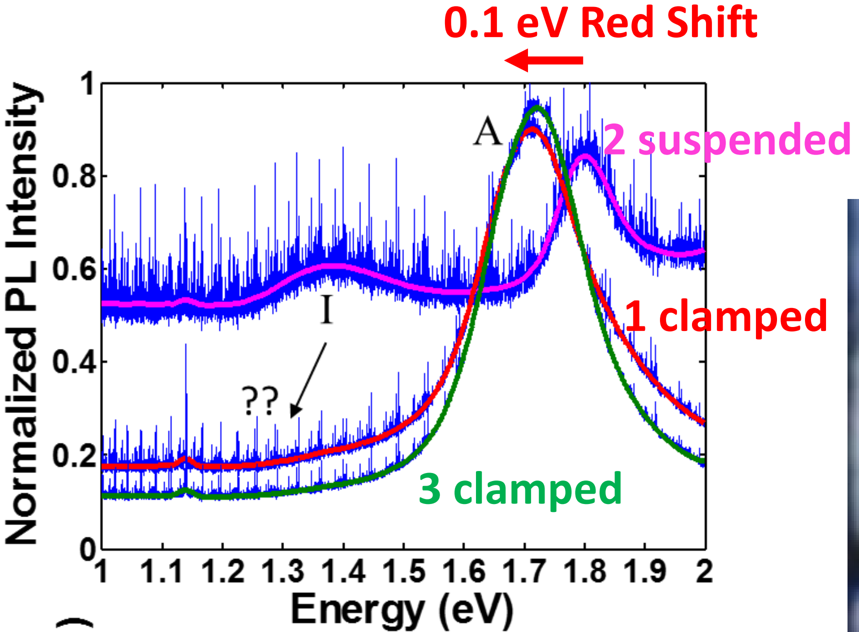
3000X increase in conductivity in strained MoS_2

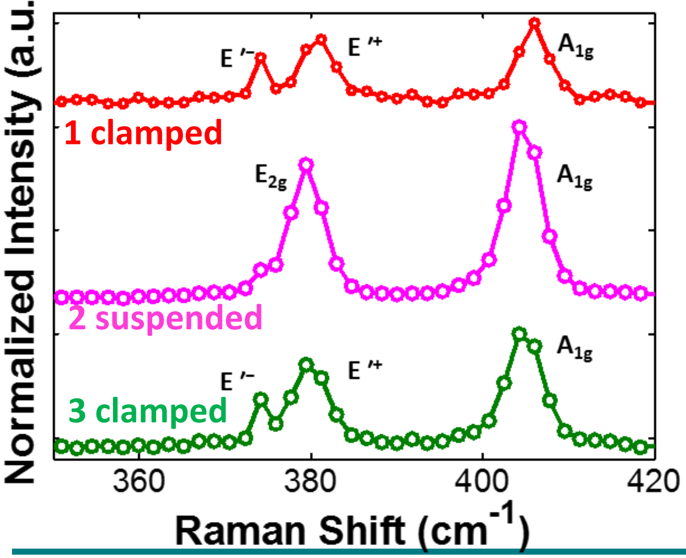


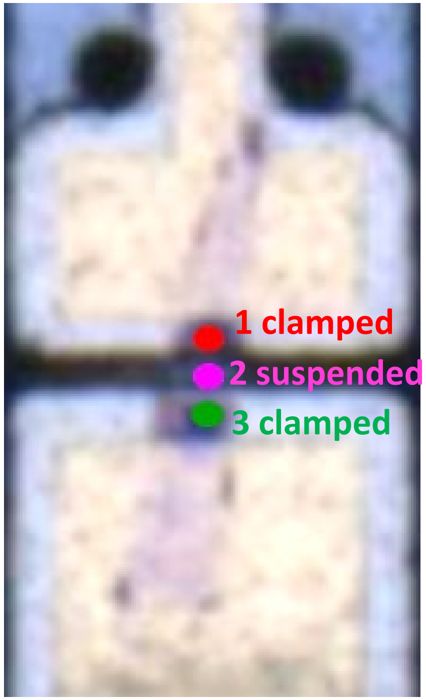
Contacts:Cr/Au (5nm/30nm)

~3% strain

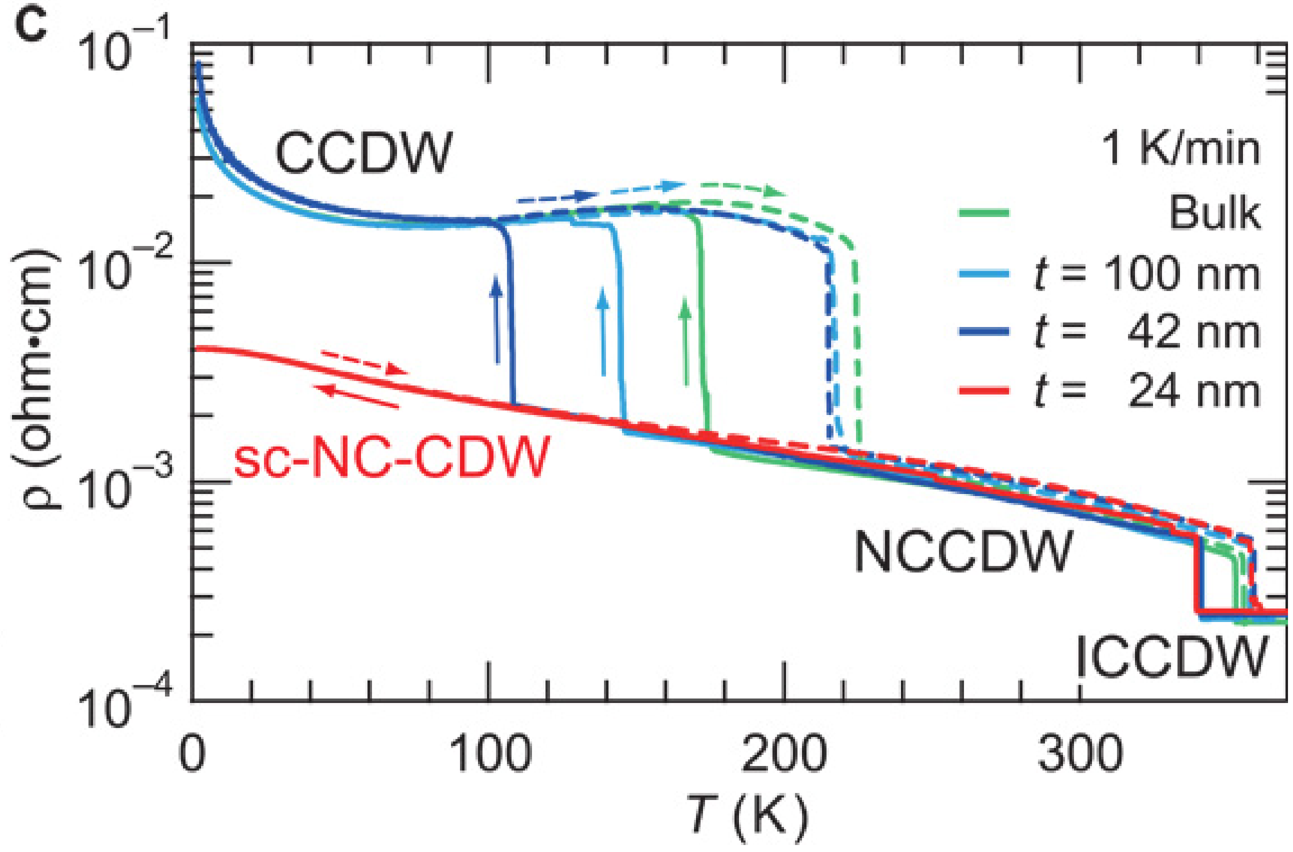
Optical measurements after straining







TaS_2-layered system with first-order charge density wave (CDW) phase transitions



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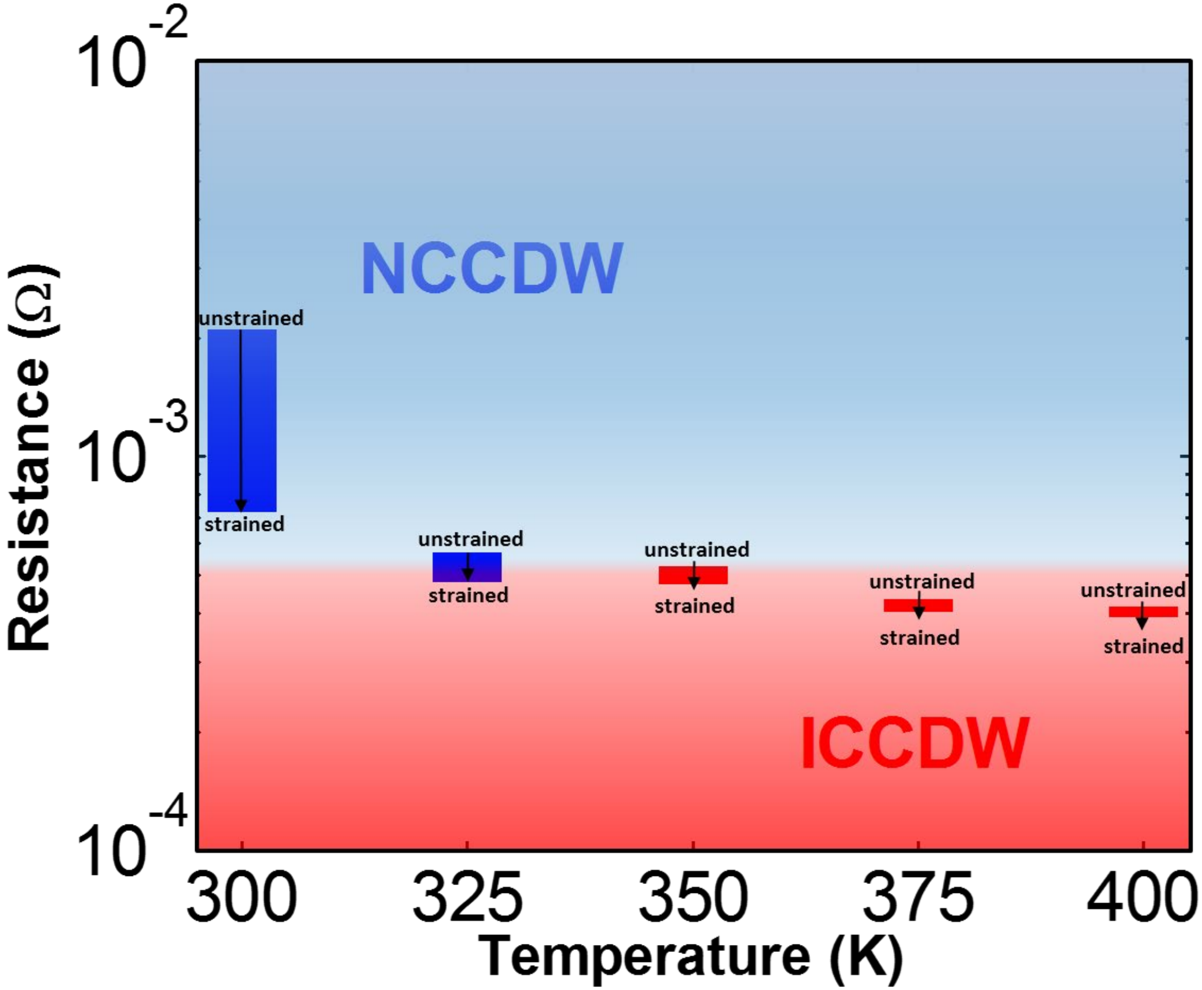
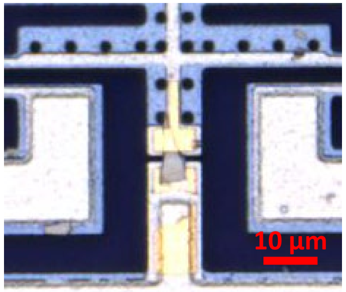
Phase transition temperature shift in strained TaS_2





Cr/Au (1nm/70nm)

Thank You!