The Effects of Hydrogen on the Degradation and Annealing of Radiation Induced Interface Traps and Oxide Trapped Charge

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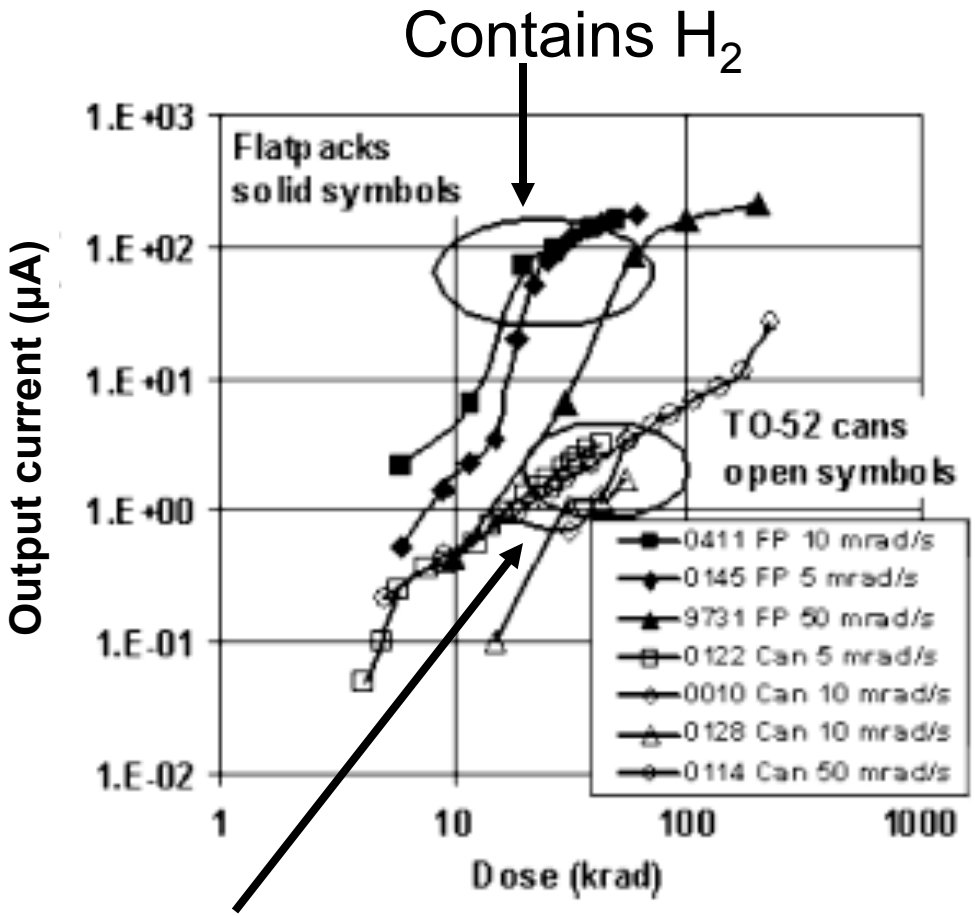
Outline

- Motivation
- Hydrogen effects on radiation response
  - Interface trap buildup
  - Oxide trapped charge annealing
- Aging and hydrogen
- Summary and Conclusions

Hydrogen in Packaging

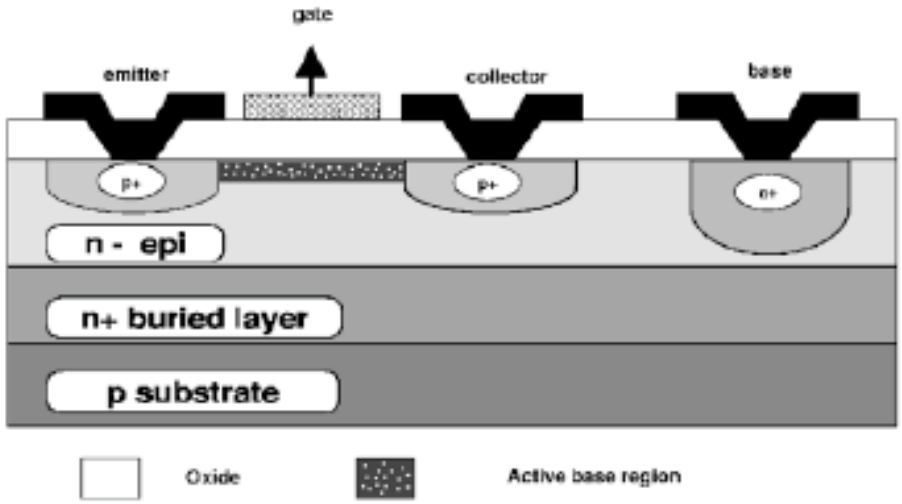
- AD590 transducers
  - Flat-packs: 0.63% H_2, high degradation
  - TO-52 cans: no detectable H_2, low degradation



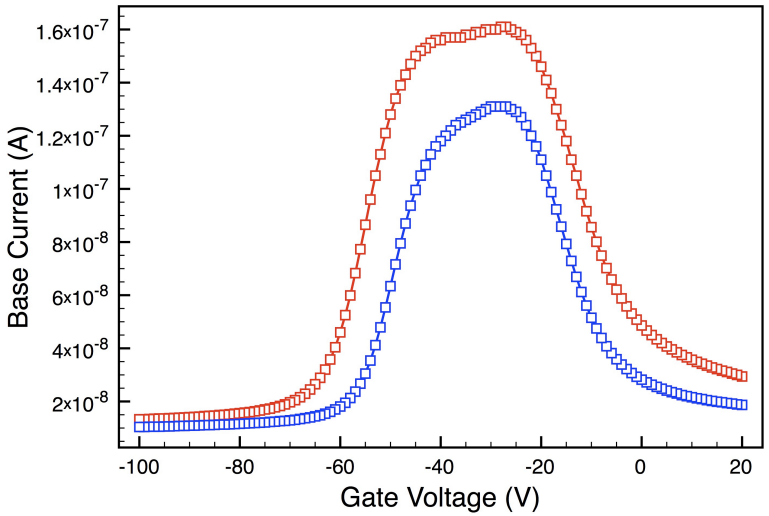
From Pease, et al., IEEE TNS, 54(2007) p.1049

How does H_2 affect radiation response?

- Soak devices in hydrogen prior to irradiation



Picture from Ball et al., IEEE TNS, 49(2002) p.3185



- Gated lateral PNP transistors provide a convenient way to study the mechanisms

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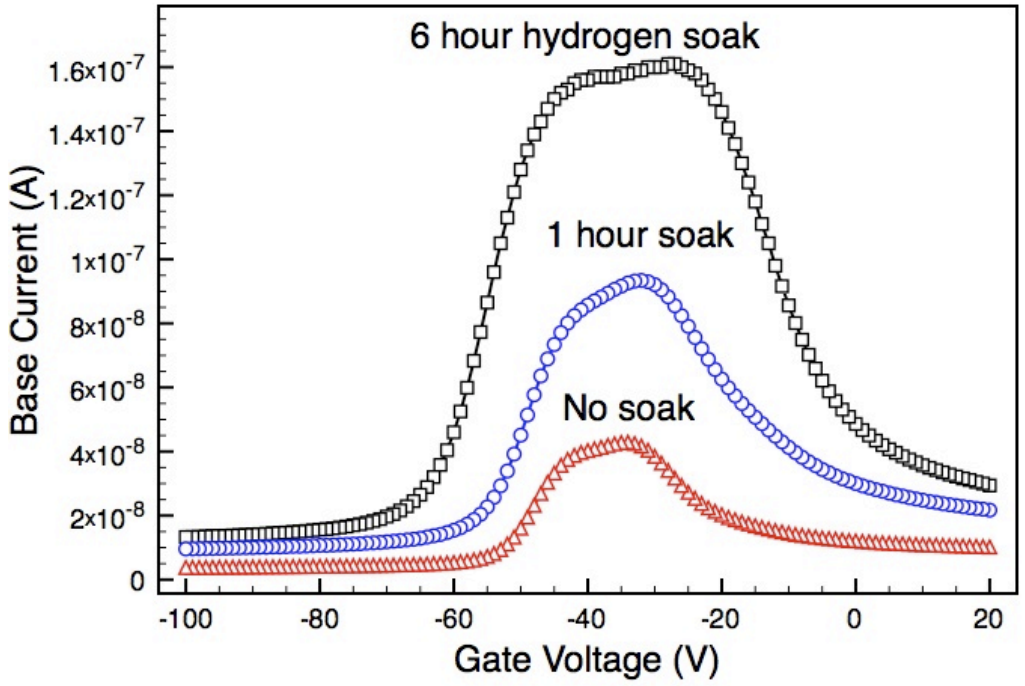
H_2 Increases Interface Trap Density

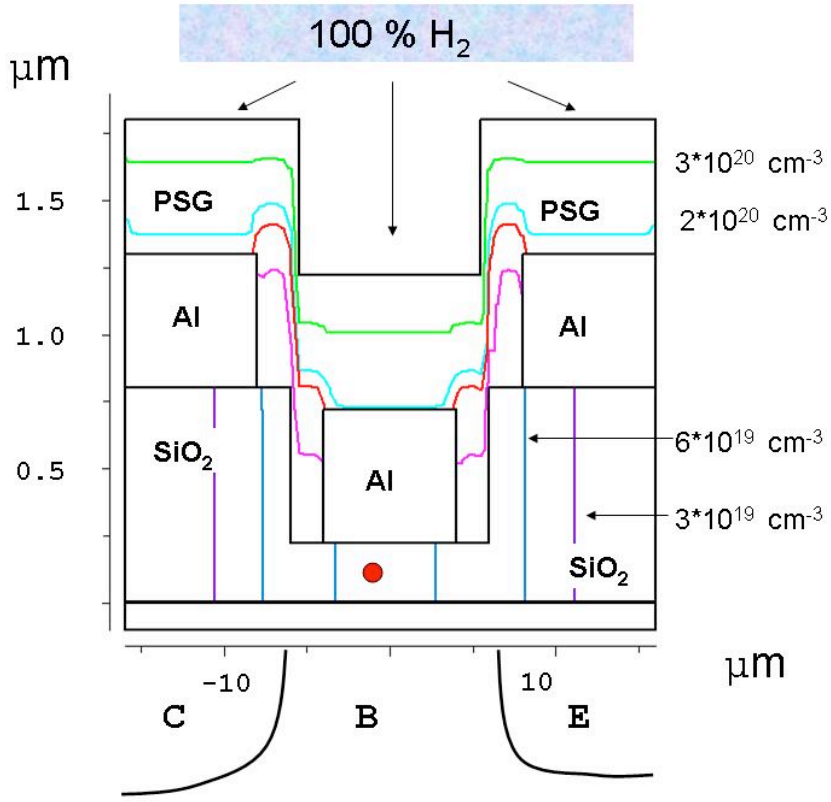
- GLPNP transistors were soaked 6 hours or 1 hour prior to irradiation
- Increased pre-irradiation soaking time produced more interface traps



Origins of Interface Trap Buildup

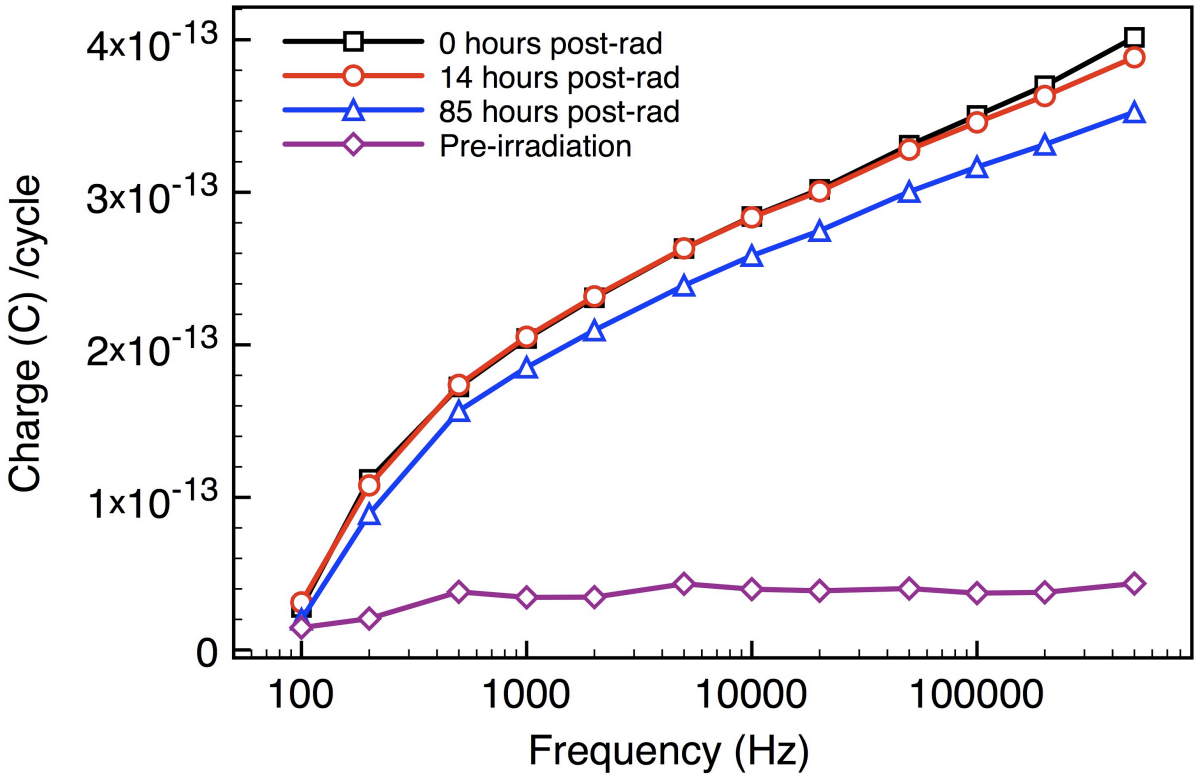
- Interface trap generation mechanisms
  - Density functional theory
  - Numerical simulation

- H_2 transport
- Hole and H_2 react to release proton
- Protons depassivates Si-H bonds



Switching States After Irradiation

- Border traps and effective interface trap density



- Results indicate that border traps do not significantly contribute to switching state density

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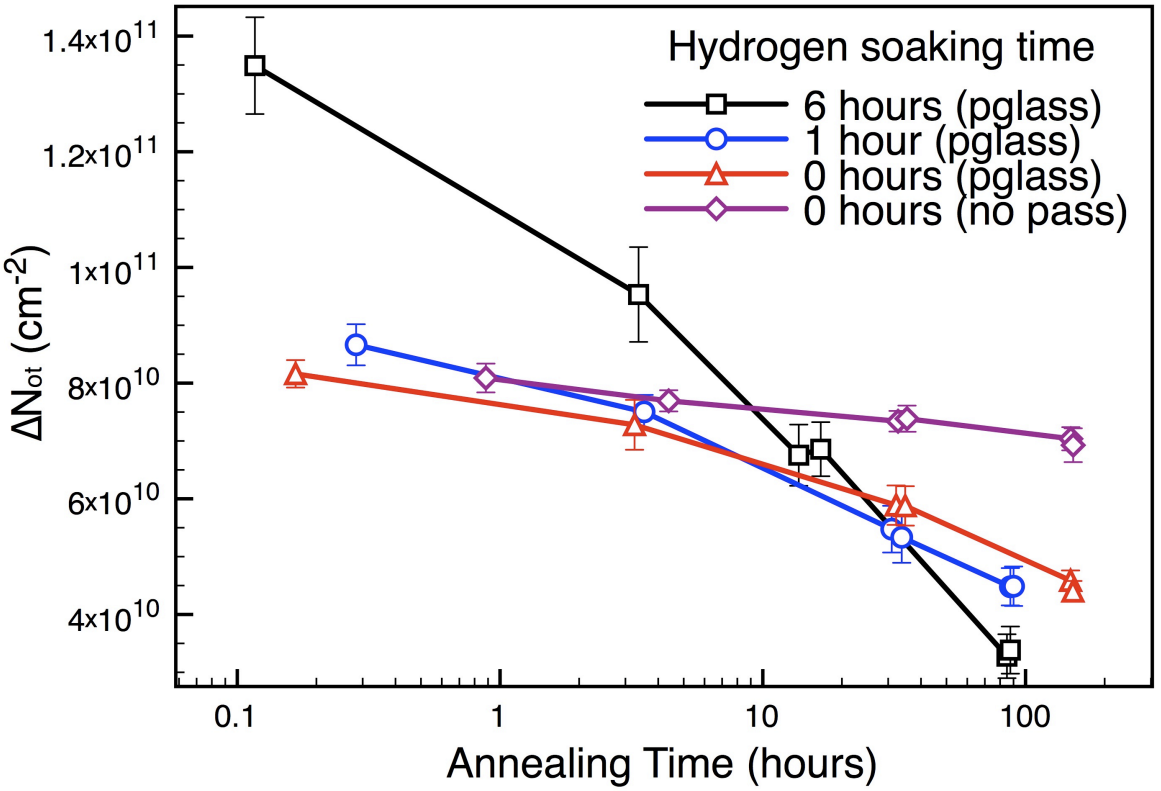
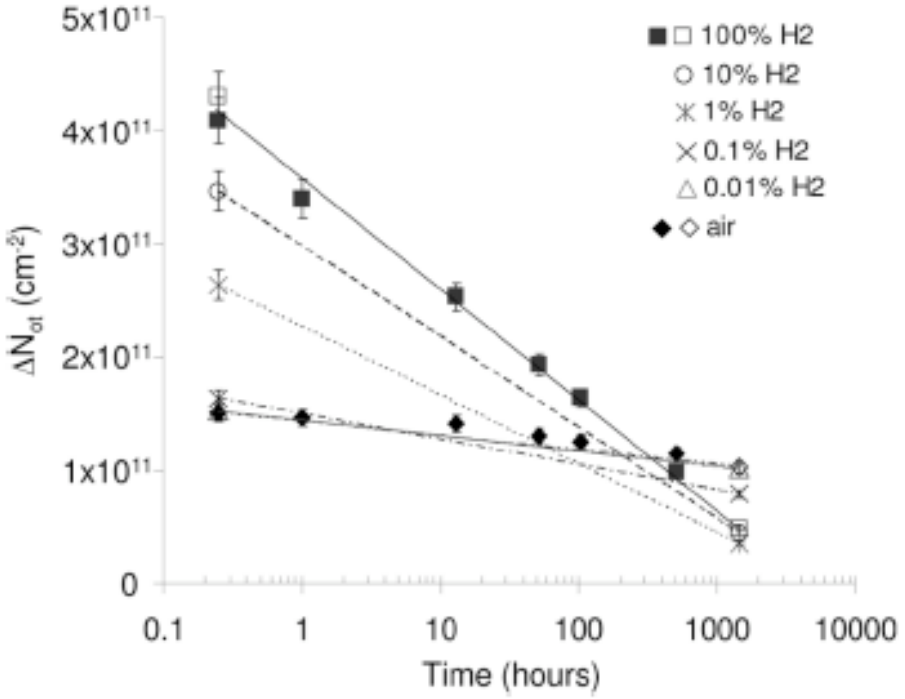
N_{ot} Buildup and Annealing

- H_2 causes changes in N_{ot}
  - Larger buildup immediately after irradiation
  - Faster annealing
- Annealing rate depends on passivation



N_{ot} Buildup and Annealing

- Parts with no passivation show similar trends
- Longer time scale, 1000 vs. 100 hours
  - P-glass devices may contain more H_2



From Chen, et al., IEEE TNS, 55(2008) p.3032

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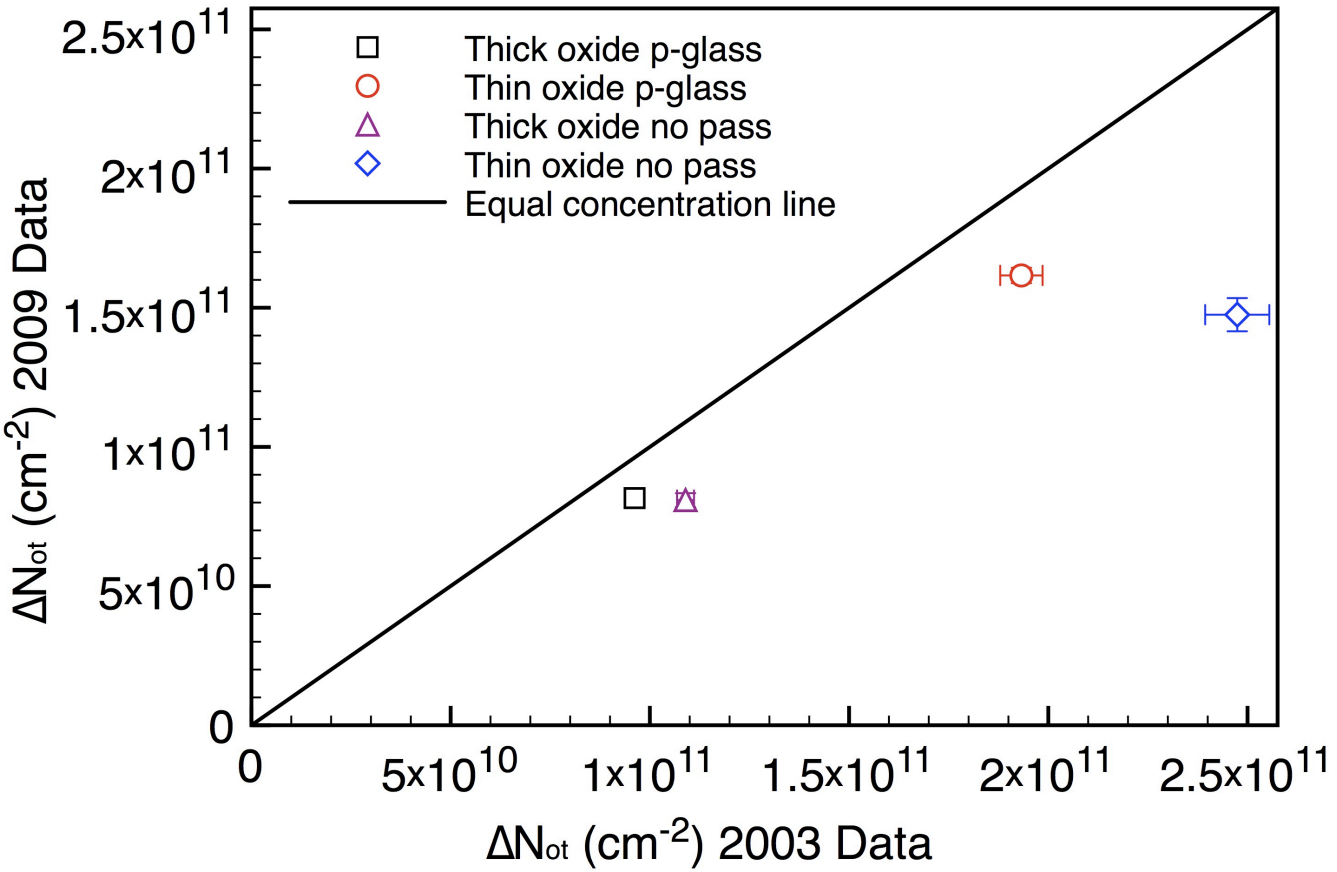
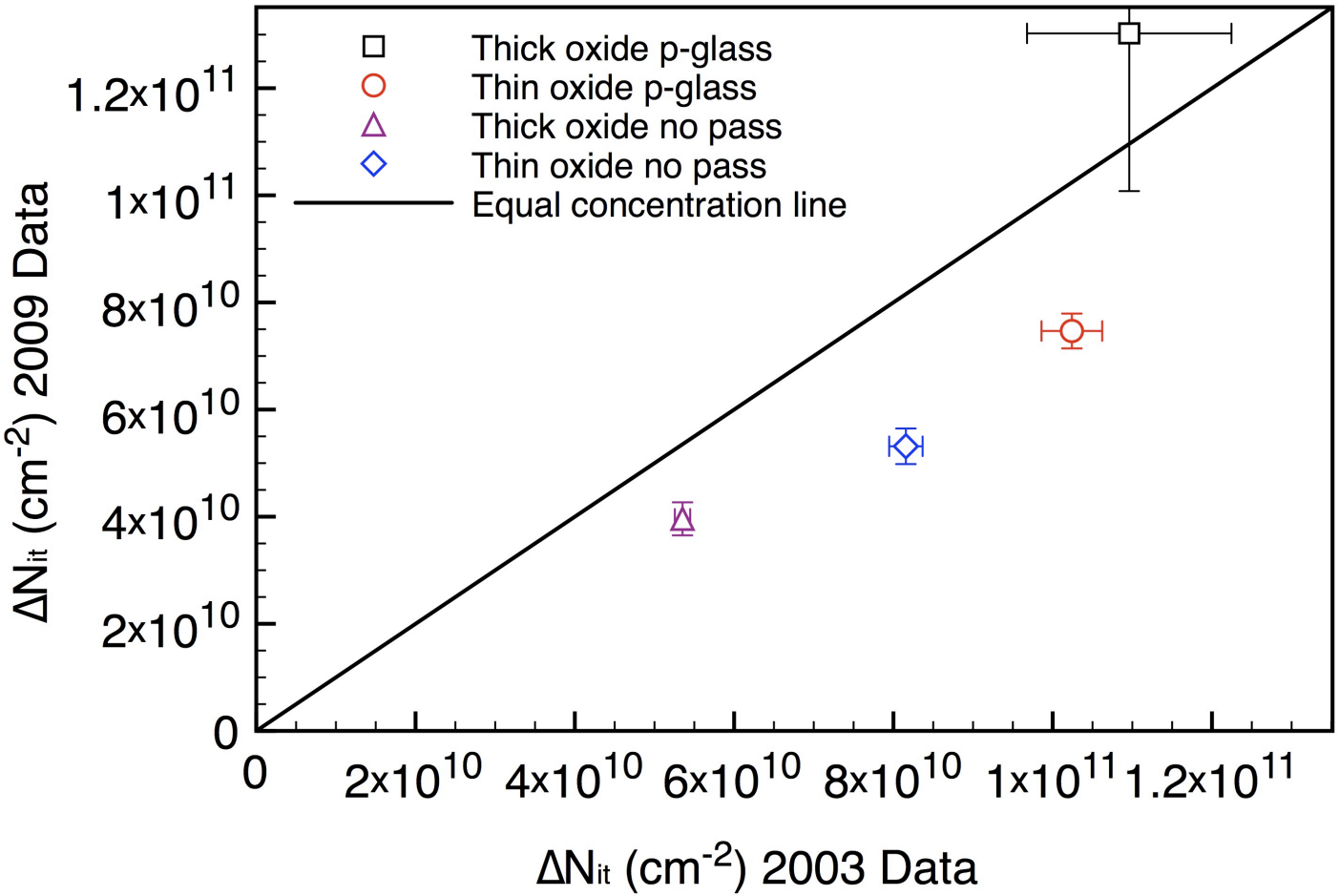
Aging Comparisons

- Aging also affects radiation response
- Is there a correlation with hydrogen?

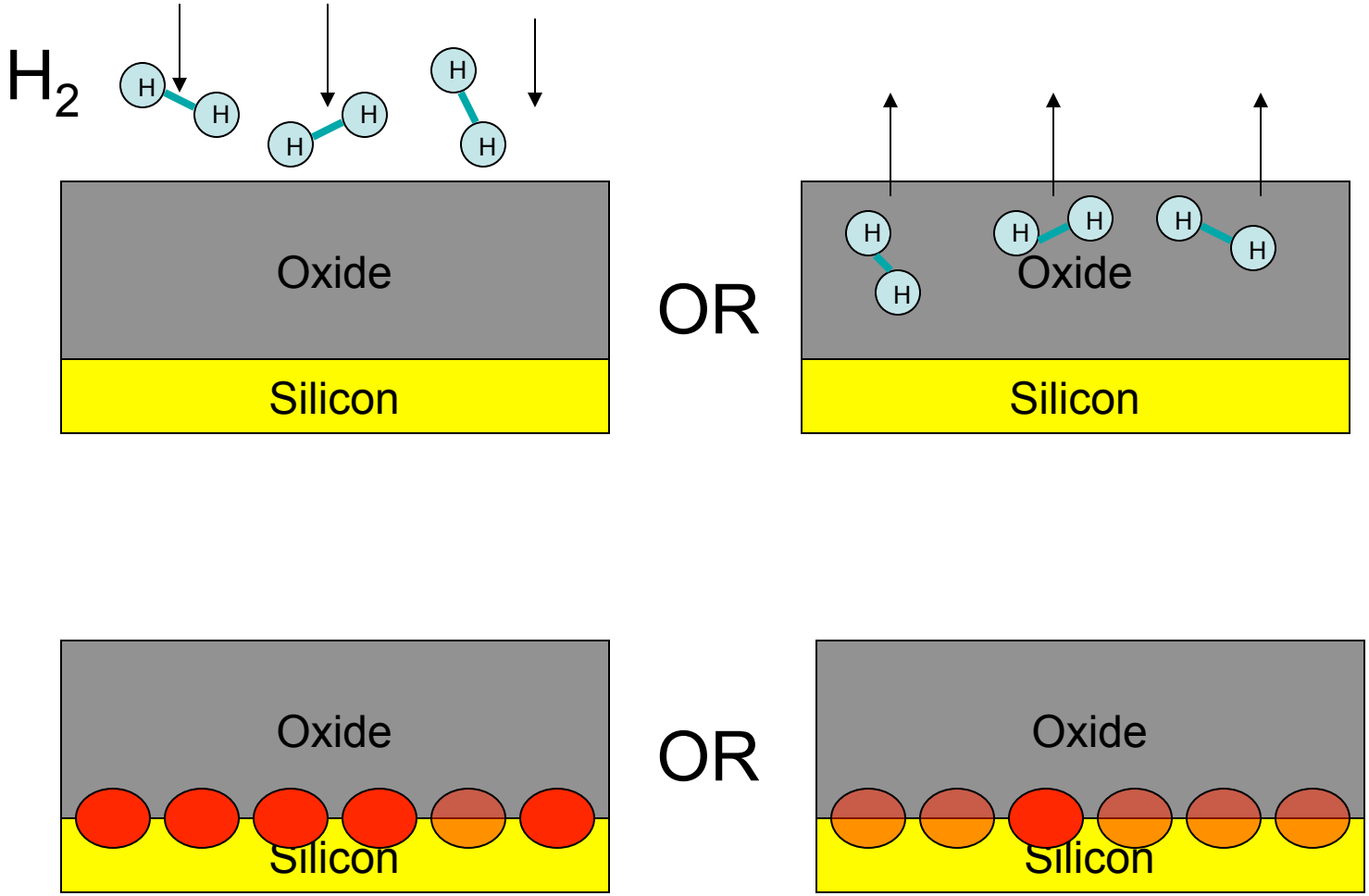


Aging Comparisons

- Traps tended to anneal with age in these devices



Dual Role of Hydrogen



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Summary and Conclusions

- Enhanced interface trap concentrations
- Different annealing rate for oxide traps
  - Underlying mechanisms altered
  - Hardness assurance implications

- Dual role of hydrogen
  - In this case aging decreased interface traps and oxide trapped charge