Bias Temperature Stress (BTS) and D_2O

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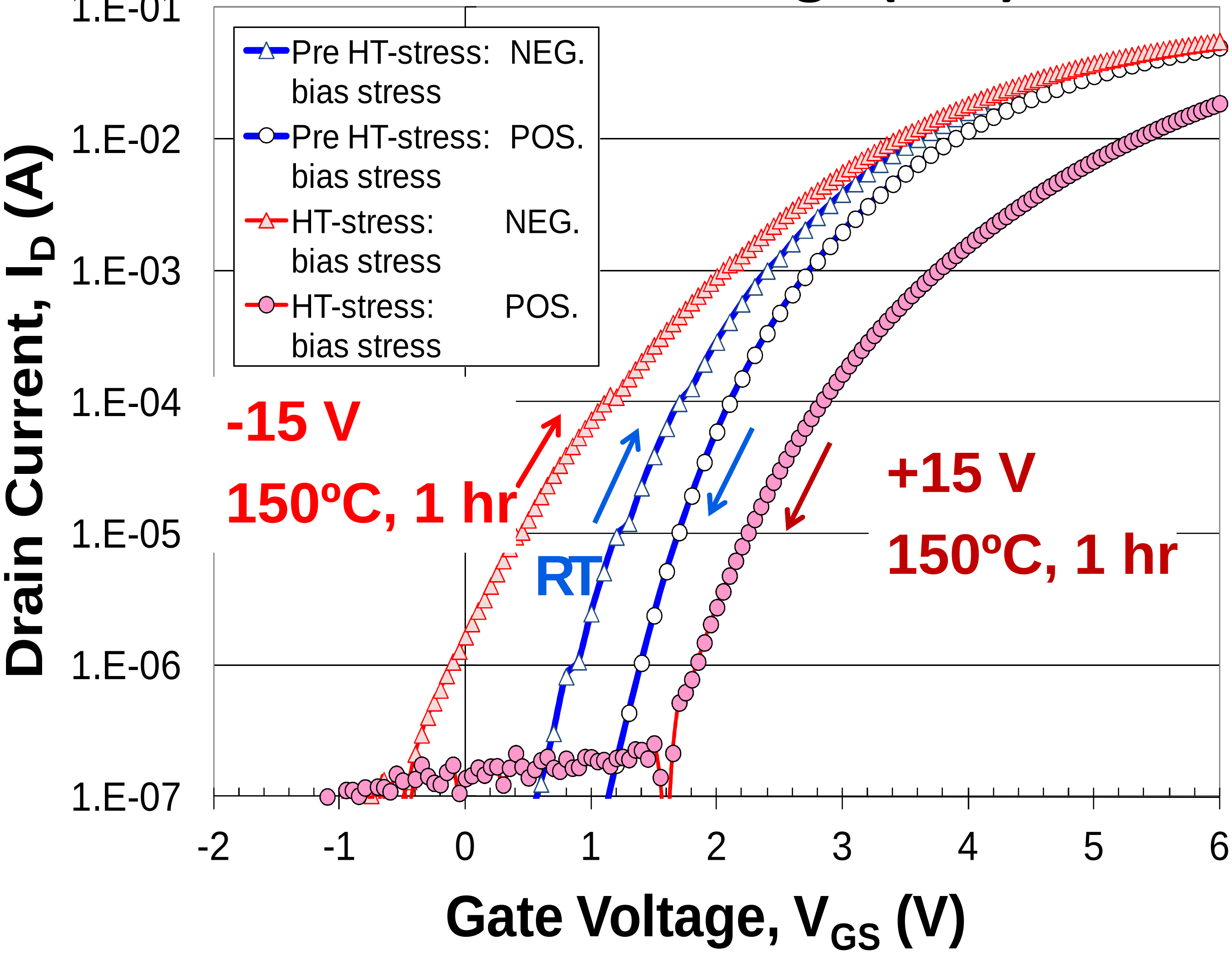
Bias Temperature Stress (BTS)

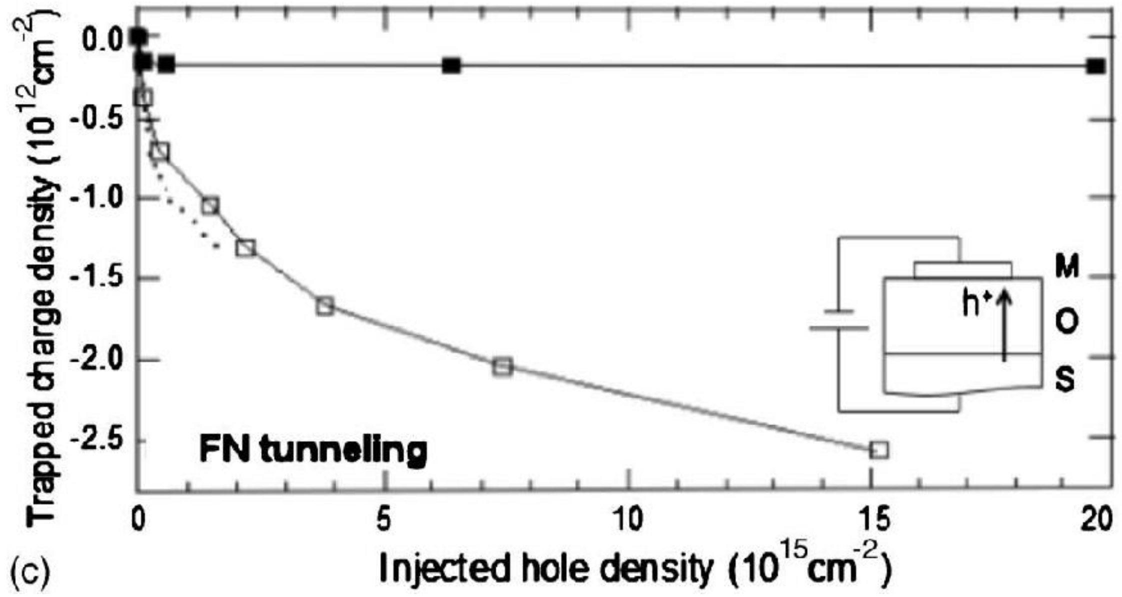
- Holding the device at high temp and high voltage for some time and then re-exam characteristics.
- Standard test used in the MOS community.
- Although not understood in detail, the combination of high voltage and high temperature allows defects/traps to be populated.
- Most importantly it is a standard device reliability test.

Bias and temperature-induced instability (BTI) of threshold voltage (Vth)



A.J. Lelis, et al., ECS Transactions, Vols. 58:4, 87 (2013).

Nitridation leads to electron immunity and increases hole trapping

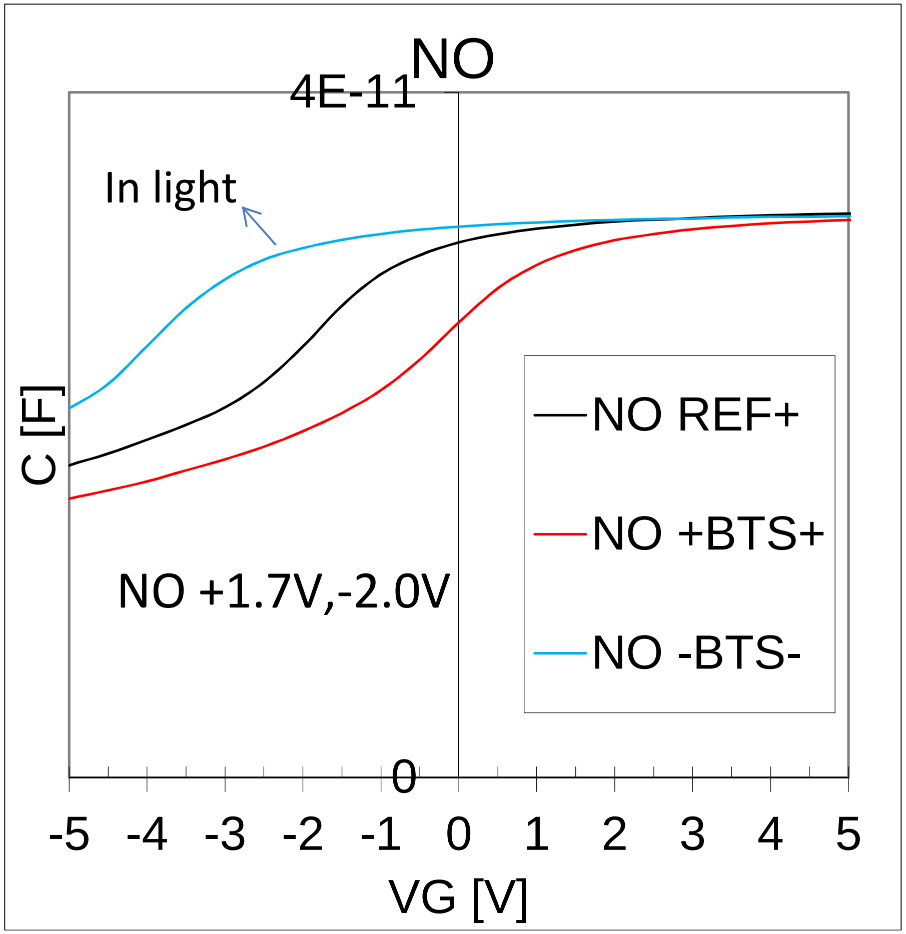


- Electron Spin Resonance (ESR) shows
- NO annealing reduces the number of *E'* centers (oxygen vacancy) in oxides
- Maybe interface SiO_xN_y

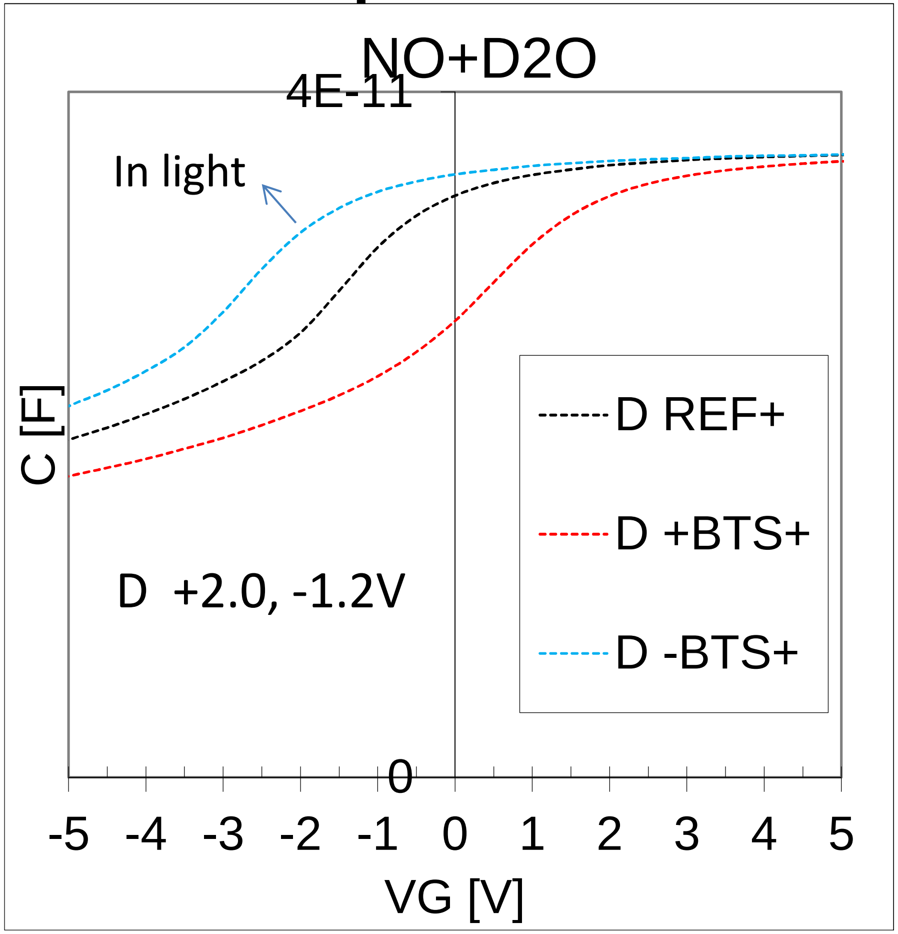
Rozen et al. J. Appl. Phys. 103, 124513 ,2008
Rozen et al. JAP 105, 124506 (2009);

- In order to obtain more insights into the BTS mechanisms, we have employed BTS on various MOSCAPs, varying crystal face and interface treatments.
- All NO annealed.
- D_2O exposure.

On Si-face, D reduces holes traps and increases electron traps



NO +1.7V,-2.0V



D +2.0, -1.2V

SiO2 200nm, 15V 150°C BTS
CV 40V to -40V 25°C

Electron Traps

Crystal Face	Electron-Trapping density ×10^{10} [cm^{-2}]	Nit ×10^{10} [cm^{-2}] 0.2~0.6eV below E_c	interface D content ×10^{12} [cm^{-2}]
Si-f	18.3	6.8	0
Si-f w/ D	21.6 ⬆	6.8	1.0
a-f	59.9	7.9	0
a-f w/ D	62.9 ⬆	7.9	2.2
C-f	>70.1	20	0
C-f w/ D	>70.1 ?	20	16

During PBTS, Electron trappings in the near interface oxide,

- Increases with D_2O exposure.
- Increases with near conduction band D_{it}.

All NO annealed
In darkness, E=+0.75MV/cm, 150°C BTS

Hole Traps

Crystal Face	Hole-Trapping density ×10^{10} [cm^{-2}]	interface D content ×10^{12} [cm^{-2}]
Si-f	21.6	0
Si-f w/ D	12.9 ⬇	1.0
a-f	<0.1	0
a-f w/ D	<0.1	2.2
C-f	5.4	0
C-f w/ D	3.2 ⬇	16

During PBTS, Hole trappings in the near interface oxide,
- Decreases with D_2O exposure.

All NO annealed
E=-0.75MV/cm, 150°C BTS, no shift in Darkness,
1min light exposure during BTS was used to generate holes for trapping.

Conclusions

- D reduces holes traps and increases electron traps
  - Possibly OH alters N related hole trap to electron traps
- D_{it} near E_c increases Electron trapping in BTS
  - Interface defect levels aligned to oxide defect levels
  - Enhance e tunneling
- a-face with NO intrinsically has very low hole trappings, but very large electron trappings.