



FUNCTIONALITY AND APPLICATION OF DOUBLE-GATE TRANSISTORS

JACOB YANG

ECE 3450

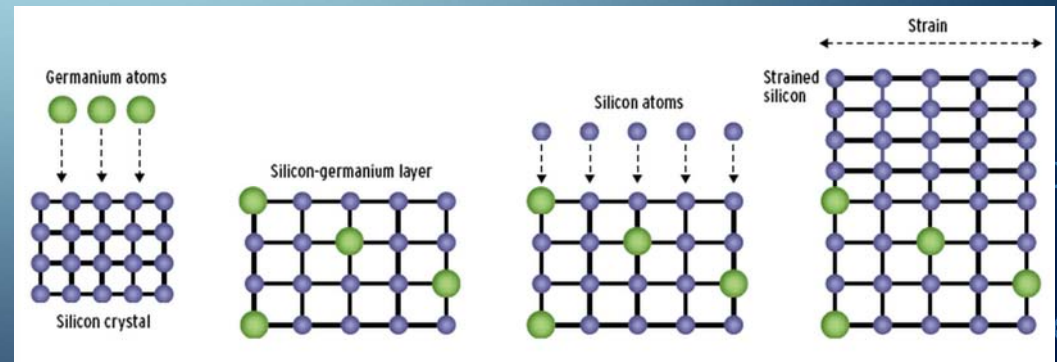
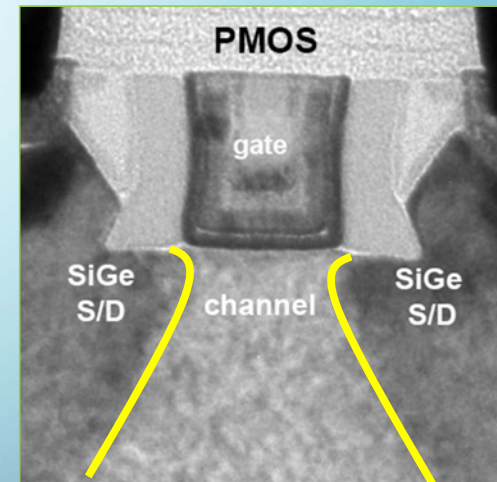
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OVERVIEW

- Straining Silicon in MOSFET
 - Problem
- Double-Gate Solution
- Double-Gate Devices
 - FinFET
 - Other devices
- Questions

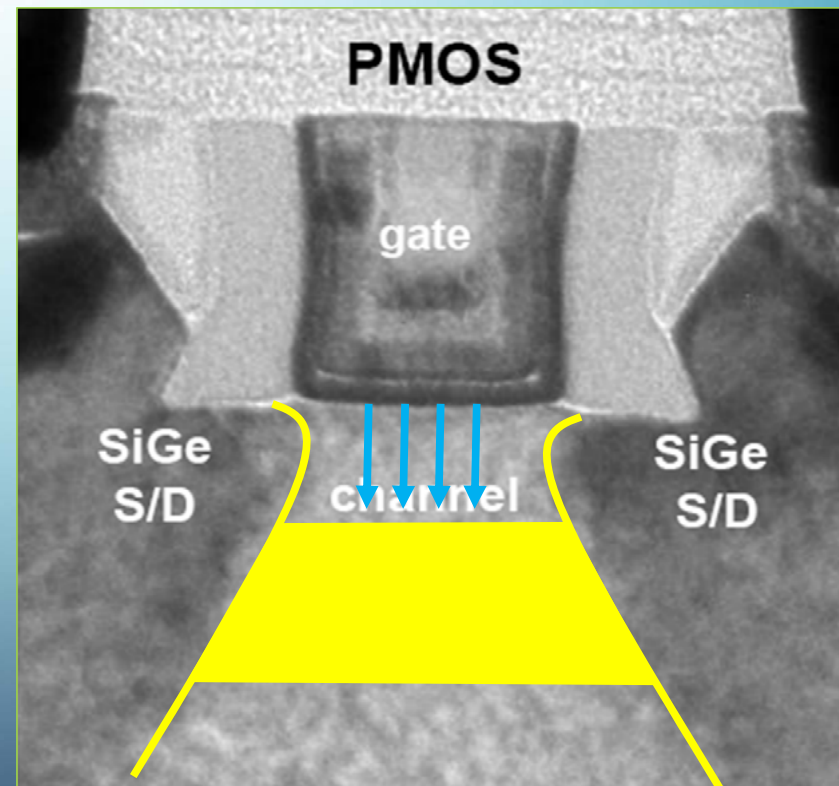
STRAINING SILICON IN MOSFET

- Because of relatively large effective mass of silicon, mobility of the silicon substrate is low
- Straining is used to increase electron and hole mobility.
 - Layer of Germanium is laid onto Silicon crystal
 - As the atoms align, spacing in this layer is expanded
 - More Si are added onto this “strained” SiGe material (greater lattice constant, reduced atomic density, higher mobility)
- Straining leads to distinct shape between the Source and Drain



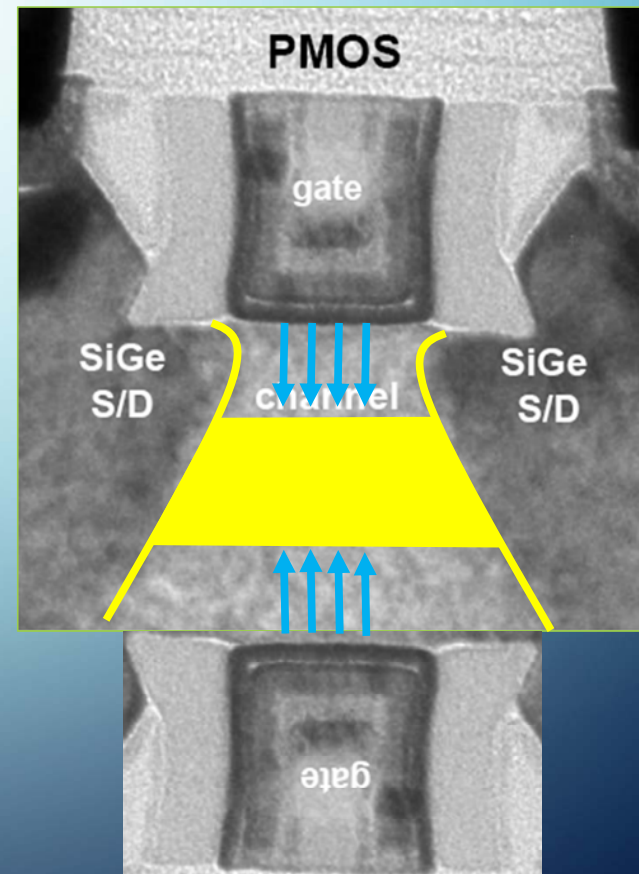
PROBLEM

- Shape of the straining makes cutoff mode more difficult to obtain
- Gate voltage has to be stronger



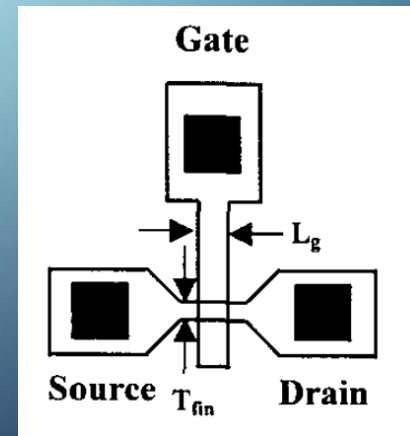
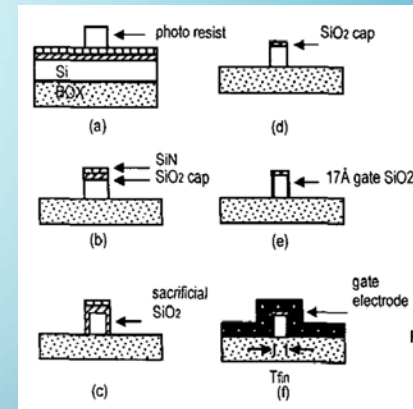
DOUBLE GATE SOLUTION

- Having two gates allow much more control over the on and off states of a transistor
- Leakage current is greatly reduced
- Combining use of high-K dielectrics and strained silicon, double-gate transistors allow for an even faster transistor



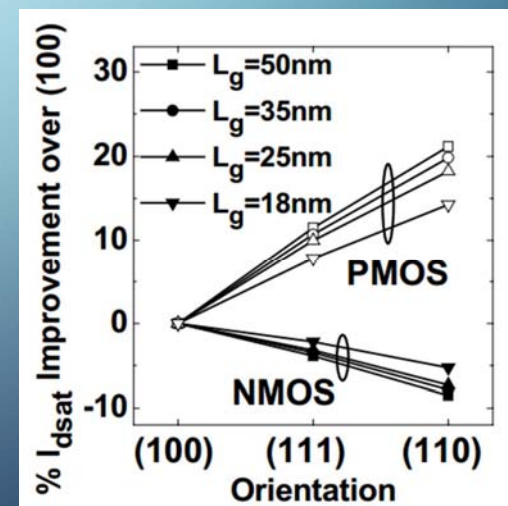
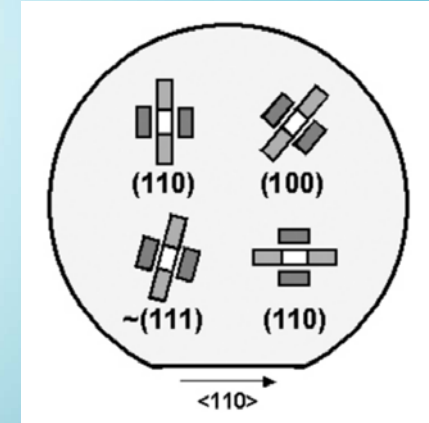
FINFET DEVICE

- SOI (Silicon-on-insulator) is etched to create a thin vertical fin (serves as the channel of device).
- Source and Drain nodes are added later
- Gate is wrapped around the channel, forming Ω -like shape
- Fabrication overall is the biggest challenge to FinFET devices (Fin height and pitch)



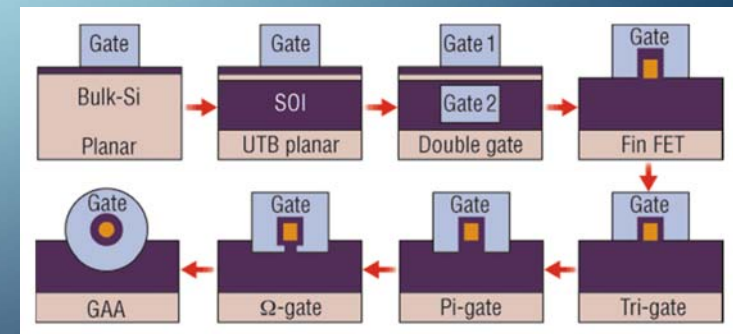
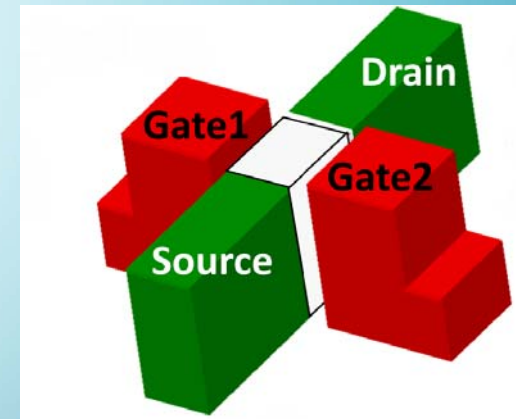
FINFET DEVICE (CONT.)

- Unlike most CMOS devices, which are fabricated in the (100) crystal orientation, FinFET devices are fabricated in the (110) crystal orientation.
- Orientation in the (110) plane causes an increase in hole mobility and decrease in electron mobility.
- As shown in the graph, the mobility improvement of the holes in a p-channel FinFET exceeds the mobility loss of electrons in an n-channel FinFET



OTHER DEVICES

- Back-gated FET
 - A masked etch can be used to separate the electrodes of the gates so they can serve different functions
 - One gate is used for switching modes while the other is used to control V_{TH} .
- GAAFET
 - Effective in reducing SCE due to greatest capacitive coupling between gate and channel





QUESTIONS?

WEBSITES USED

- http://www.eecs.berkeley.edu/~tking/presentations/KingLiu_SOI2012
- <http://egloos.zum.com/star1034/v/2230323>
- <https://books.google.com/books?id=e5k-Q9Ob8rQC&pg=PA363&lpg=PA363&dq=why+does+110+plane+have+higher+hole+mobility+but+lower+electron+mobility&source=bl&ots=iqQsCRPslQ&sig=wvzclfXCyrwdrSztN3NjWgcaVLA&hl=en&sa=X&ei=rM0wVbiwHOTksASh4ICYDw&ved=0CDwQ6AEwBA#v=onepage&q=why%20does%20110%20plane%20have%20higher%20hole%20mobility%20but%20lower%20electron%20mobility&f=false>
- <http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=1175825>
- <http://arxiv.org/ftp/arxiv/papers/1112/1112.3573.pdf>