Total Dose Effects on HfO_2 based Ge MOS capacitors

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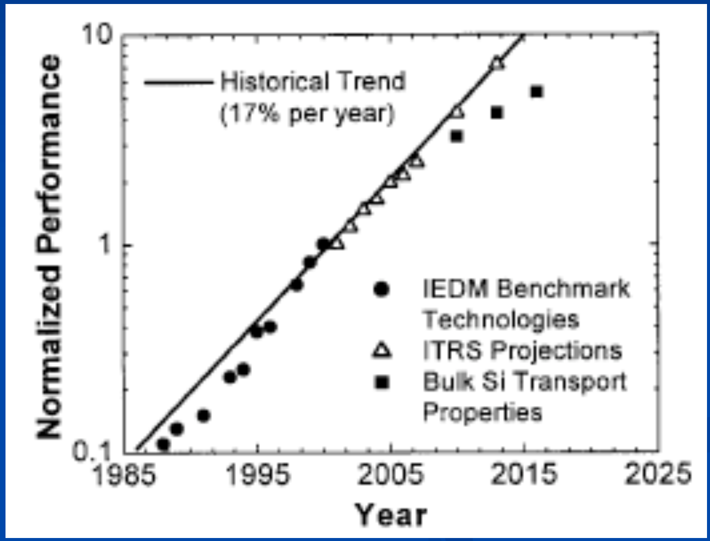
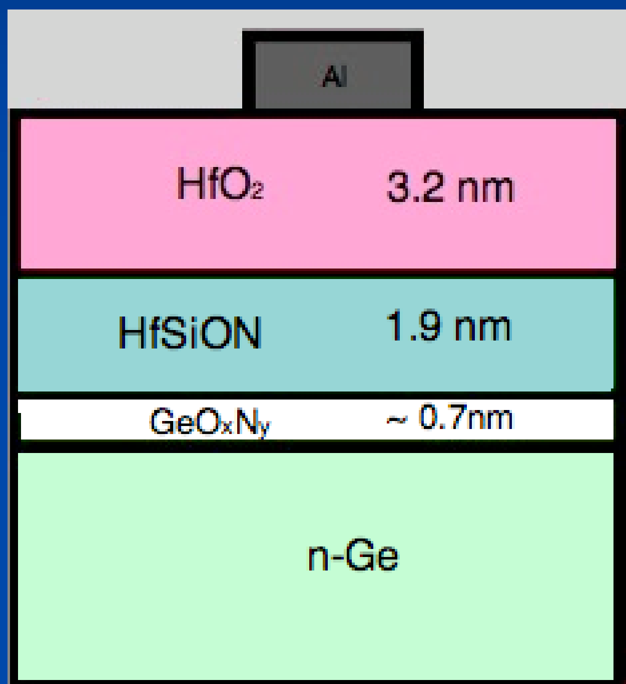
Motivation



- Germanium has higher and more symmetric electron & hole mobilities than Si
- Smaller bandgap
- High-k possible on Ge
- Radiation response

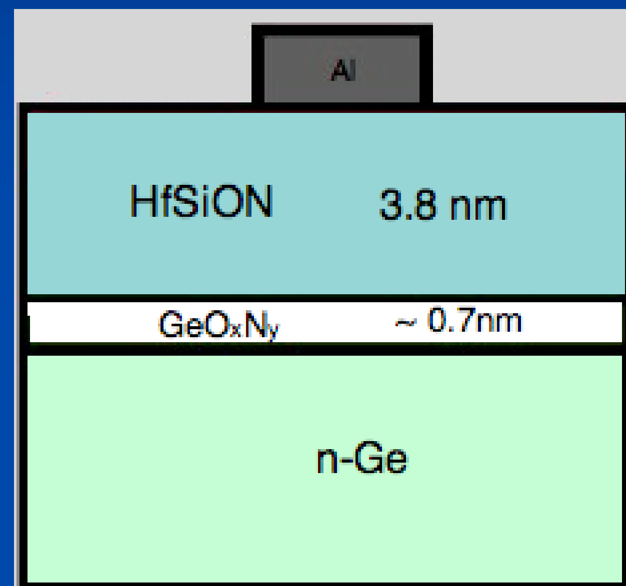
Device details

(with HfO_2)



HfO_2/HfSiON/Ge

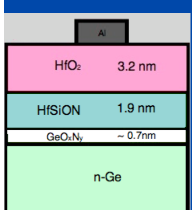
- Higher C_{ox}

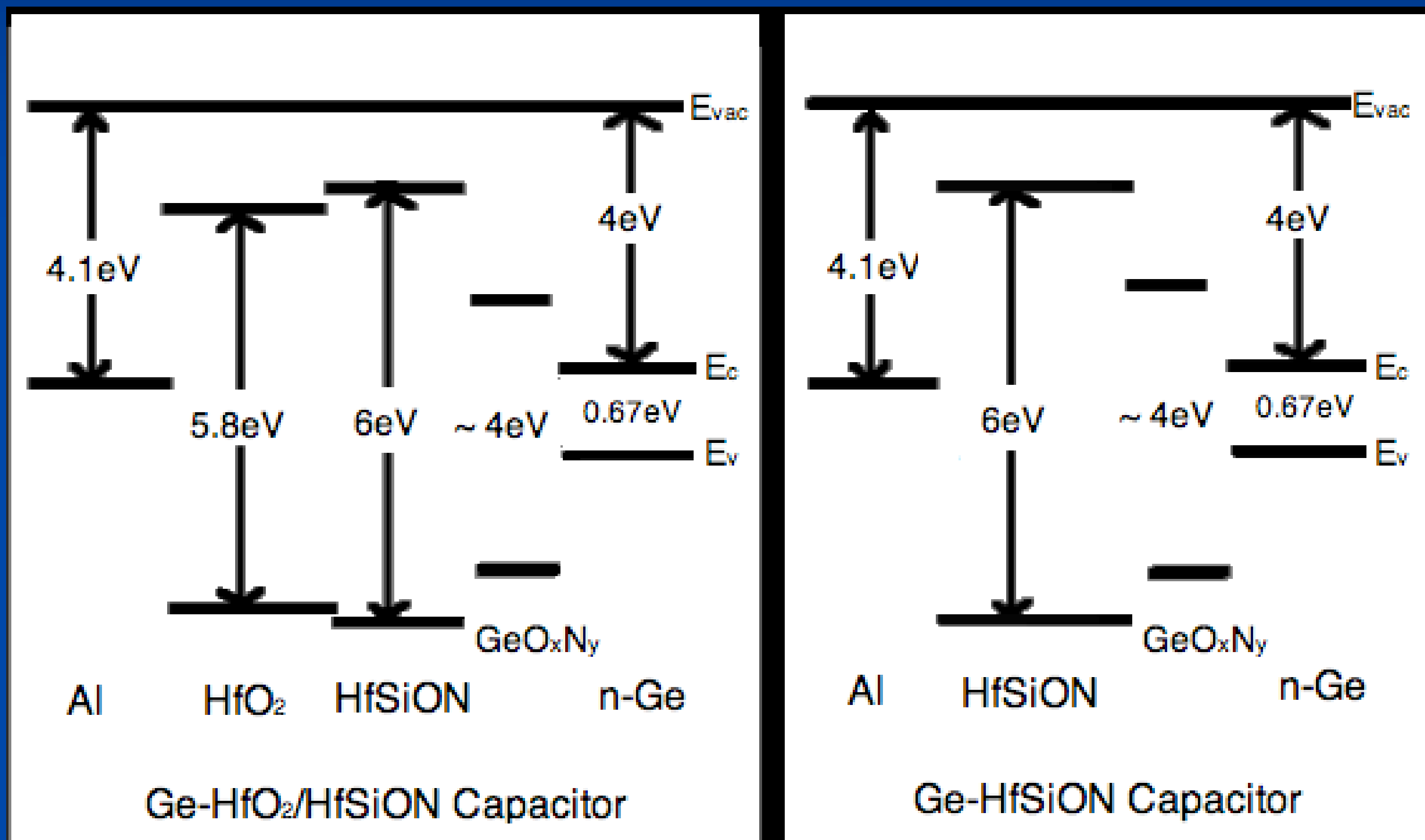


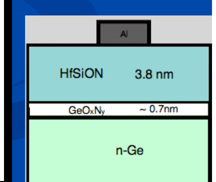
HfSiON/Ge

- Smaller C_{ox}
- Better radiation response

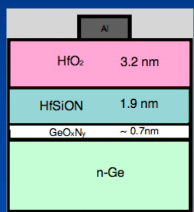
Energy Band Diagram



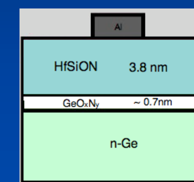


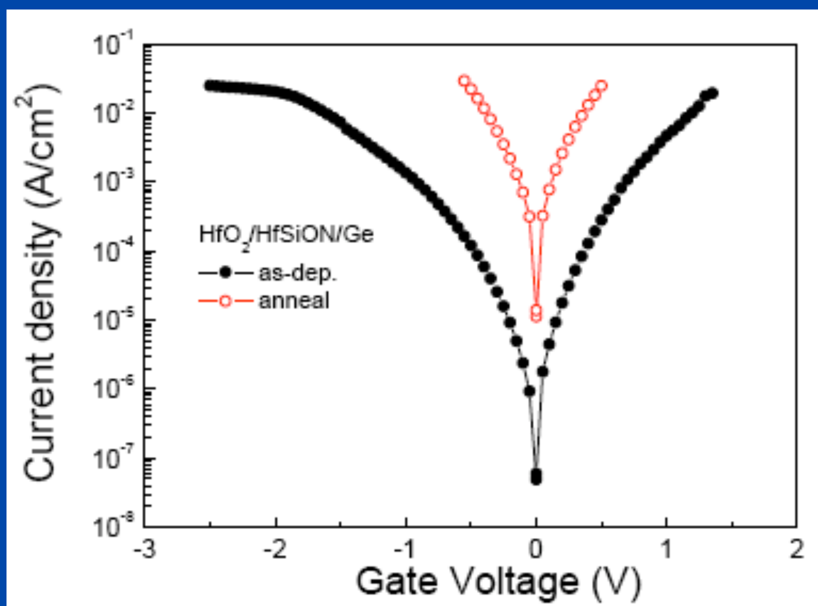


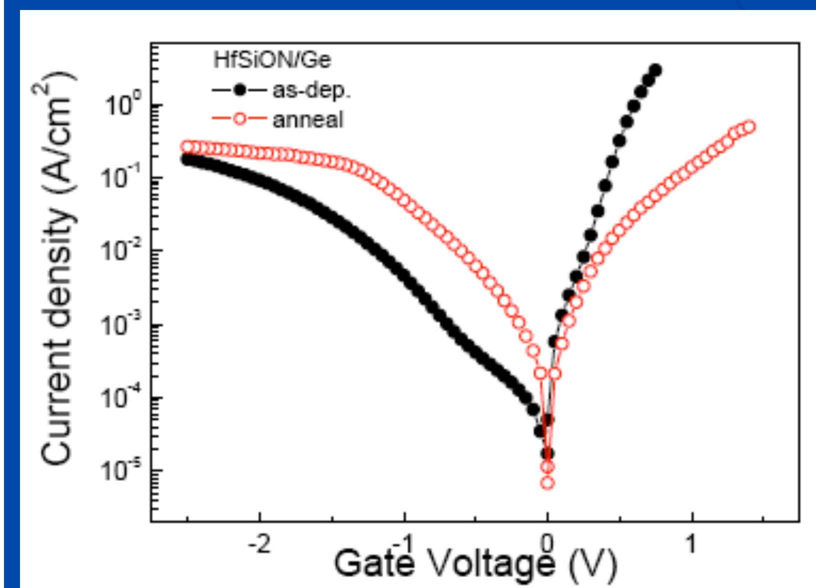
Gate Currents



(with HfO_2)

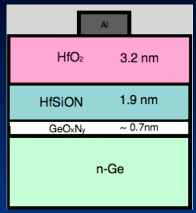




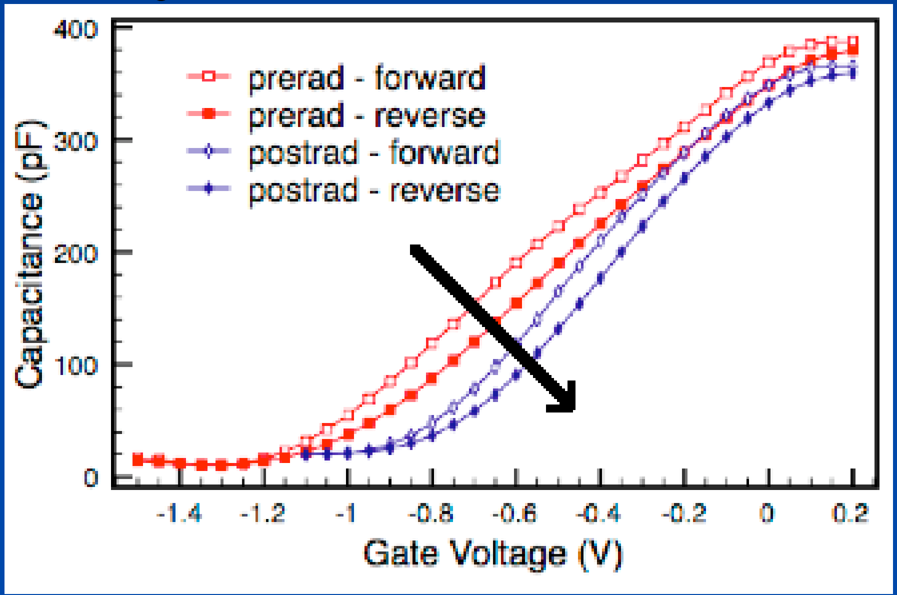


Problem of leakage currents in Germanium devices

Radiation results

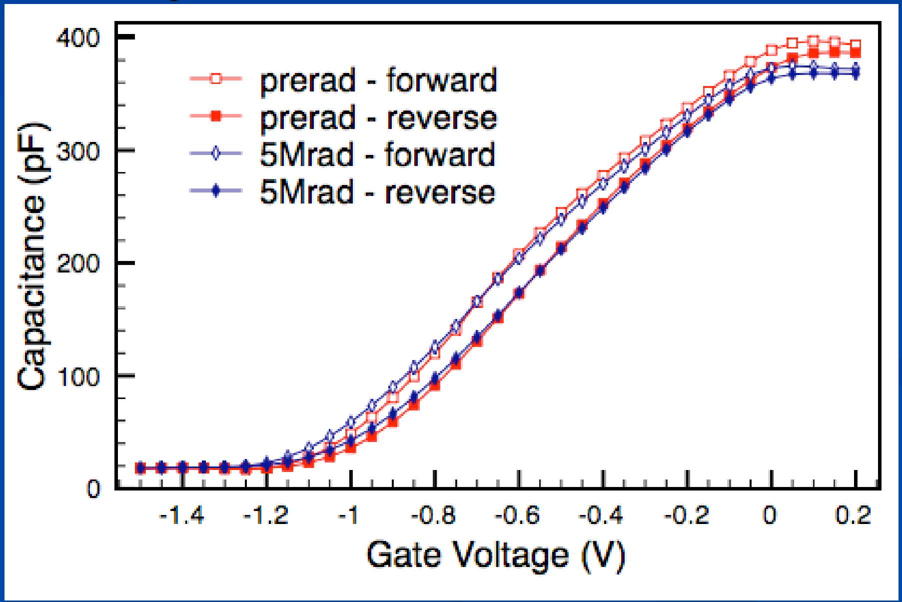


$V_g > 0$ (During irradiation)



- biased device - formation of interface traps and oxide traps

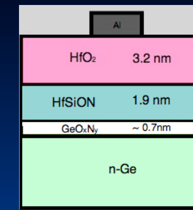
$V_g = 0$ (During irradiation)



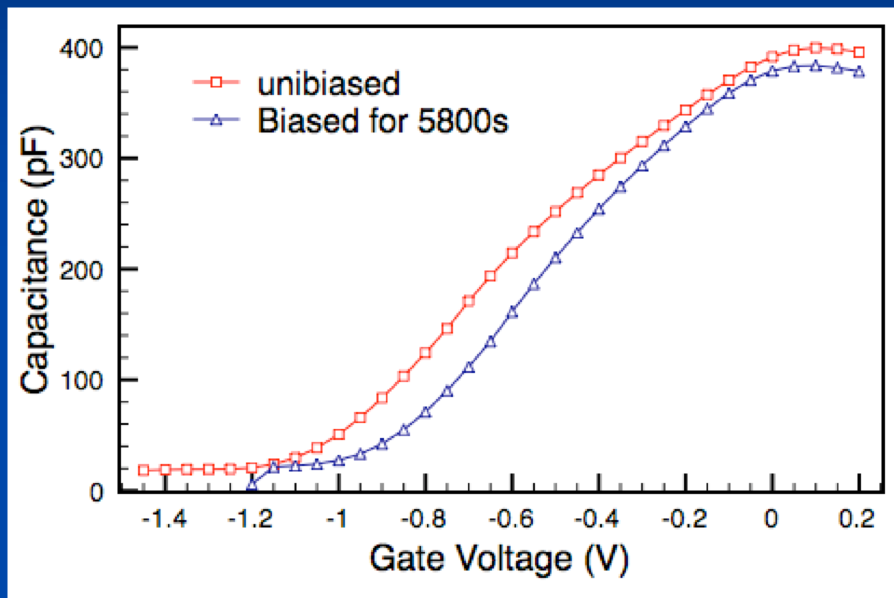
- unbiased device - not a lot of oxide/ border traps though it shows some stretch-out ~ 50mV

Devices radiated at 31.5 krad(SiO_2)/min, C-V at 1MHz

Constant Voltage Stress



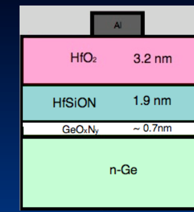
(with HfO_2)



$V_g > 0$

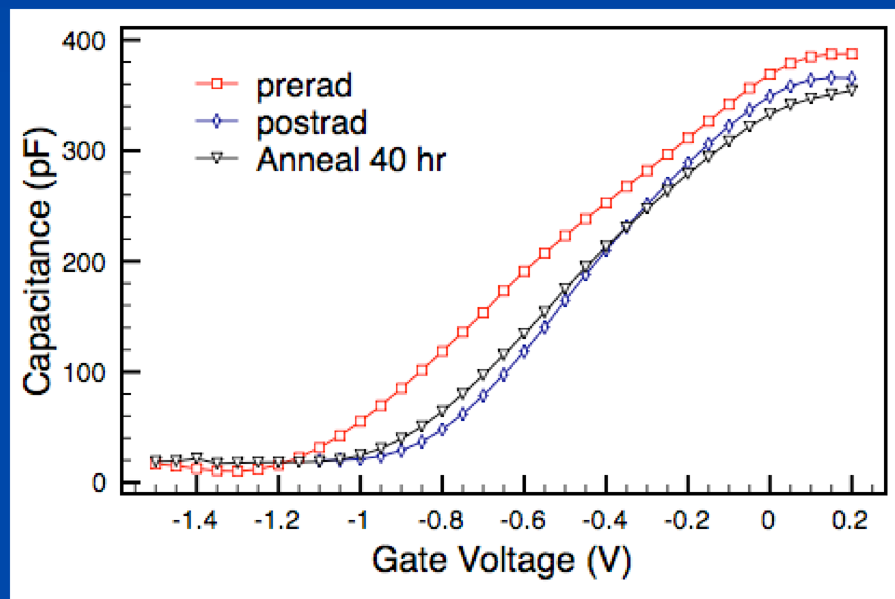
- **Major oxide trap shift due to bias**
- **Radiation did induce interface traps**
- **Large gate current of the order of 1 A/cm^2. So another possibility is that the gate leakage current is neutralizing some of the radiation induced charges**

Anneal Measurements



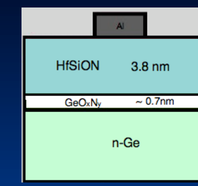
(with HfO_2)

V_g > 0 (During radiation)

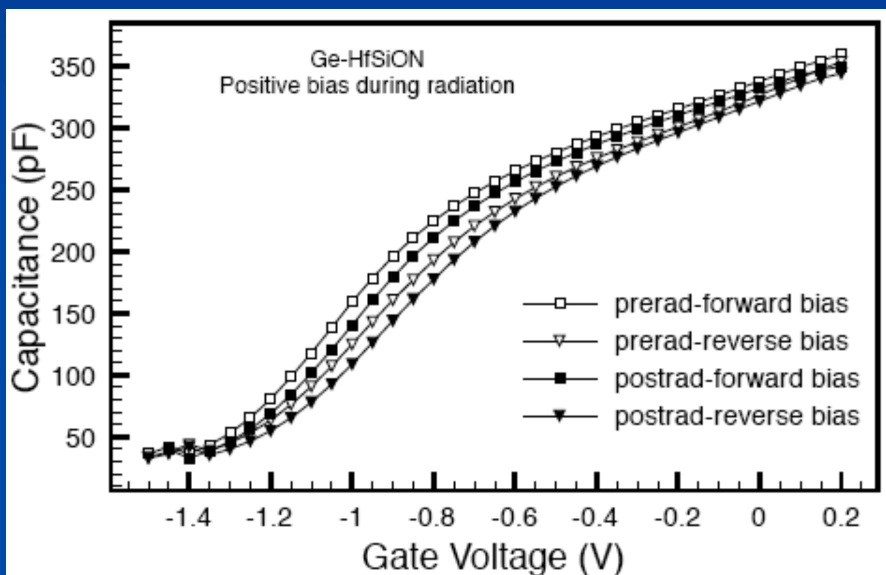


C-V shifted back near 3Mrad values for the biased device.

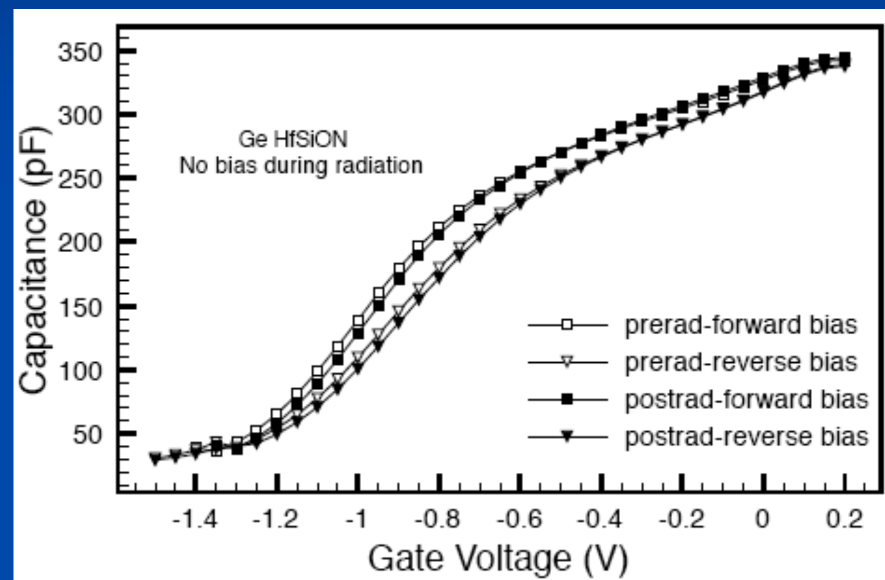
Ge-HfSiON



Vg > 0 (During irradiation)



Vg = 0 (During irradiation)



- hysteresis shows presence of border traps
- positive bias radiation - shift. Due to the bias and not radiation as shown in HfO_2/HfSiON/Ge system
- no bias radiation - no shift in C-V

Conclusion

- High-k dielectrics possible on Ge.
- The dielectrics show hysteresis and effect of bias.
- HfSiON/Ge capacitors show a little better radiation and bias response than HfO_2/HfSiON/Ge capacitor. But HfO_2/HfSiON/Ge capacitors have higher accumulation capacitance value and lower leakage.
- HfSiON seems to be a good interface on top of which higher dielectric constant oxide can be grown without sacrificing radiation response.