TER effect modulated by interface band profile engineering

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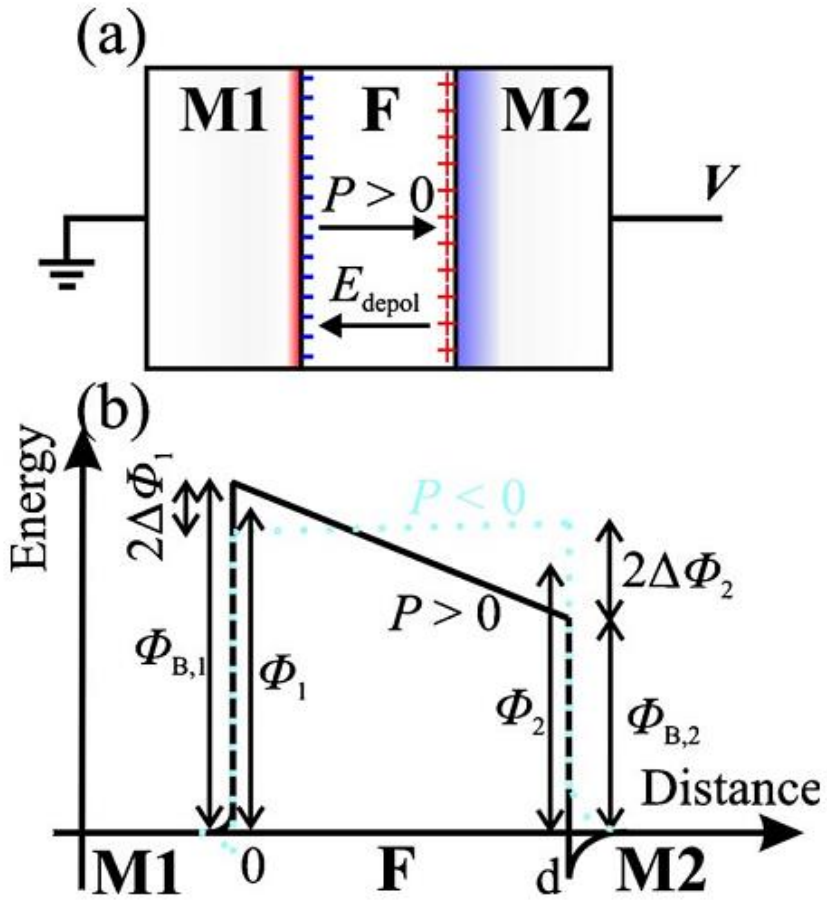
06/16/2017

Prof. Xu’s group meeting

Normal ferroelectric tunnel junction



$$w = \sqrt{\frac{2\varepsilon_0\varepsilon_{\text{stat}}(V + V'_{bi})}{eN_{\text{eff}}}}$$

Barrier thickness ≤ *2w*

$$\Delta\Phi_i = \frac{l_i Q_s}{\varepsilon_0\varepsilon_{\text{M},i}} e, \quad i = 1,2$$

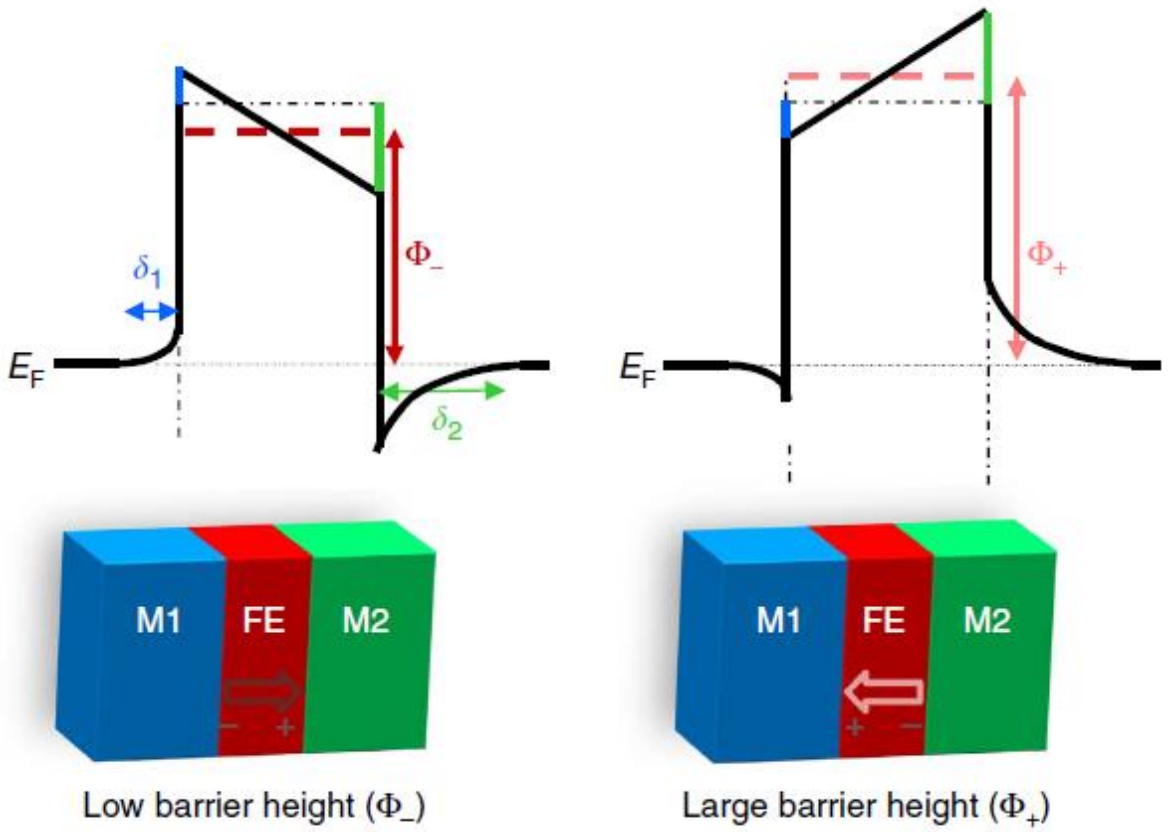
$$E_{\text{depol}} = -\frac{(P - Q_s)}{\varepsilon_0\varepsilon_{\text{stat}}}$$

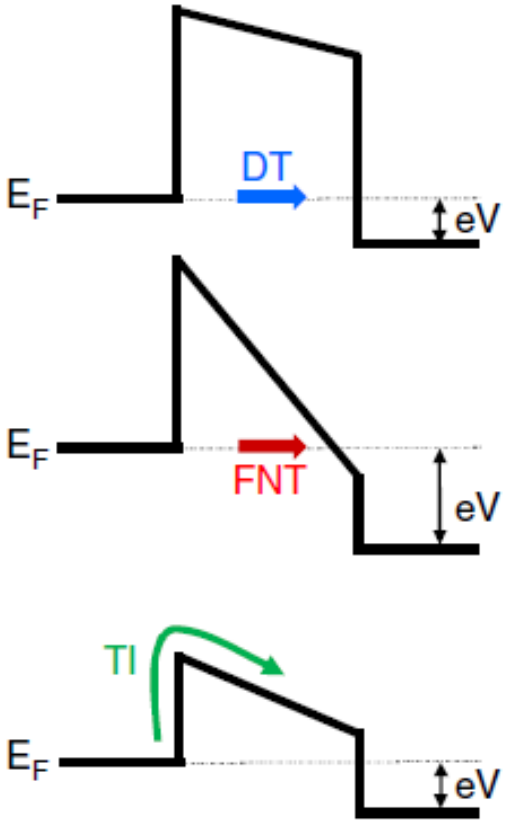
$$Q_s = \frac{Pd}{\varepsilon_{\text{stat}}\left(\frac{l_1}{\varepsilon_{\text{M},1}} + \frac{l_2}{\varepsilon_{\text{M},2}}\right) + d}$$

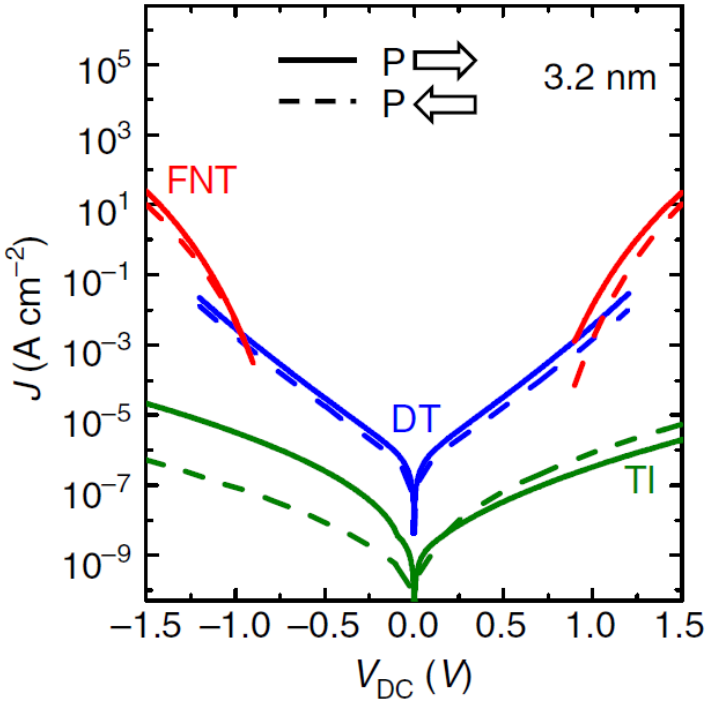
Asymmetric screening charge will affect the band structure.

Zhuravlev, et. al. PRL 94, 246802 (2005)

Normal ferroelectric tunnel junction







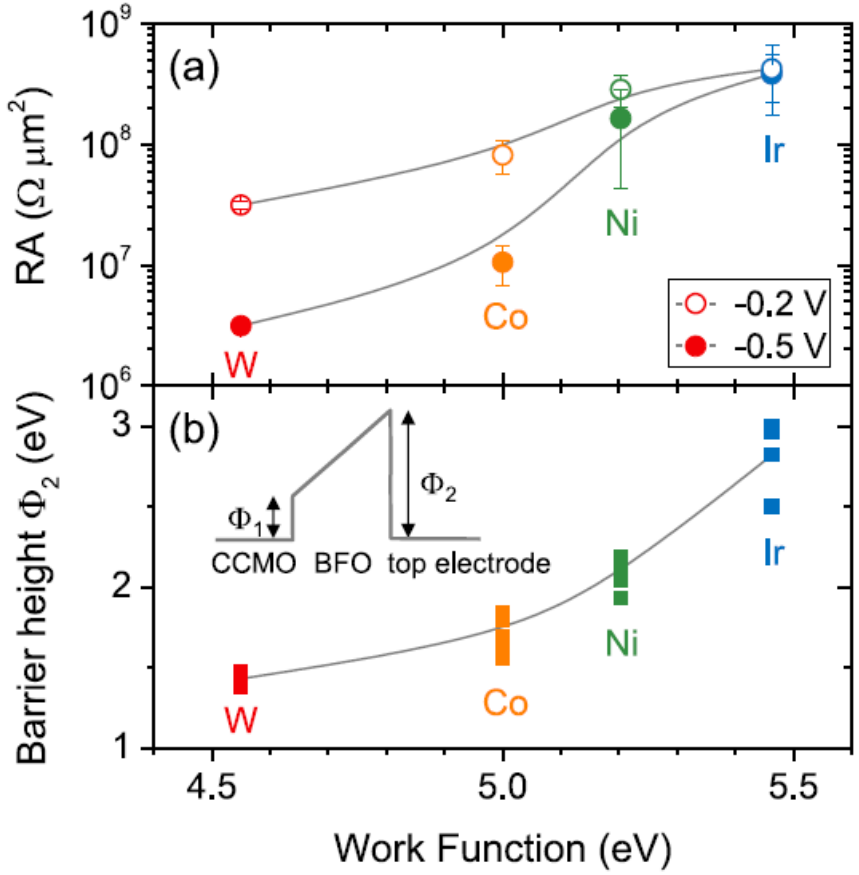
FE reversal changes screening charge type.

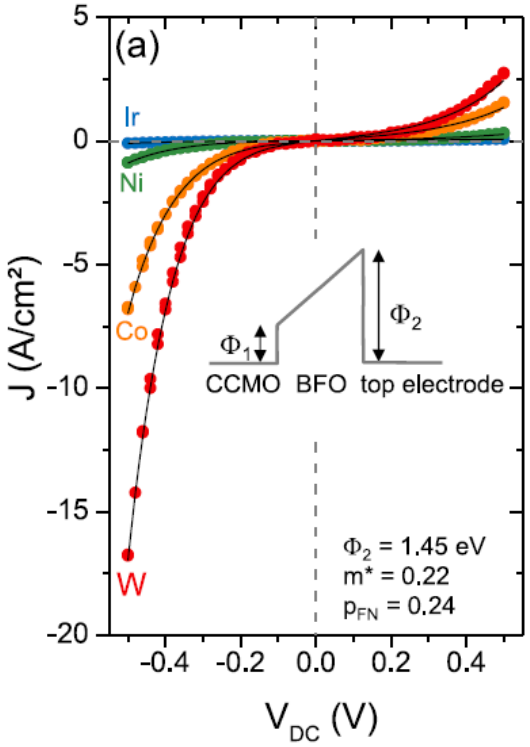
Different transport mechanisms through a junction barrier.

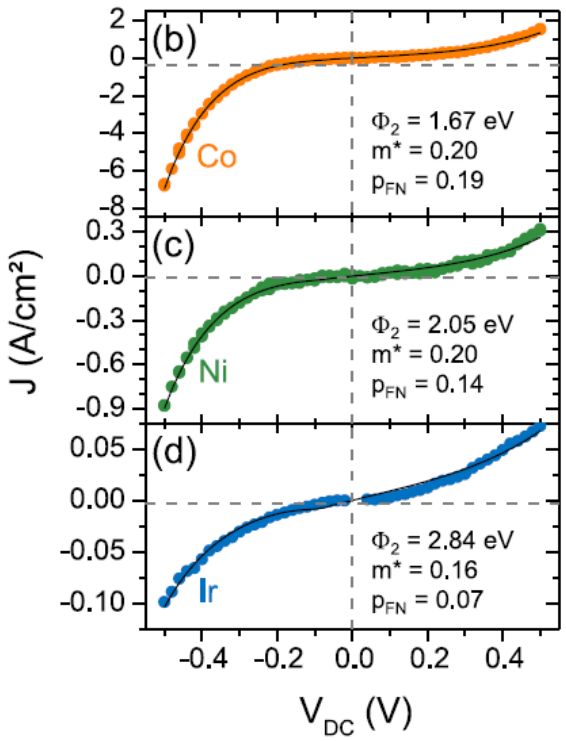
Zhuravlev, et. al. PRL 94, 246802 (2005)

Pantel, et. al. PRB 82, 134105 (2010)

FTJ with different metal electrodes





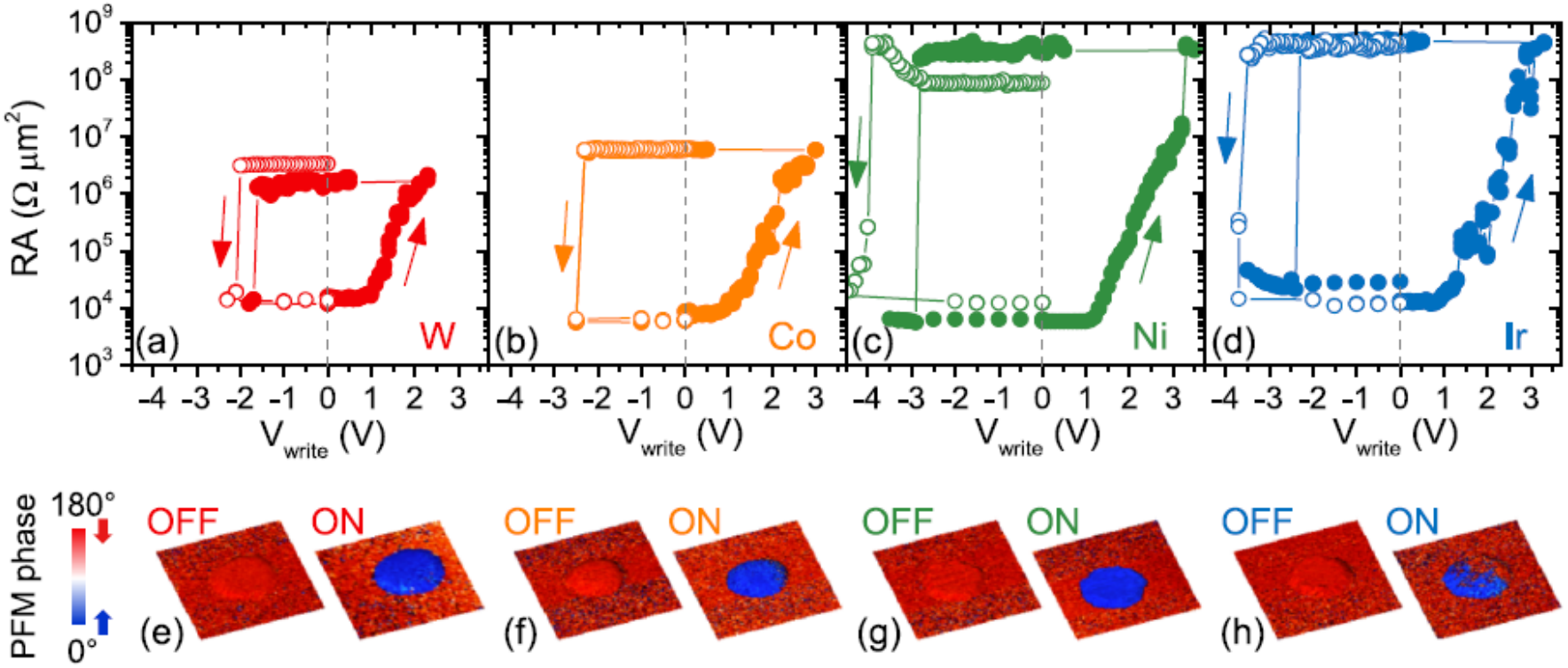


$$J = J_{DT} + p_{FN} \times J_{FN}$$

Electrodes with different work functions. Negative bias favors FN tunneling.

Boyn, et. al. APL Mater. 3, 061101 (2015)

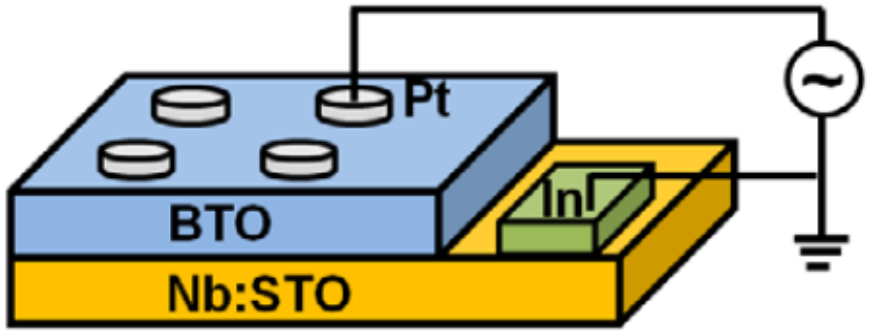
FTJ with different metal electrodes



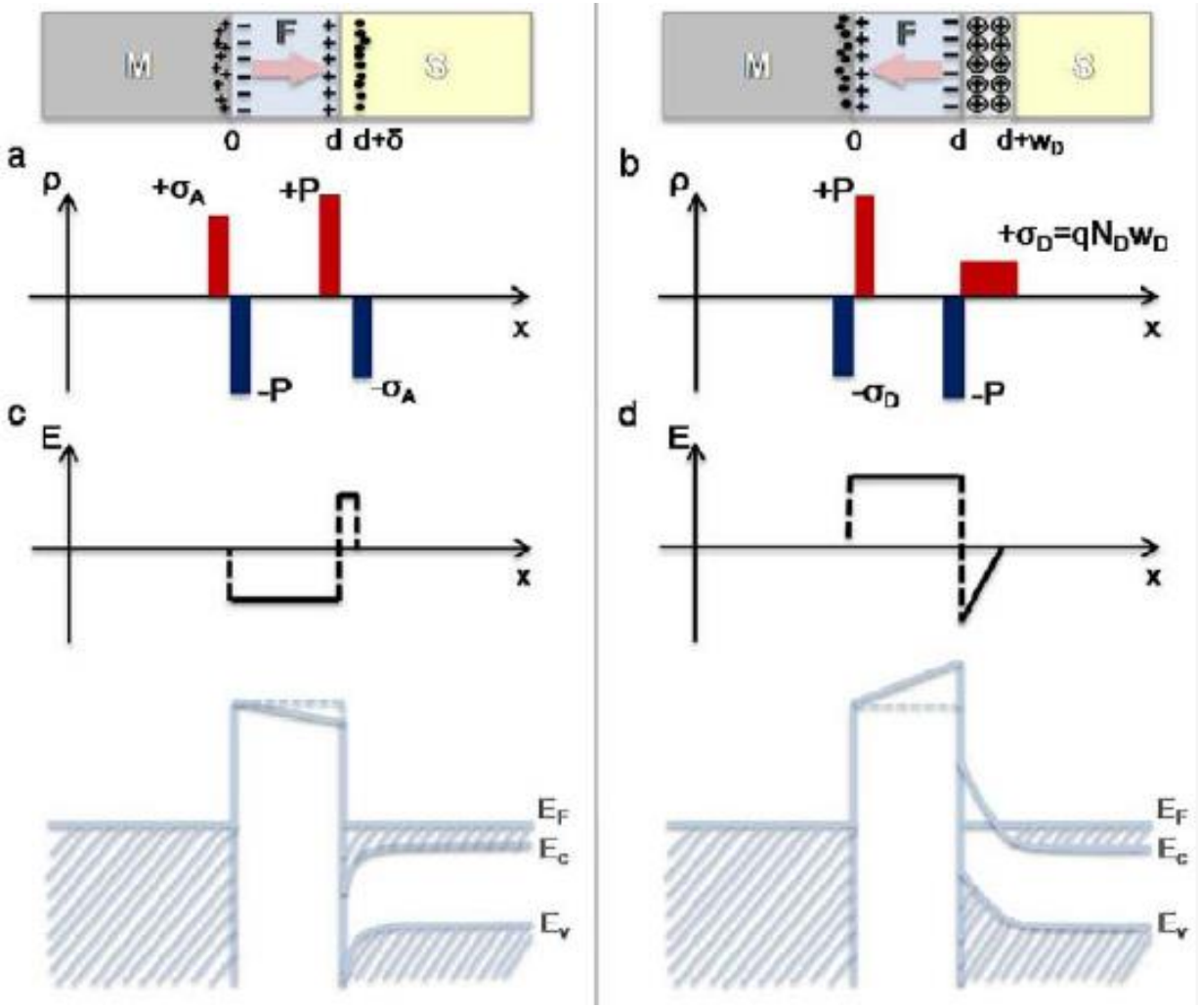
Typical TER values vary from 200 for W to 20 000 for Ir. This variation is mainly due to the large increase of the OFF state resistance with the TE work function as the ON state resistance does not show a clear trend.

Boyn, et. al. APL Mater. 3, 061101 (2015)

FTJ with semiconducting electrode

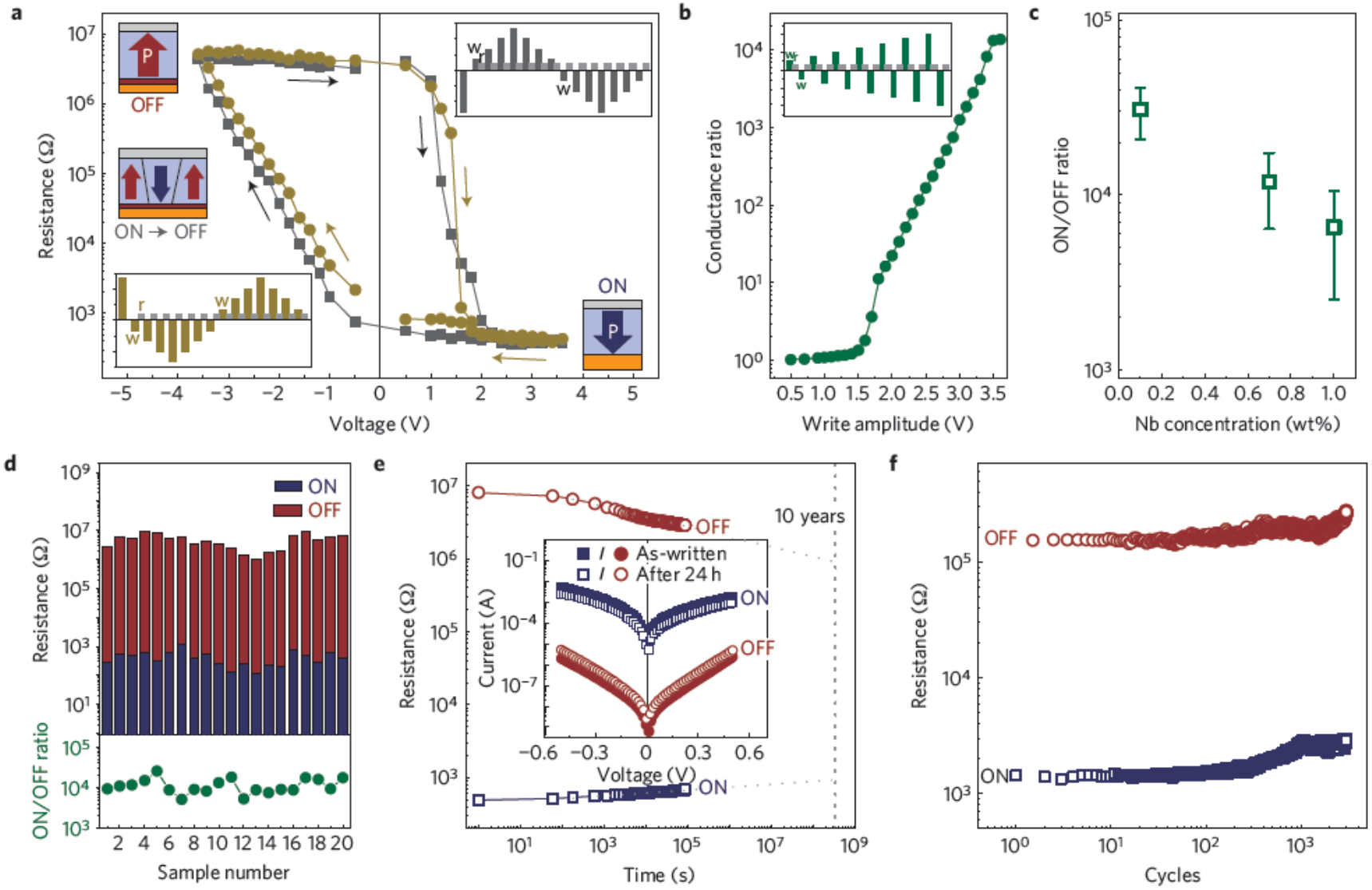


Semiconducting electrode with FE controlled depletion layer.



Wen, et. al. Nat. Mater. 12, 617 (2013)

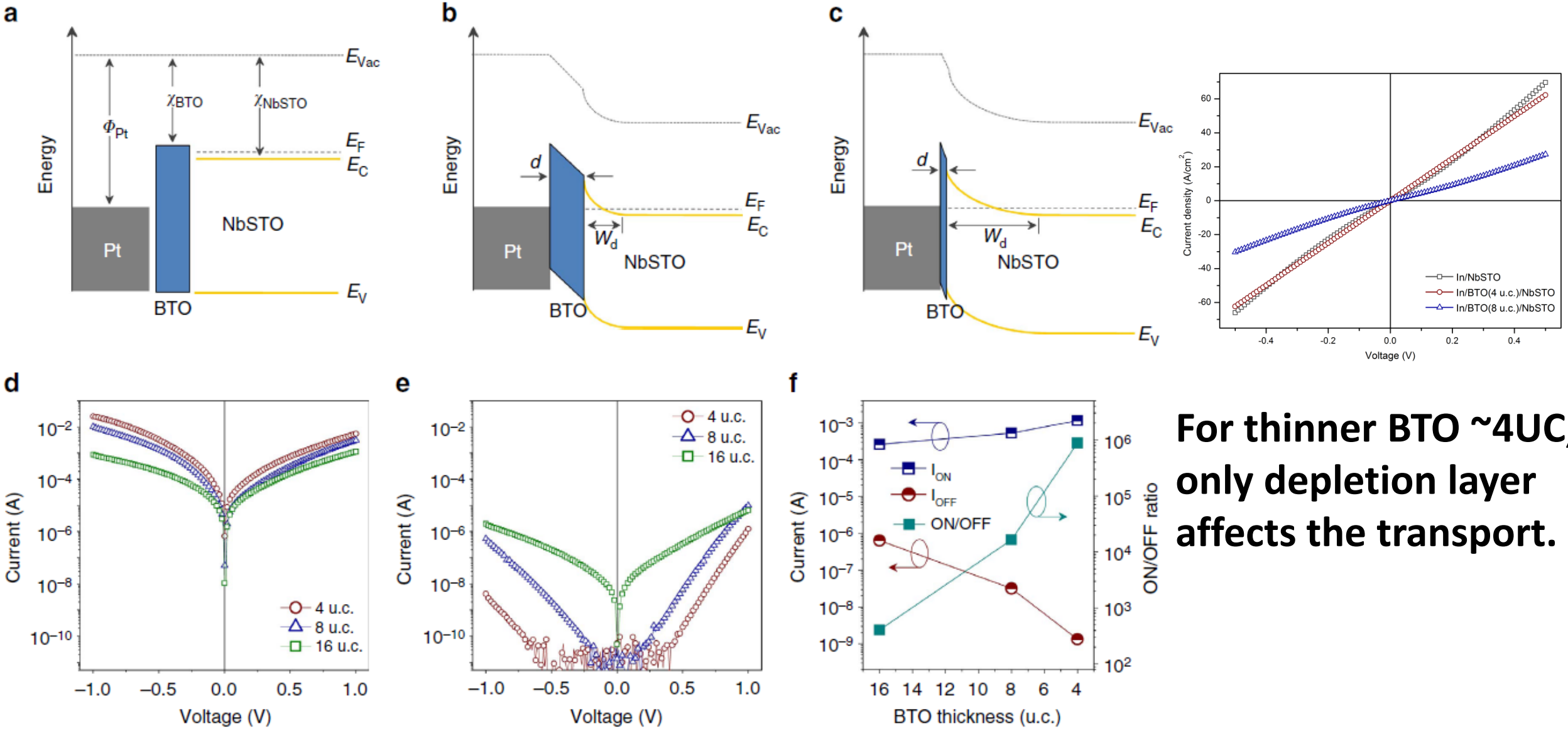
FTJ with semiconducting electrode



Wen, et. al. Nat. Mater. 12, 617 (2013)

TER is enhanced by SE electrode.

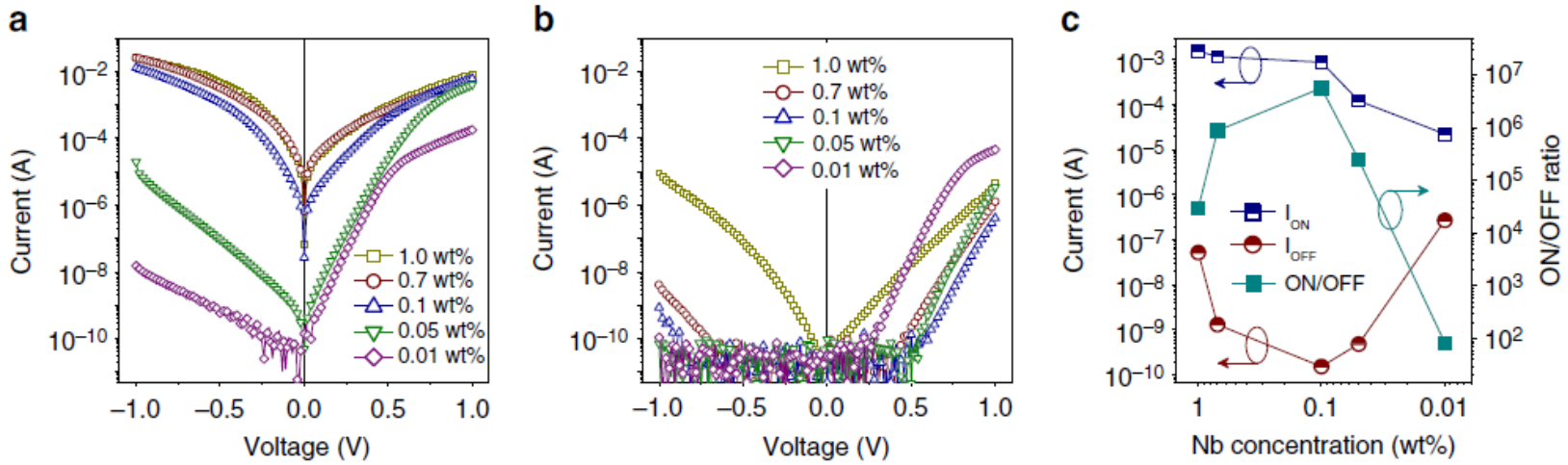
FTJ with semiconducting electrode

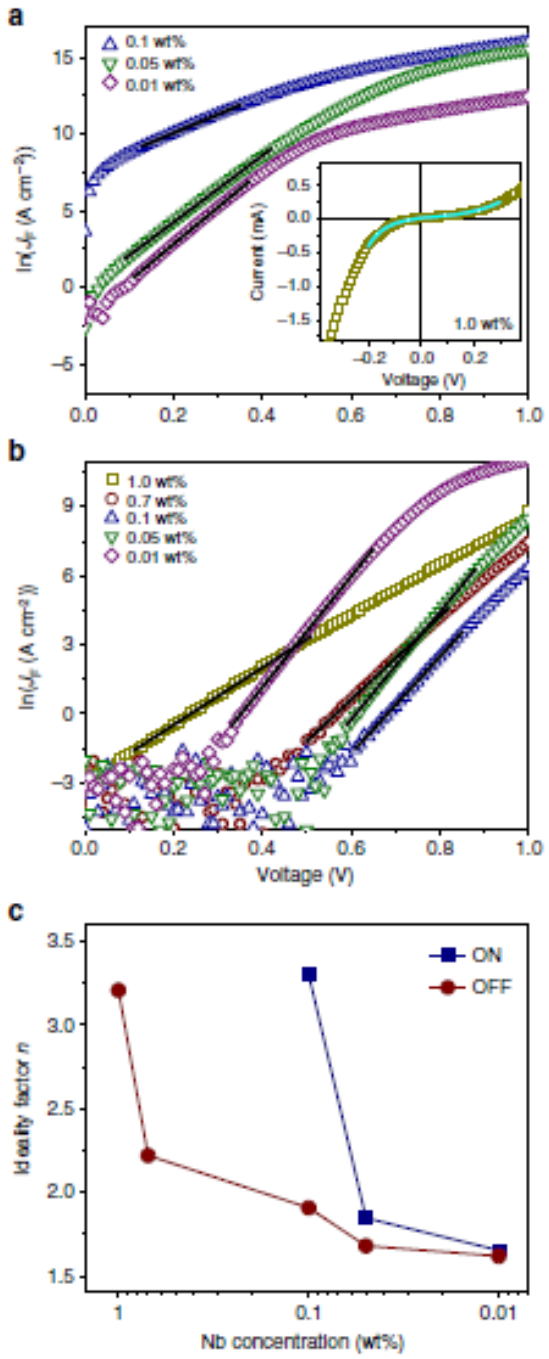


For thinner BTO ~4UC, only depletion layer affects the transport.

Xi, et. al. Nat. Commun. 8, 15217 (2017)

FTJ with semiconducting electrode





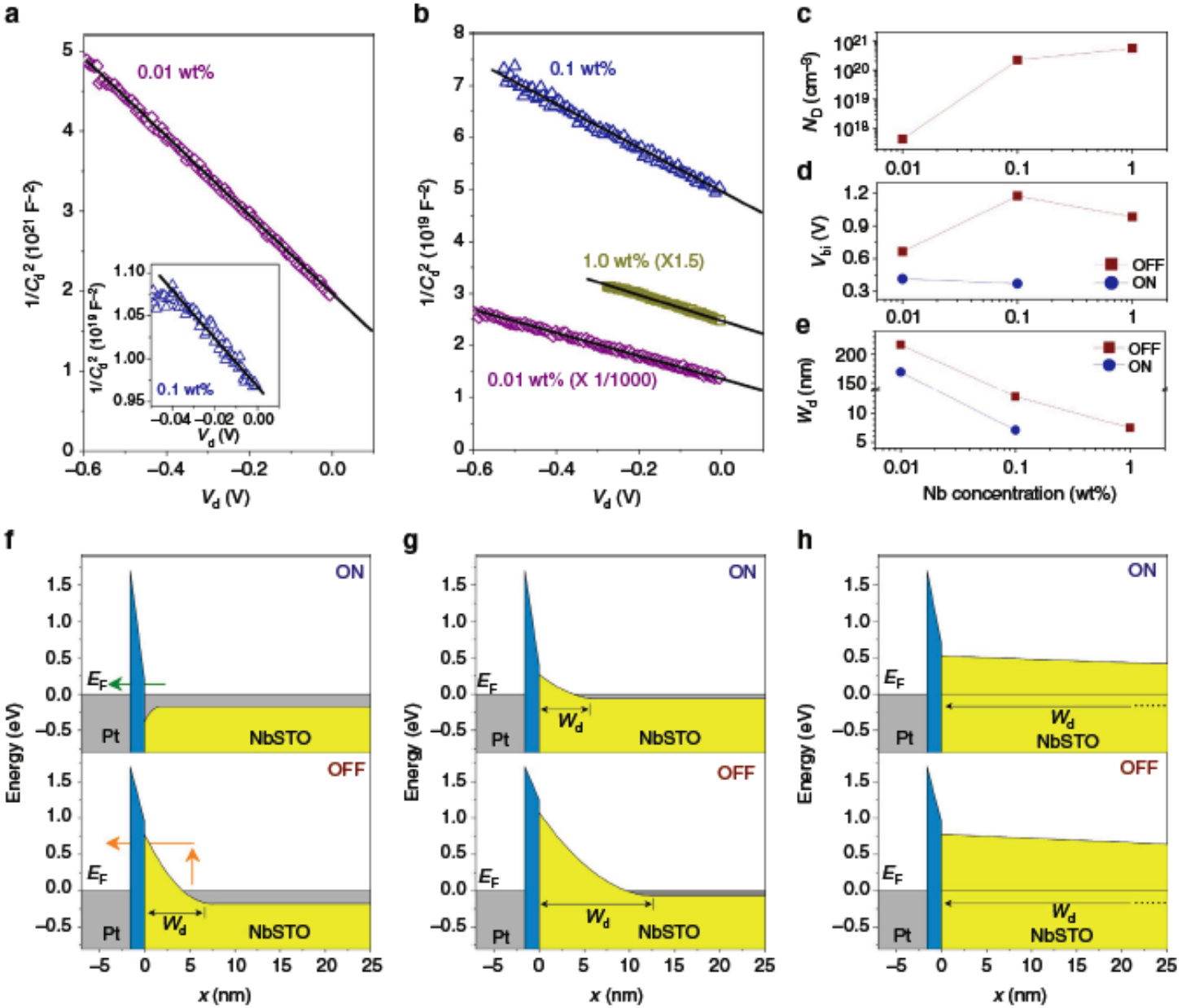
Doping level in NSTO affects TER as well.

DT for 1wt% FTJ; TI for lightly doped FTJ at OFF state.

Xi, et. al. Nat. Commun. 8, 15217 (2017)

FTJ with semiconducting electrode

Capacitance measurement shows the structure of the band.



Xi, et. al. Nat. Commun. 8, 15217 (2017)