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Advanced SiGe-free Strained Si on Insulator Substrates: Thermal Stability and Carrier Mobility Enhancement

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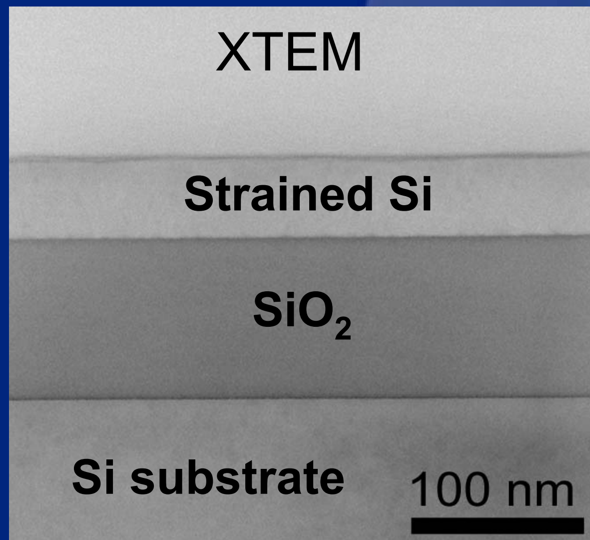
Outline

- Motivation
- SSOI substrate fabrication process
- Recent improvements
- SSOI substrate data
  - Uniformity
  - Surface roughness
  - Strain thermal stability
  - First mobility enhancement demonstration by HgFET
- Summary

Strained Si On Insulator



- Combination of 2 high-performance technologies: Strained Si and SOI
- SiGe-free structure
  - 20% SSOI, ε = 0.8%
- Strained Si layer defined epitaxially
- Capable of very thin structures <200 Å

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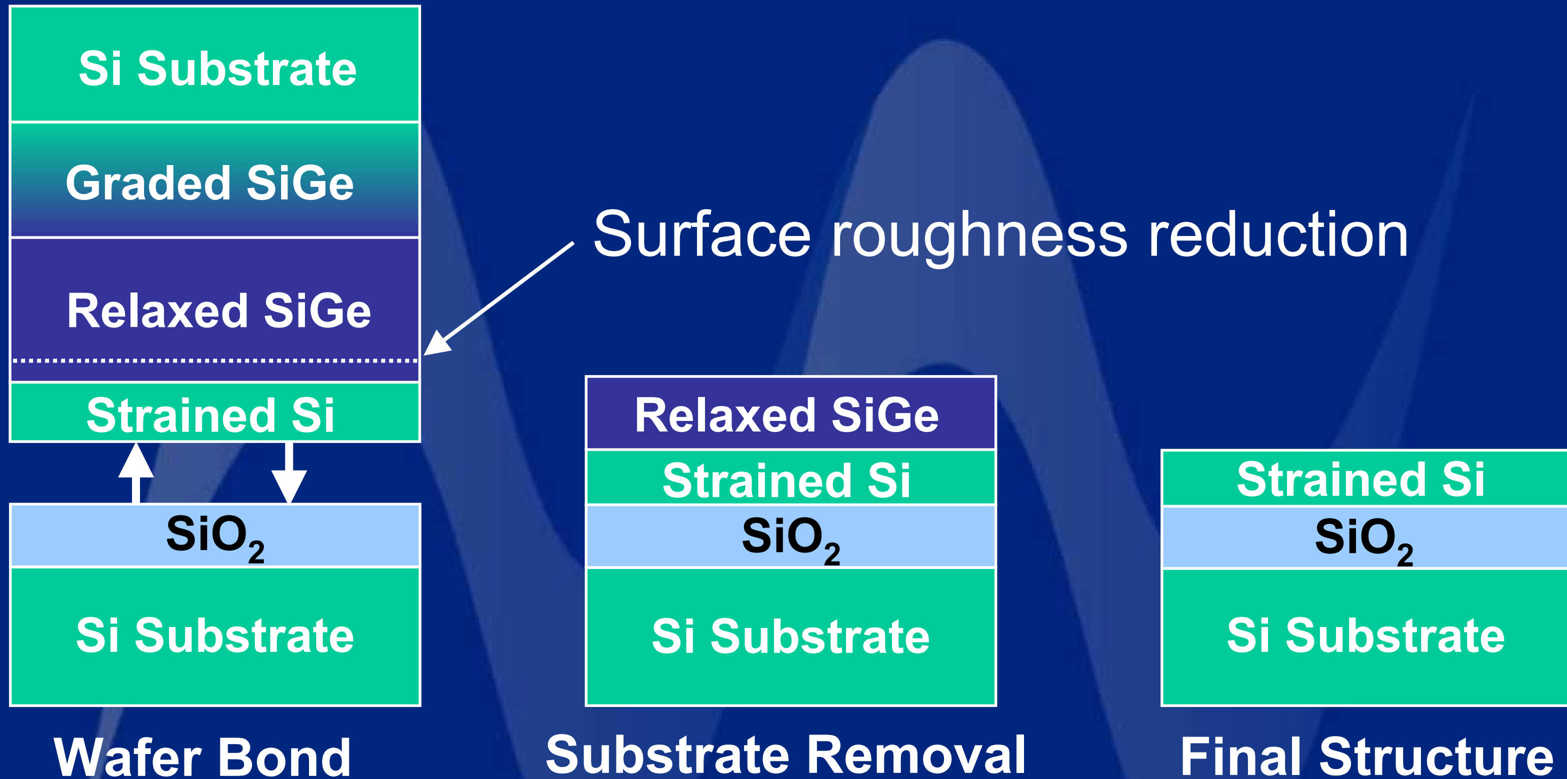
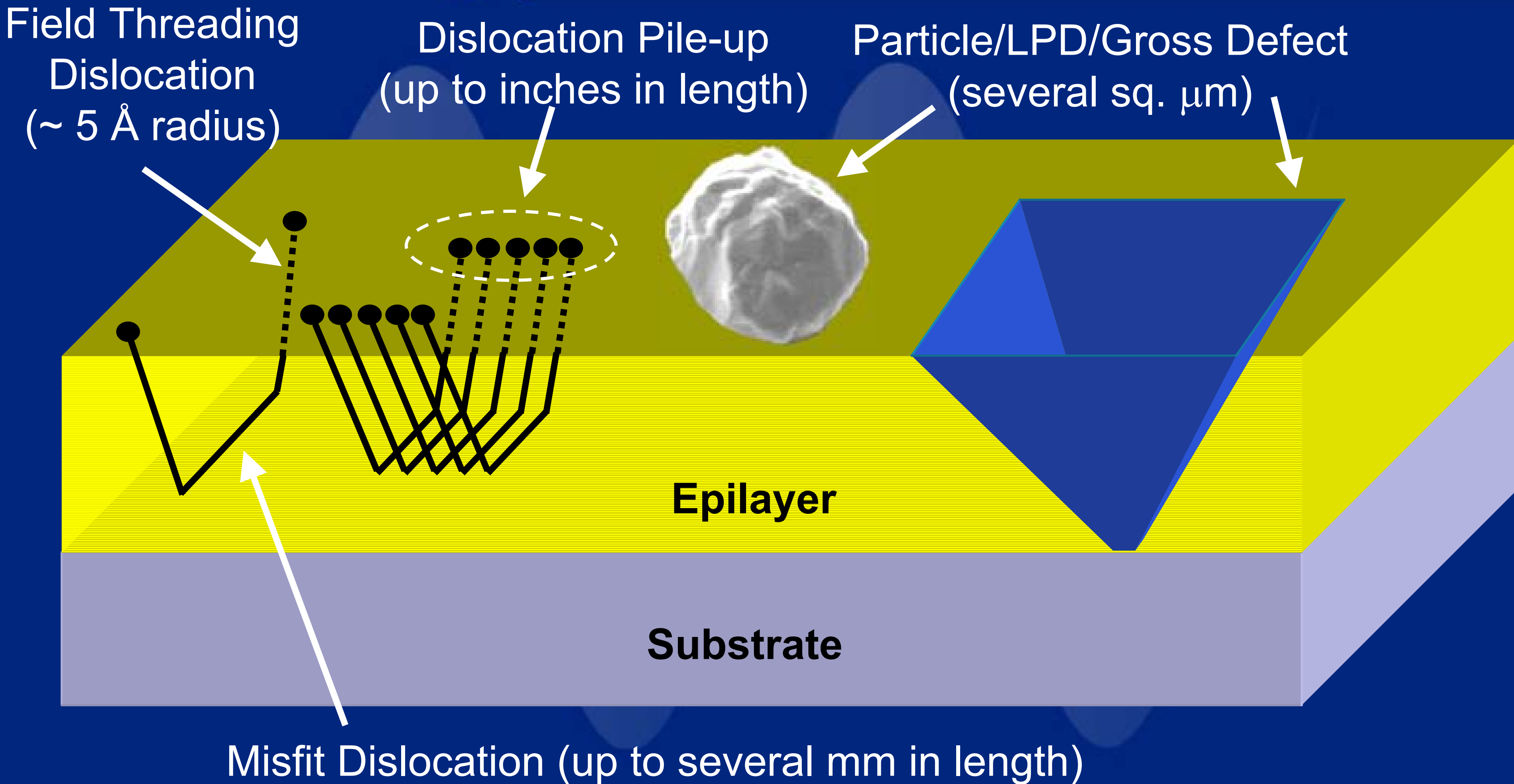
SSOI Substrate Fabrication Process



Starting material quality critical to process

Bulk Strained Si Substrate Defects Transferred to SSOI



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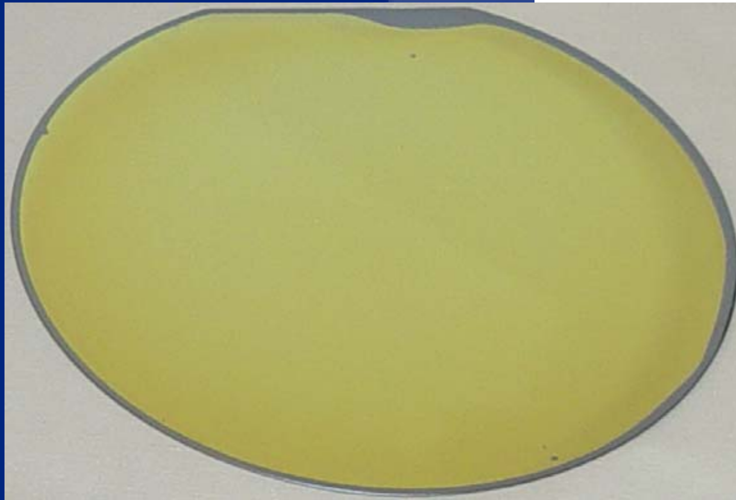
Recent SSOI Substrate Improvements

- Bond yield
  - Minimization of epi induced particles and pileups
  - Optimization of wafer bonding clean and anneal steps
- Film uniformity
  - Improved SiGe compositional uniformity
  - Improved epi strained Si thickness uniformity
  - SiGe removal by combination oxidation/wet-etch
- Surface roughness
  - SiGe removal by combination oxidation/wet-etch

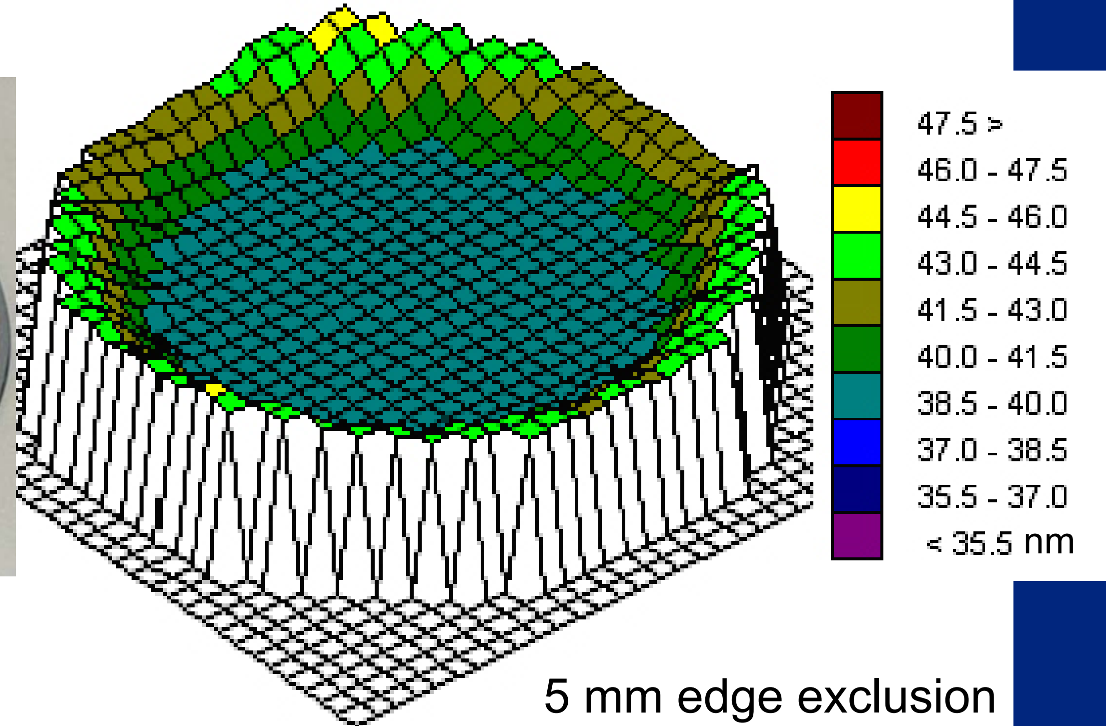
Sample Size/Uniformity:
20% 400 Å SSOI

Uniformity = ± 7.9 %, σ = 5.8%

150 mm wafer



100 nm BOX



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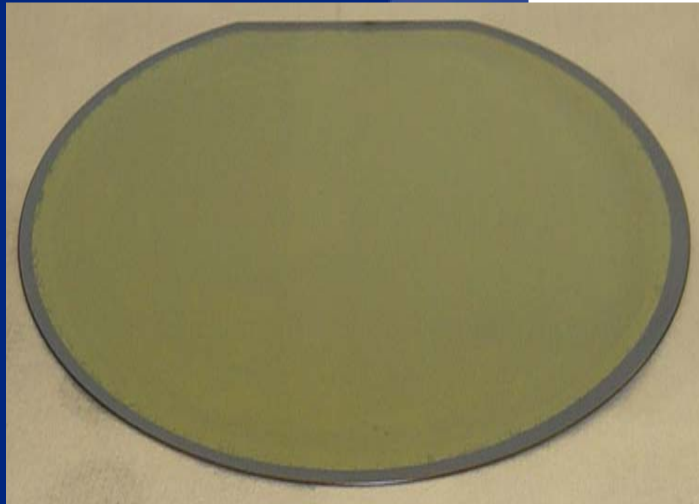
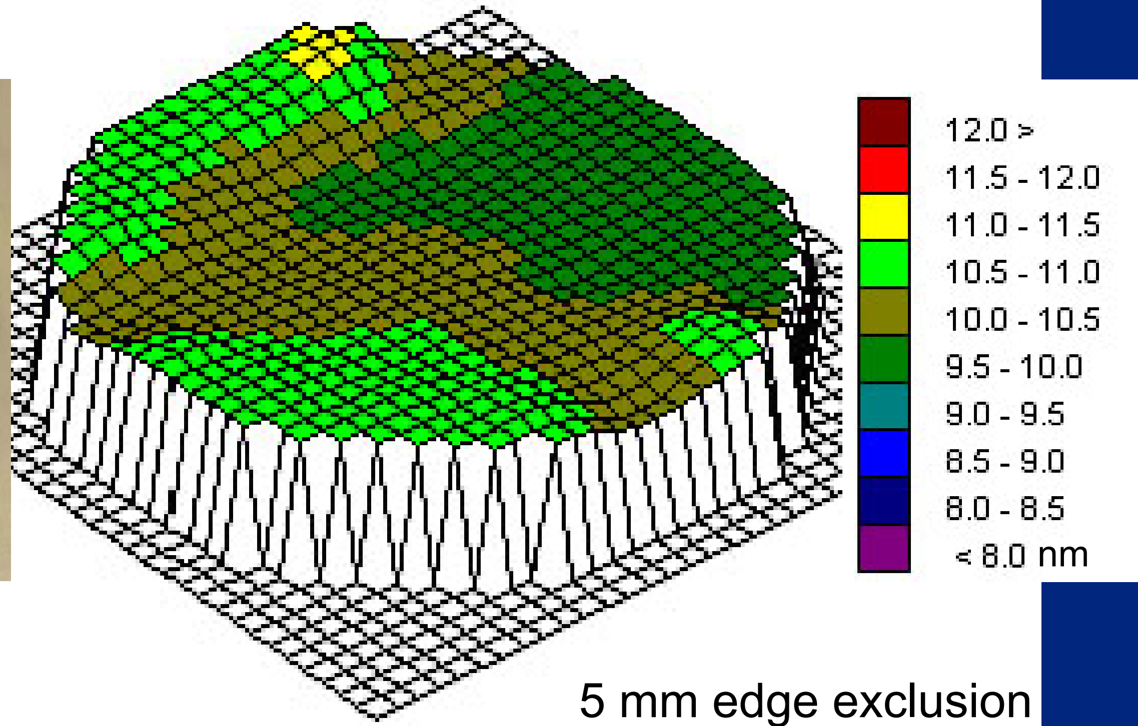
Sample Size/Uniformity:
20% 100 Å SSOI

Uniformity ± 7.12%, σ = 4.6%

150 mm wafer



200 nm BOX

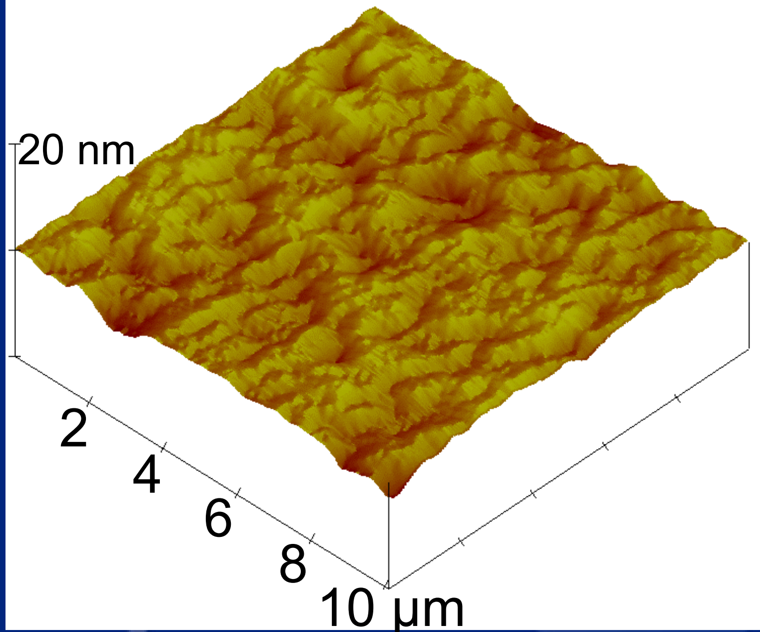


5 mm edge exclusion

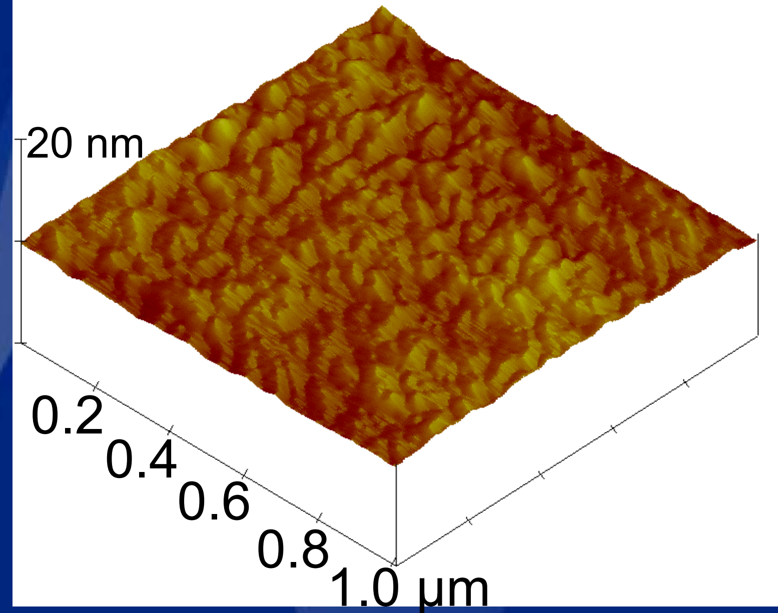
Ultrathin SSOI films achieved

Surface Roughness

20% 400 Å SSOI



0.72 nm RMS



0.49 nm RMS

Cross-hatch is not observed

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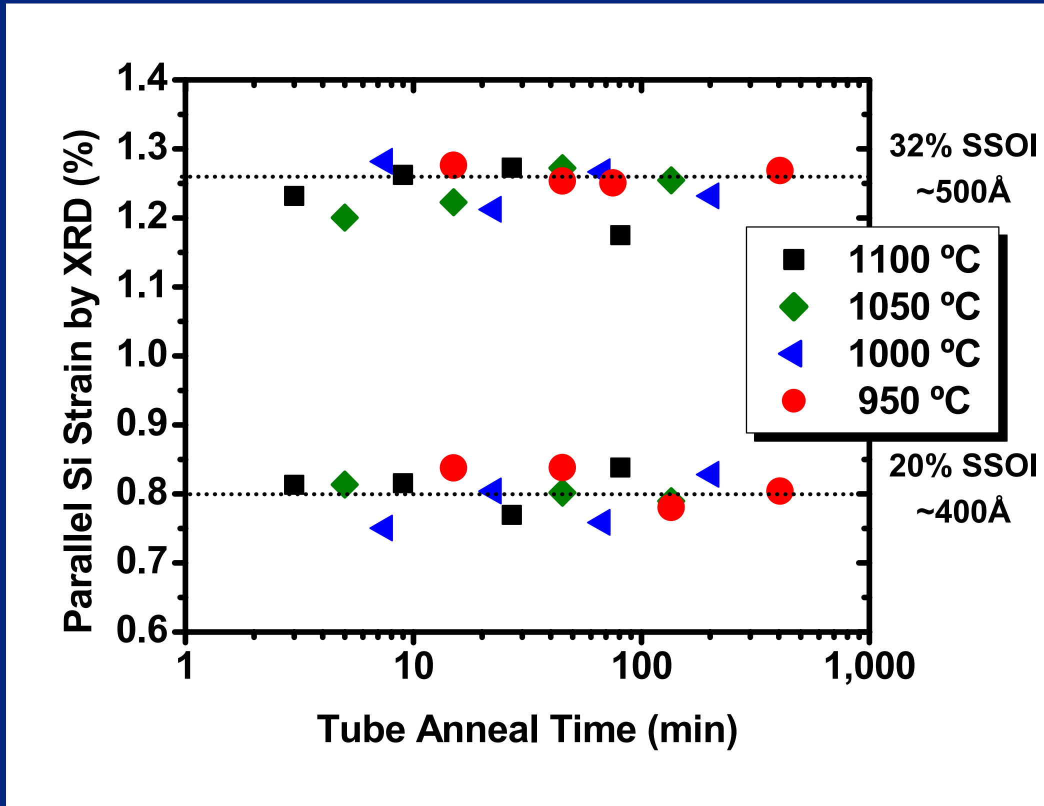
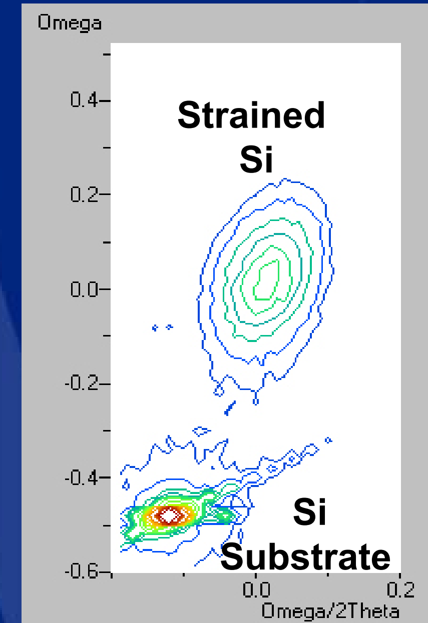
Strain Thermal Stability:

Measured by XRD (verified by Raman)



224GI RSM

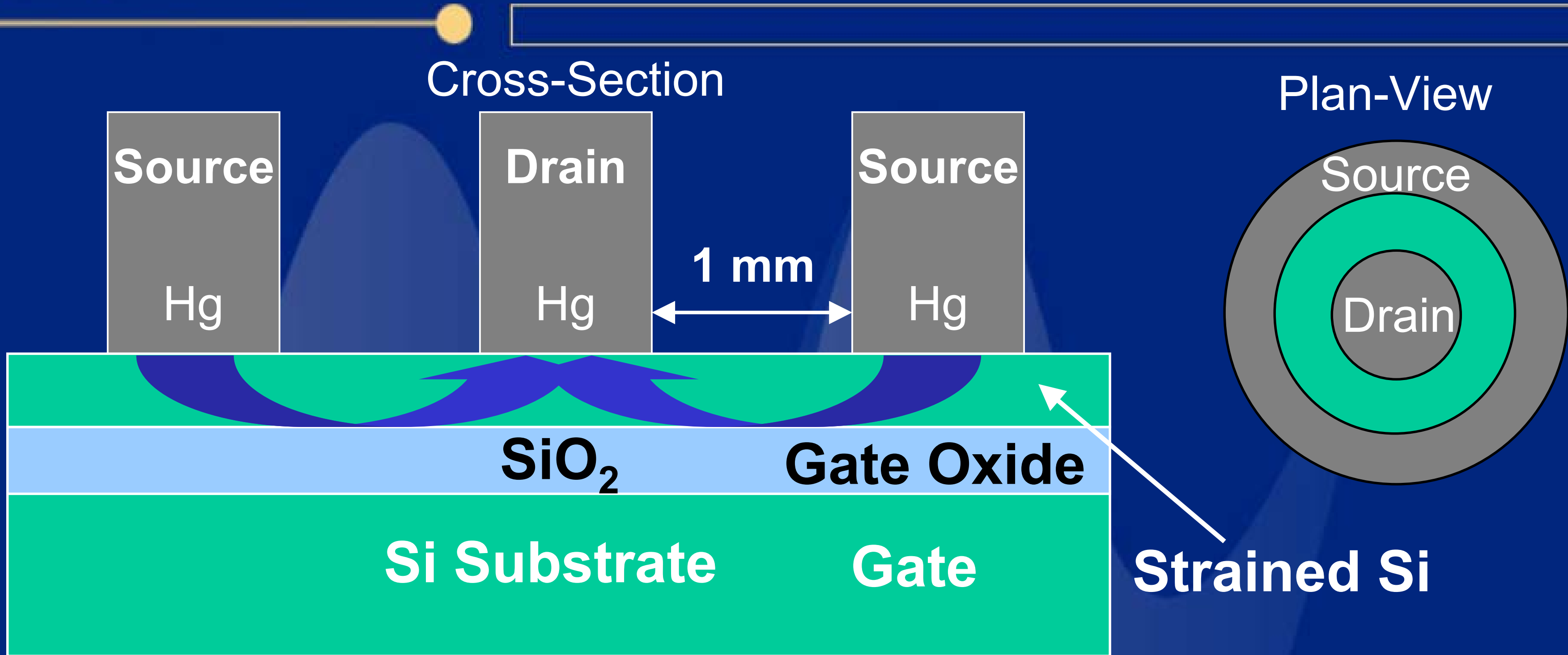
32% SSOI 1050°C 45 min



-M. Erdtmann,et al., SSDM p.290(2003)

Tensile strain maintained during 1100ºC anneals for thick films

HgFET Overview

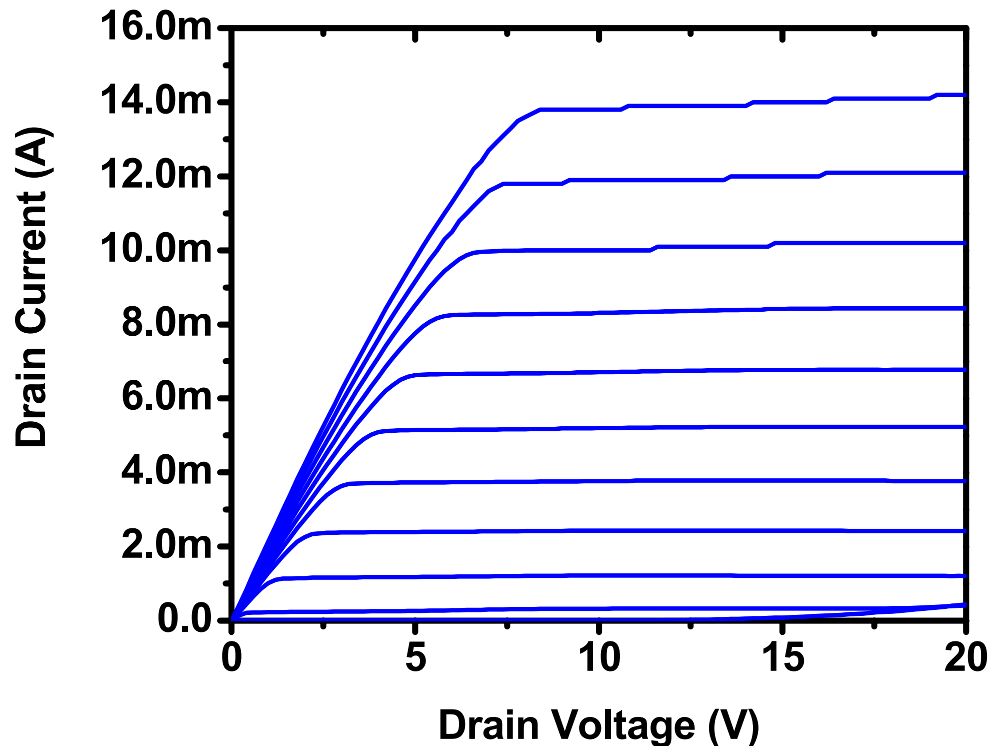


-H. J. Hovel, Solid State Elec. **47**, 1311 (2003)

- Common SOI characterization technique to measure mobility, DITs, etc.
- Easy Set up
- Large concentric area technique > 10 mm^2

Electron Mobility Measurements

20% 450 Å SSOI HgFET results



- Extracted SSOI mobility 902 $cm^2/Vsec$
- SOI mobility 600-650 $cm^2/Vsec$
- DITs comparable to SOI

-H. J. Hovel, Solid State Elec. **47**, 1311 (2003)

40-50% Electron Mobility Improvement over SOI

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Summary

- SSOI advancements
  - Thickness variation of < 8% on ultrathin 100 Å films
  - Surface roughness < 5 Å
  - Improved thermal stability with > 1.2% strain unaffected by annealing up to 1100°C
- First SSOI electron mobility enhancement demonstrated
  - 40-50% enhancement over SOI

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