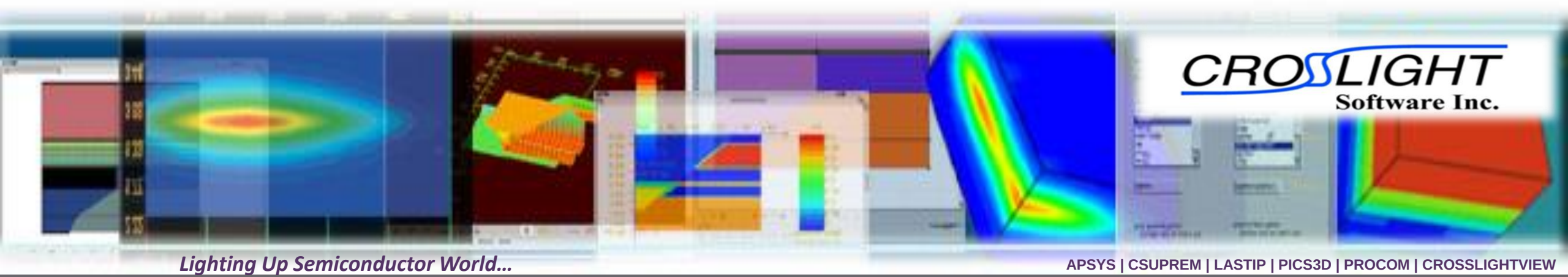
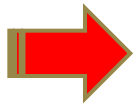


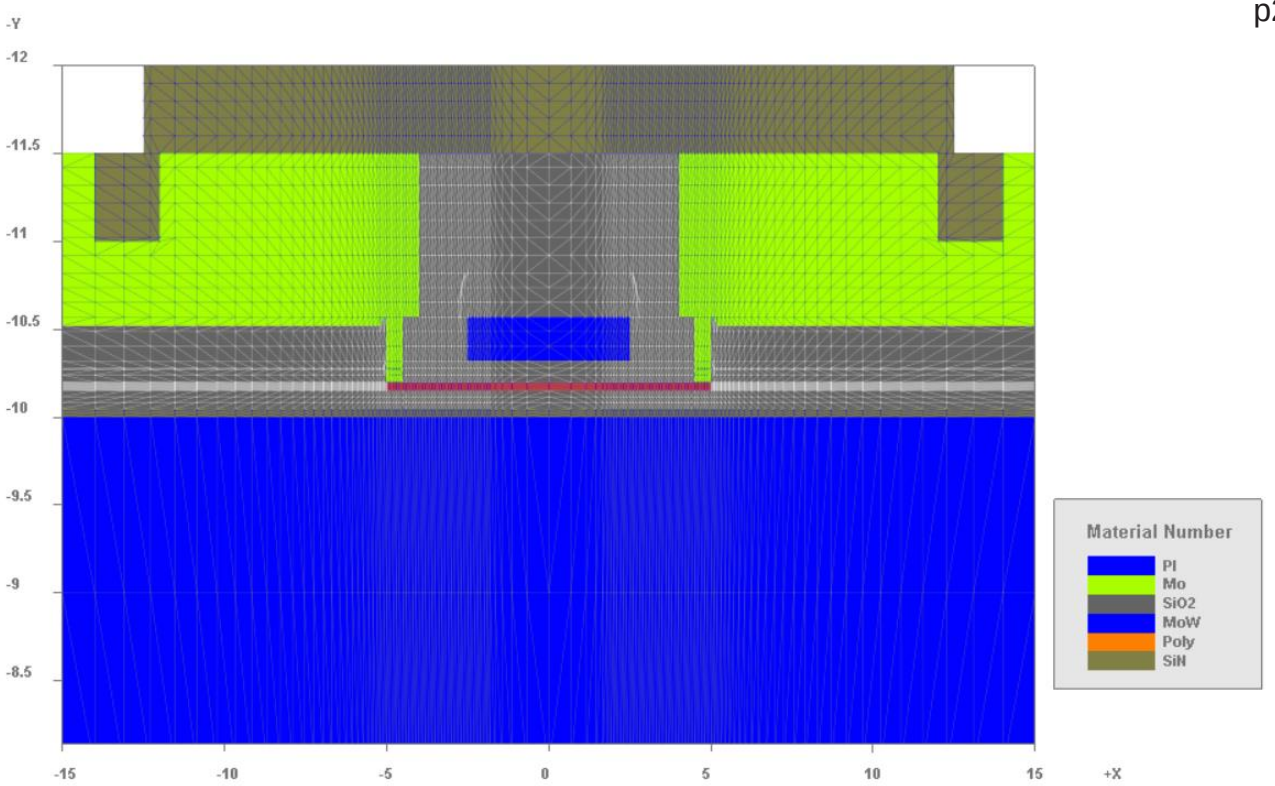
Crosslight Simulation of Effects of Bending in Thin Film Transistors

Contents



- Structure and experiments
- Stress and material models
- Commands
- Results
- Summary

Structure



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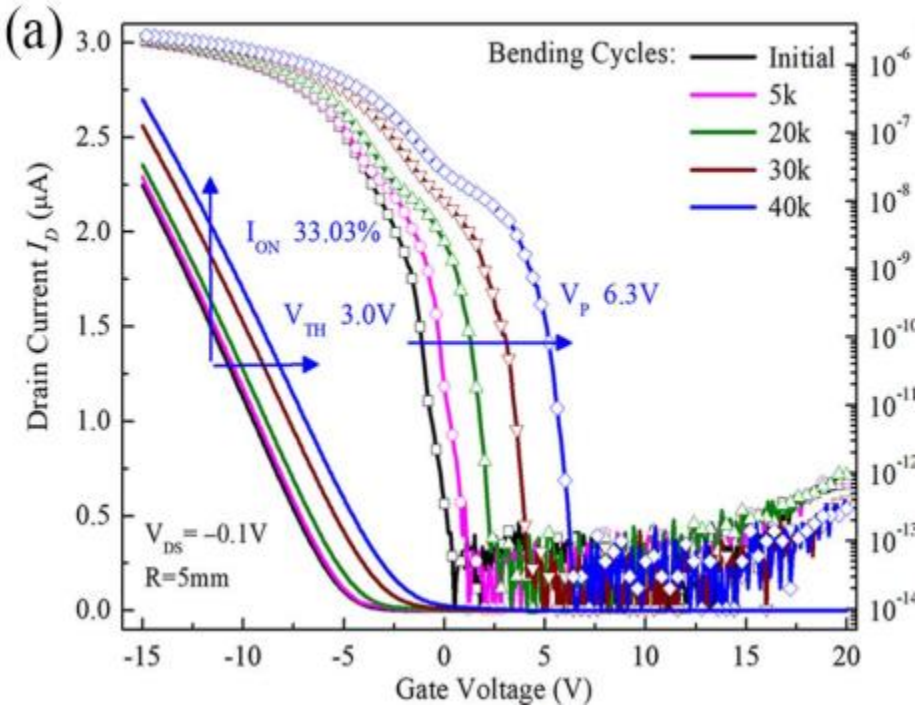
p2214

Spontaneous Degradation of Flexible Poly-Si TFTs Subject to Dynamic Bending Stress

Wei Jiang, Mingxiang Wang, *Senior Member, IEEE*, Huaisheng Wang, and Dongli Zhang



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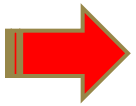

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Model

$$c_{11} * \frac{\partial^2 V_x}{\partial x^2} + c_{44} * \frac{\partial^2 V_x}{\partial y^2} + c_{12} * \frac{\partial^2 V_y}{\partial x \partial y} + c_{44} * \frac{\partial^2 V_y}{\partial y \partial x} = -bx$$

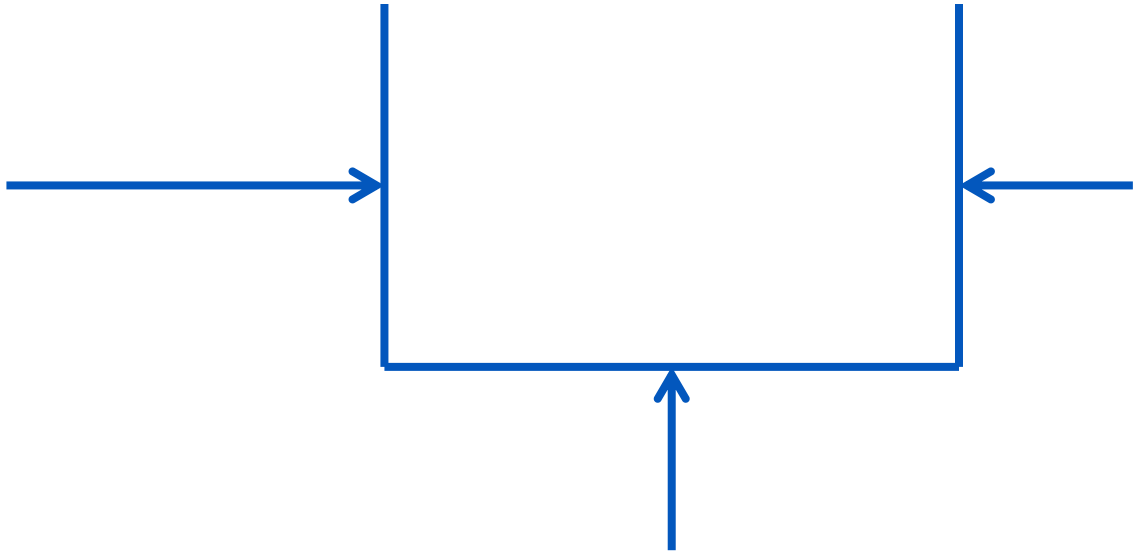
$$c_{12} * \frac{\partial^2 V_x}{\partial y \partial x} + c_{44} * \frac{\partial^2 V_x}{\partial x \partial y} + c_{44} * \frac{\partial^2 V_y}{\partial x^2} + c_{11} * \frac{\partial^2 V_y}{\partial y^2} = -by$$

V=displacement vector
bx/by=initial
stress/boundary stress

$$bx = \frac{\partial \sigma_{0,xx}}{\partial x} + \frac{\partial \sigma_{0,xy}}{\partial y}$$

$$by = \frac{\partial \sigma_{0,yy}}{\partial y} + \frac{\partial \sigma_{0,xy}}{\partial x}$$

Strain boundary (default)



By default, boundaries are Csuprem model is such that all displacement at left/right/bottom are restricted

Not suitable for bending

Revised Strain Boundary

y.free.boundary=bottom
    Revised bottom boundary

x.free.boundary=left/right
    Revised left/right boundary

y.fixed.boundary=left/right
   Fix the y-direction so that the object would not move in y-direction after bending

Contents

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Files and Commands

Ltps_TFT_30um_nostrain for no-strain

(1) Run Csuprem on 2d.in

(2) Run APSYS on tft2_vt.sol, tft2_iv.sol

(3) Customized MoW, Pi material macro defined as LTPS.mac

Ltps_TFT_30um_strain for with strain

Let work function of MoW be stress dependent:

```
affinity variation=function
function(stress_xx)
4.9+abs(stress_xx)
end_function
```

Files and Commands

```
#Key commands in    2d.in

external_pressure  xrange_from=-15.0 xrange_to=15.0  depth=0.5 sigma=-1.0e11 bottom
stress temp1=25 temp2=25  y.free.boundary=bottom   x.free.boundary=left/right
y.fixed.boundary=left/right

struct outf=08_final_disp.str add.disp=t
```

External pressure acting from the bottom within a range.
Depth affects mesh region where external pressure acts on.
The results shall not be sensitive to choice of depth of external initial pressure.

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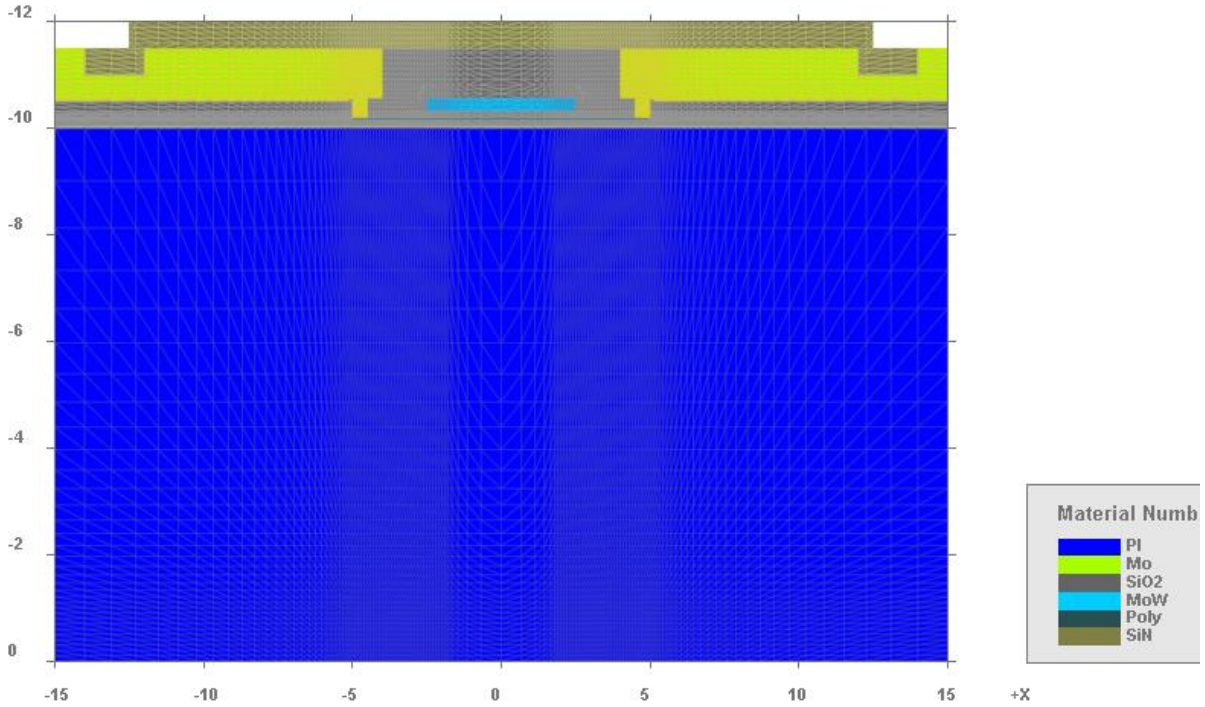
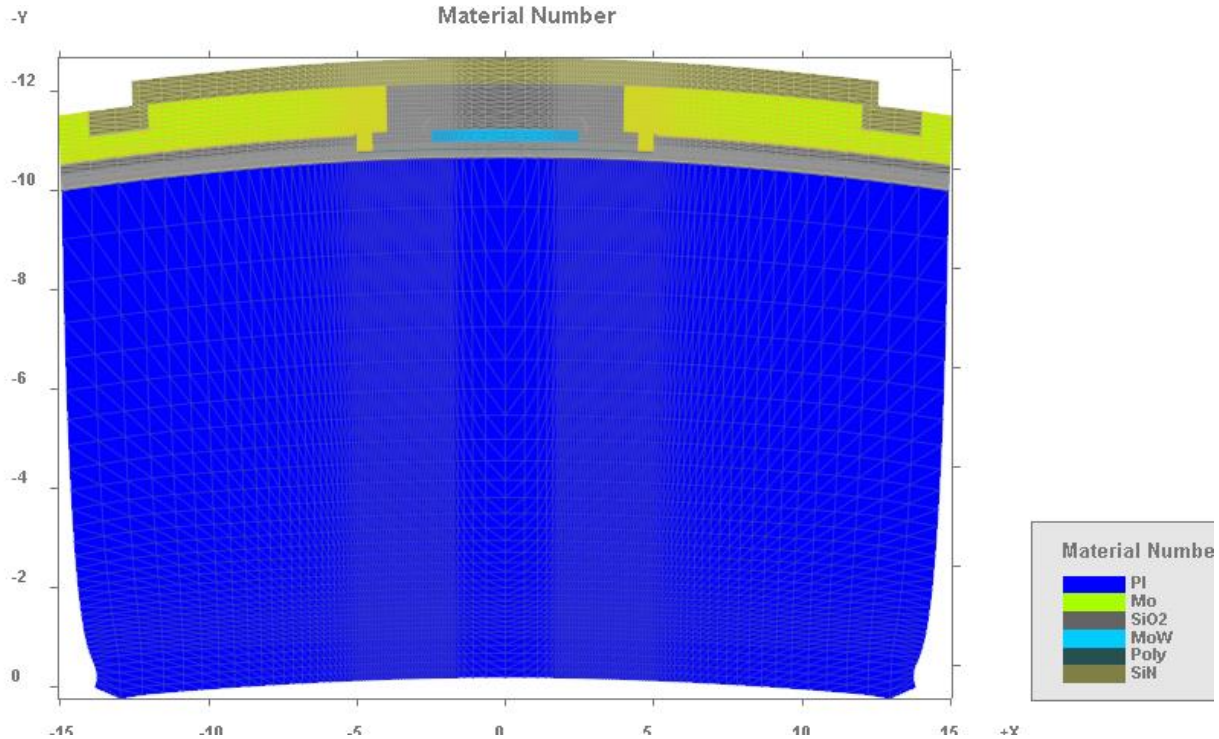
With and Without Bending





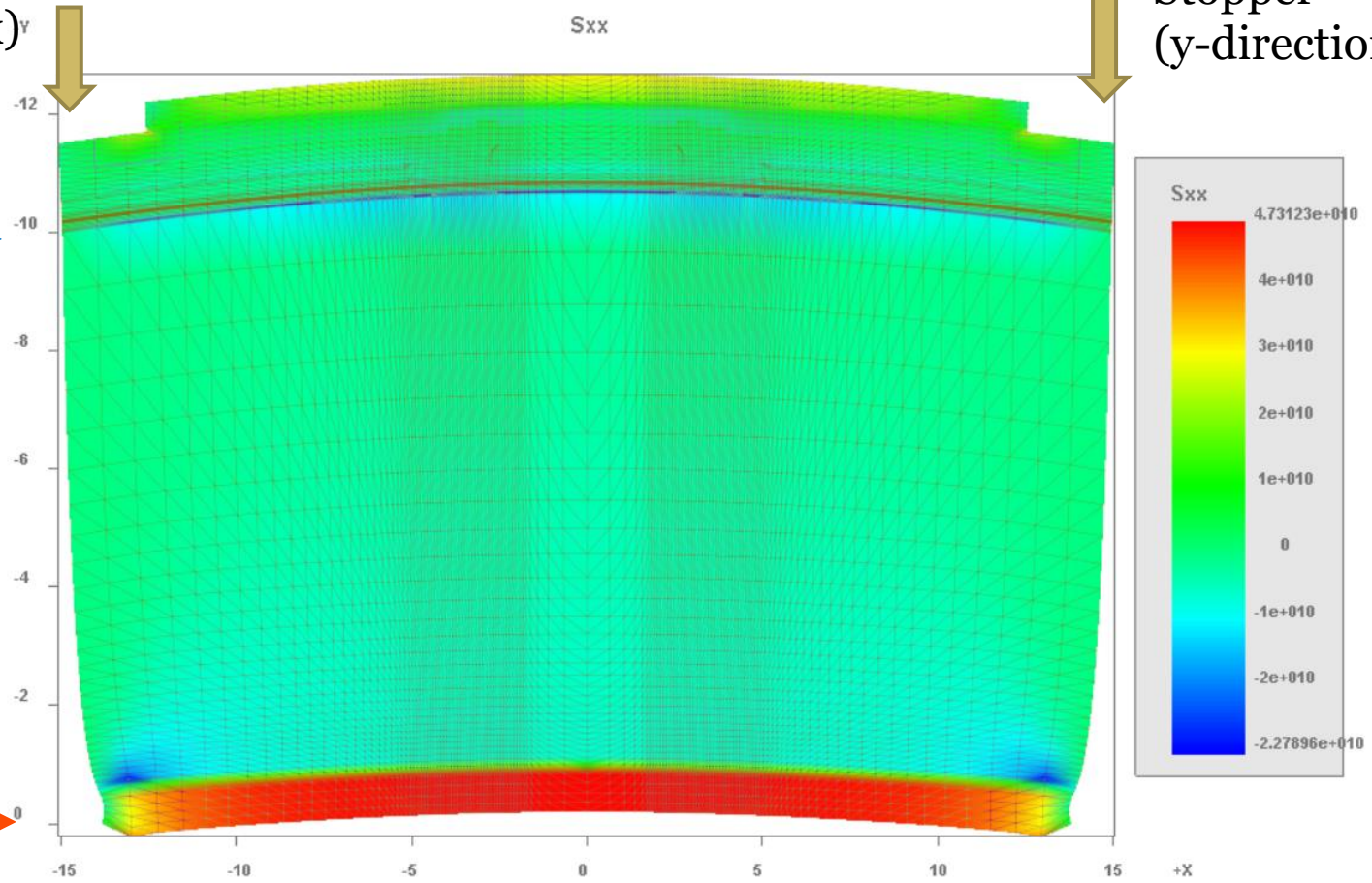
Stress Distribution

Stopper
(y-direction fix)

Stopper
(y-direction fix)

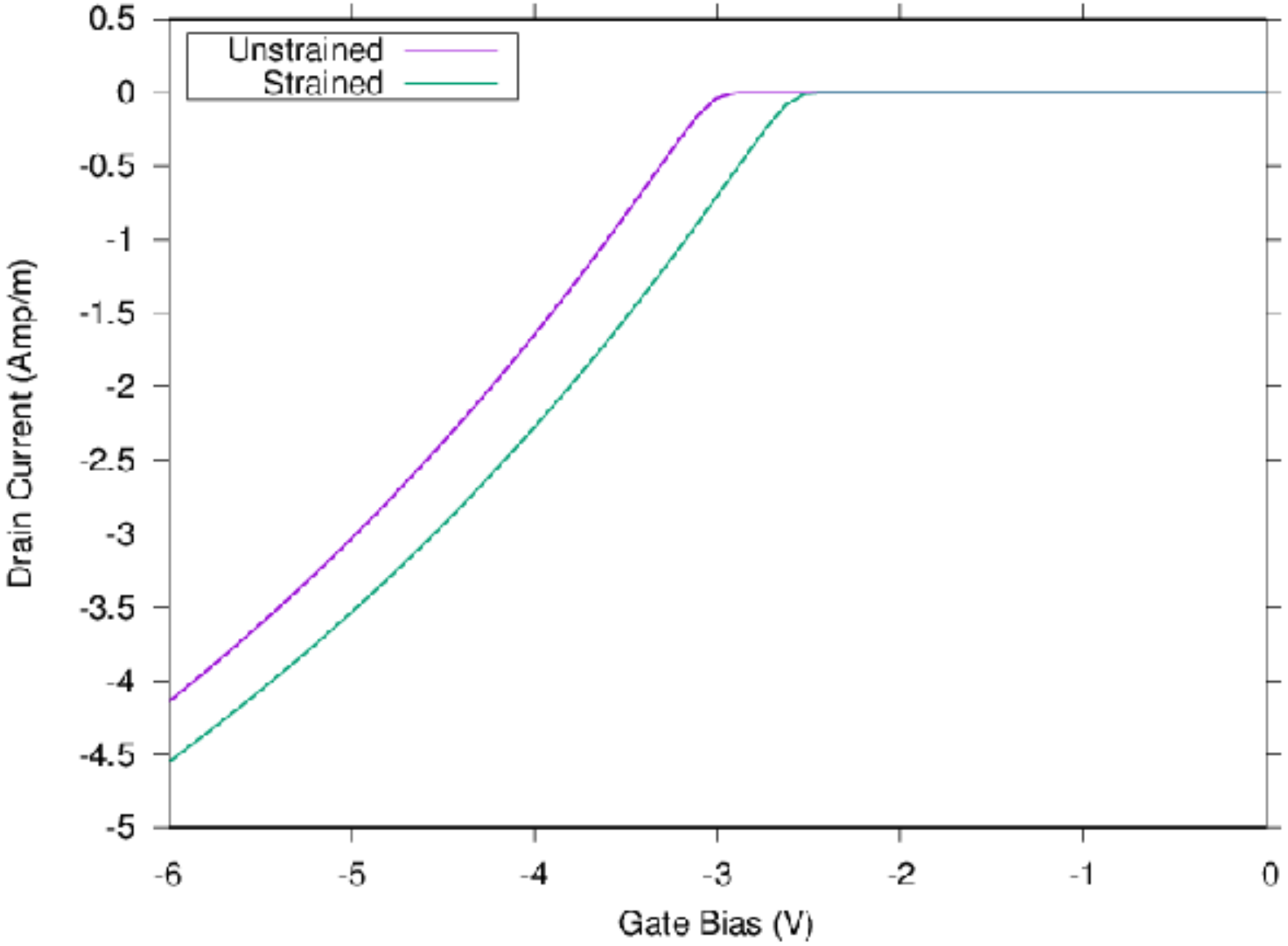
Tensile
Stress
(negative Sxx)

Compressive
Stress
(positive Sxx)



External pressure

Shift of Threshold Voltage



Summary

- Crosslight provides convenient TCAD tools for simulating stress effects in TFT

- While stress computation is relatively straightforward, the exact mechanism for Vt shift may be more complicated

- Stress induced gate work function shift, charged traps generation, doping deactivation can all be factor(s) and Crosslight TCAD can be a useful tool for analysis and design

Thanks for your attention!

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