Influence Of Ballistic Effects In Ultra-Small MOSFETs

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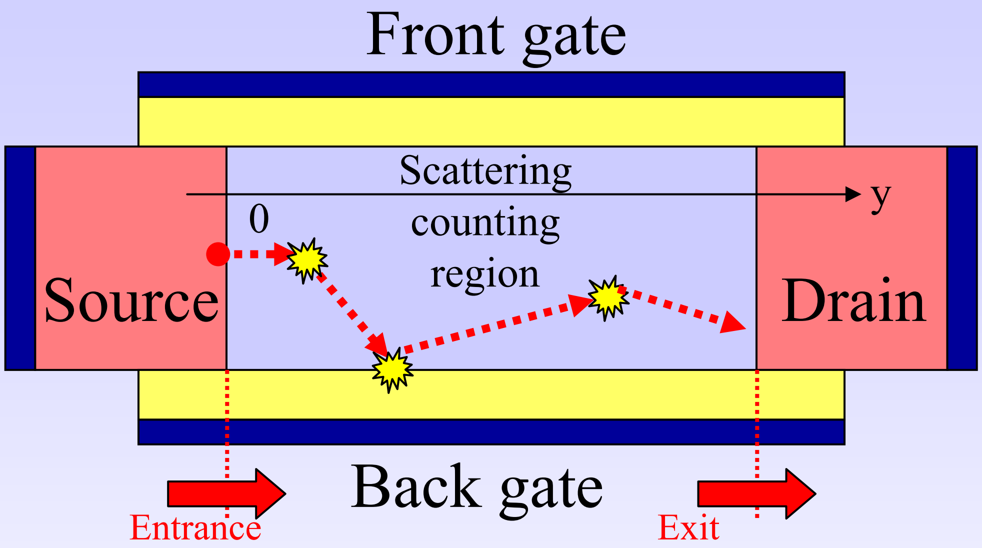
- Channel length and ballistic transport
- Bias dependence on ballisticity
- Ballisticity and long-channel effective mobility

Transport in decanano MOSFET



Quasi-ballistic transport: electron mean free path is similar to L_{ch}

Monte Carlo simulation

- B_{int} = % of ballistic electrons at the drain-end
- $B_{eff} = \dfrac{I_{on}}{I_{on\_with\_a\_ballistic\_channel}}$

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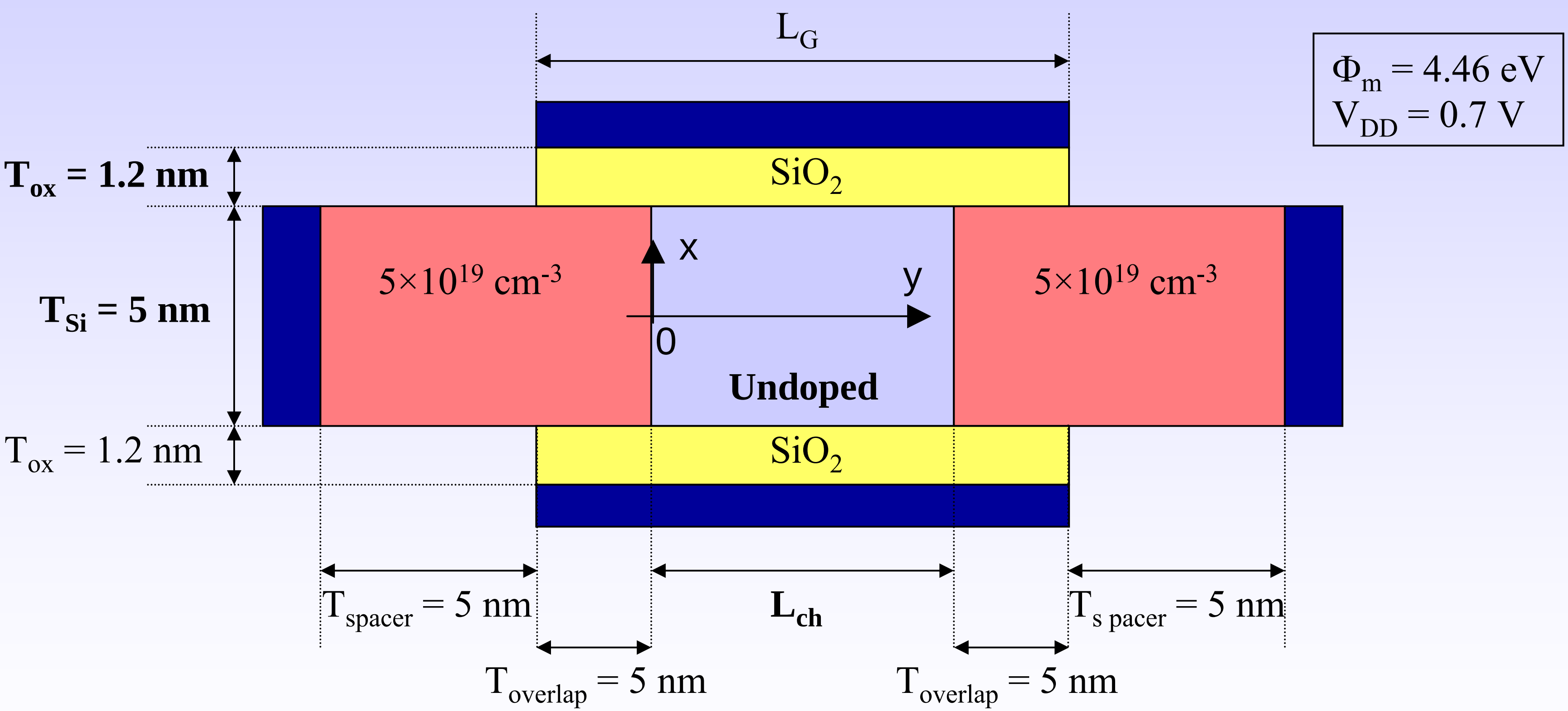
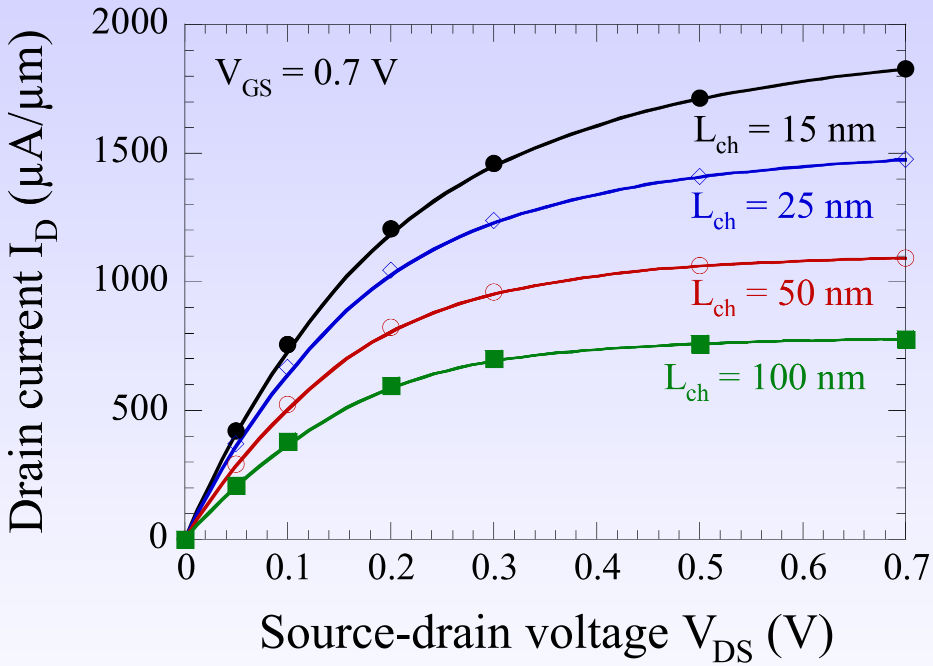
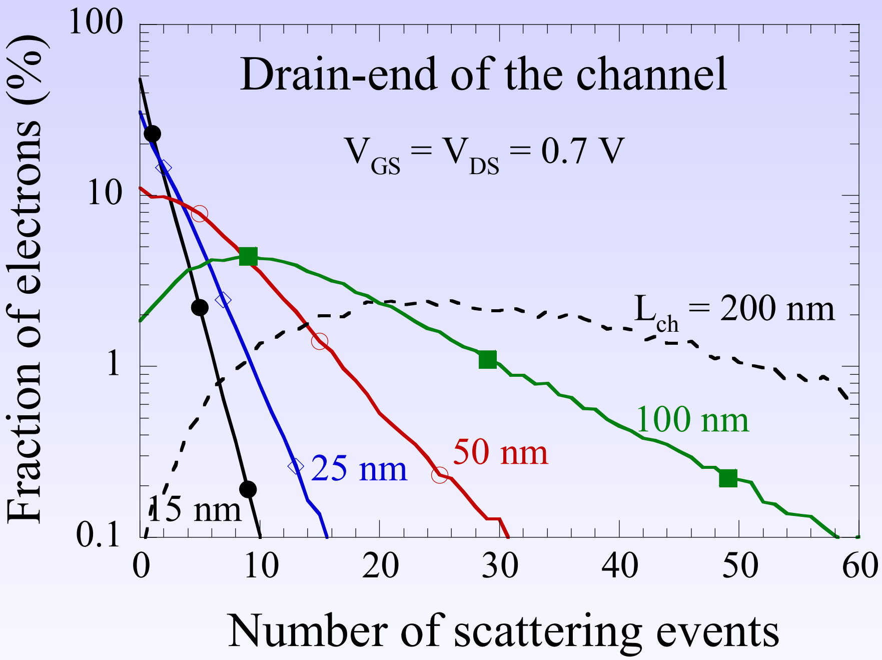
Studied devices



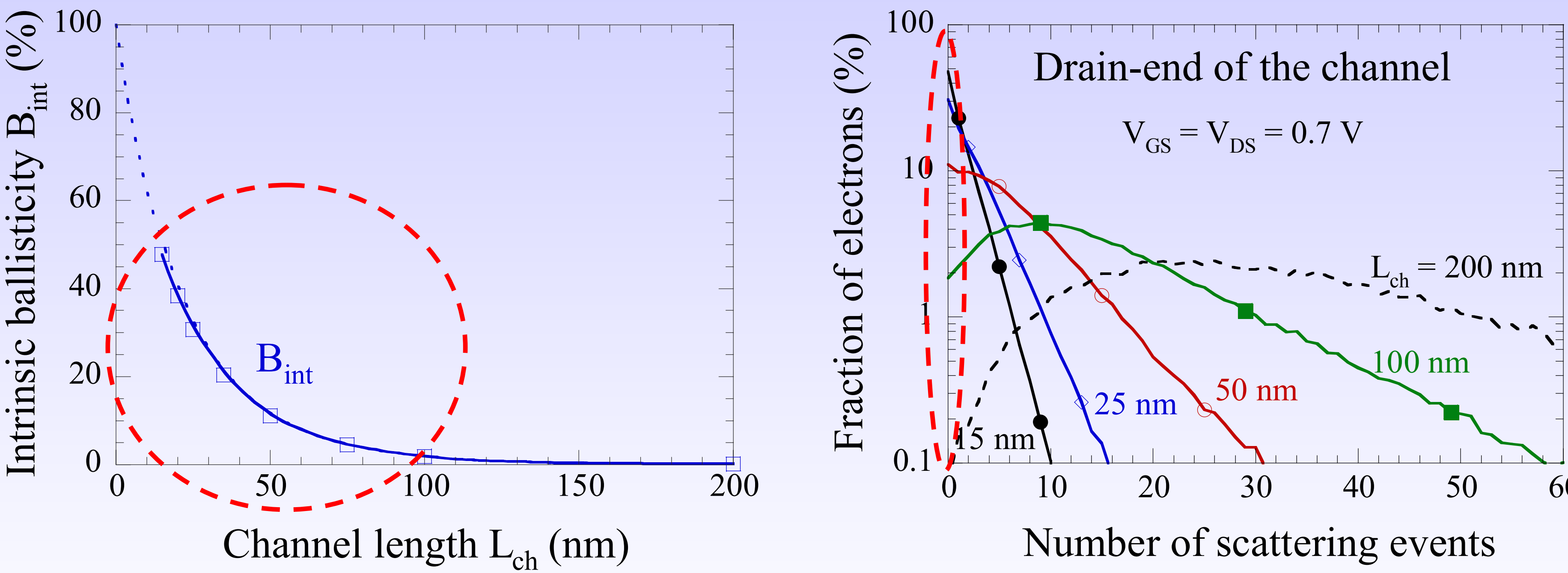
From quasi-stationary to quasi-ballistic





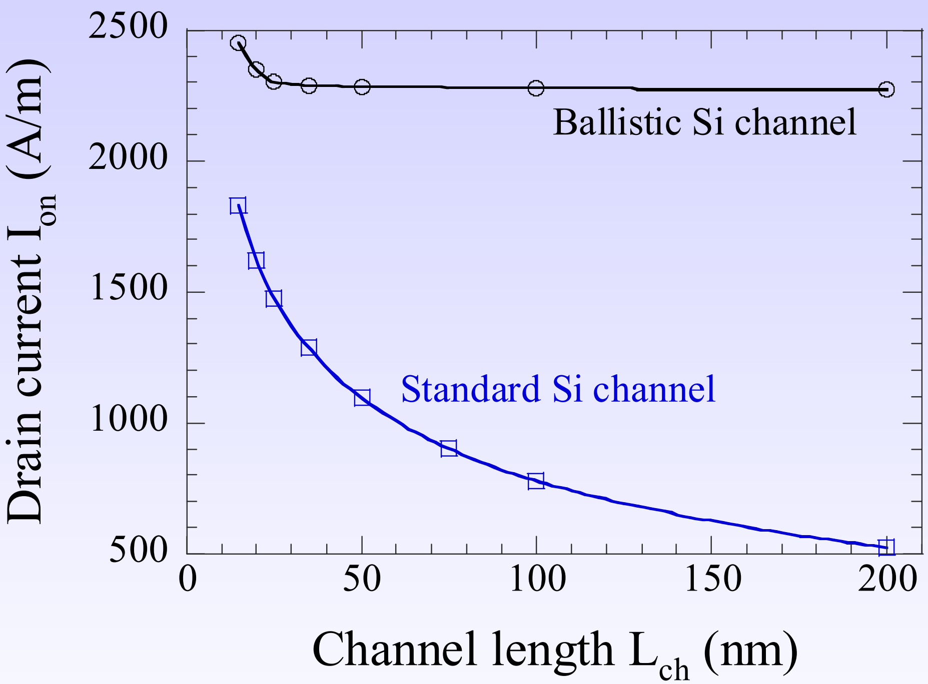
Transition for $L_{ch} \approx$ 50 nm in undoped channels

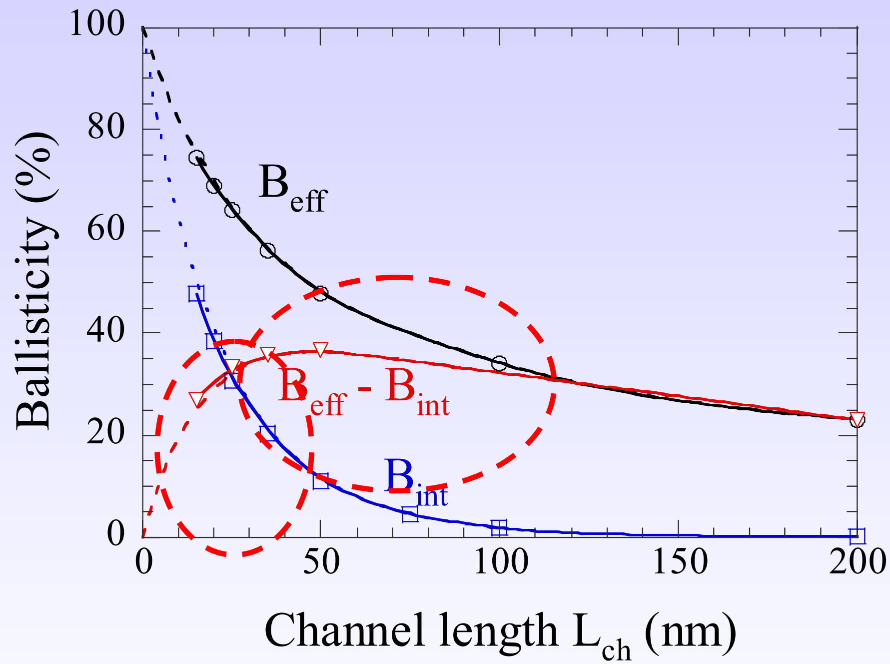
Ballisticity and channel length



➡ B_{int} strongly increases for $L_{ch} < 100$ nm

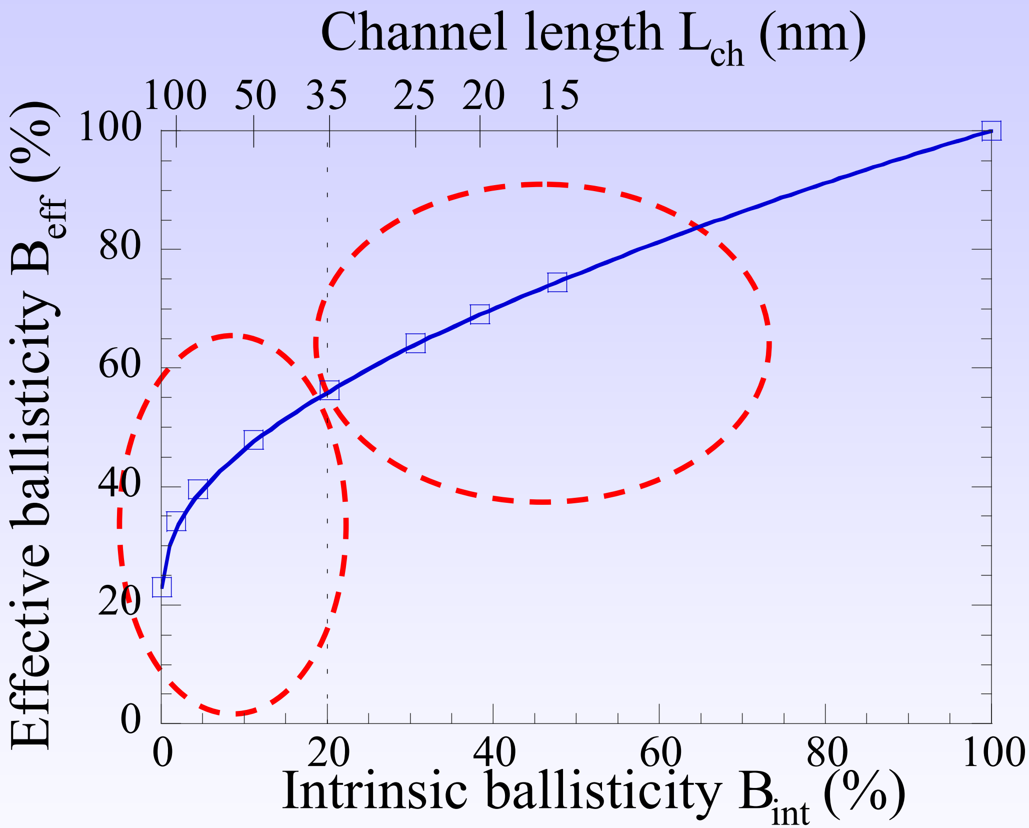
Ballisticity and current





➡ Gap between B_{int} and B_{eff} no more constant for L_{ch} < 30 nm

$B_{eff}(B_{int})$ in undoped channels



- Strong impact of B_{int} on B_{eff} for B_{int} < 20 %
- $B_{eff}(B_{int})$: quasi linear correlation for B_{int} > 20%

Decreasing impact of B_{int} on B_{eff}

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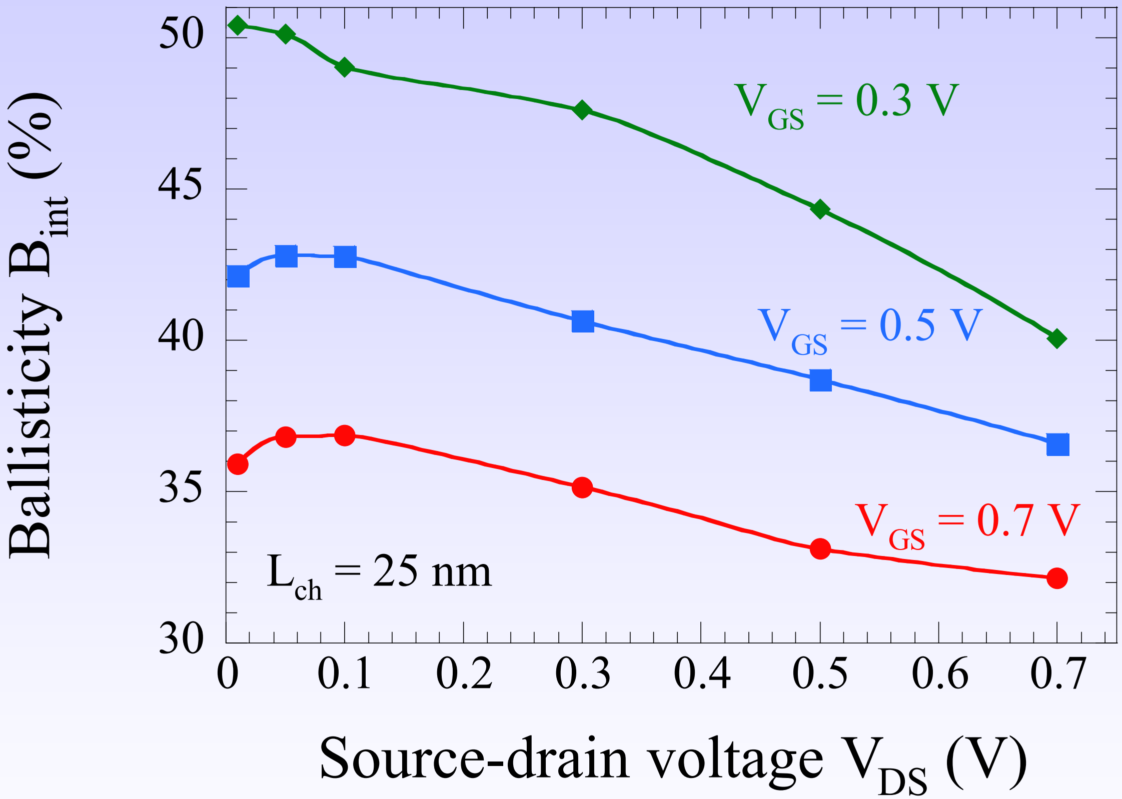
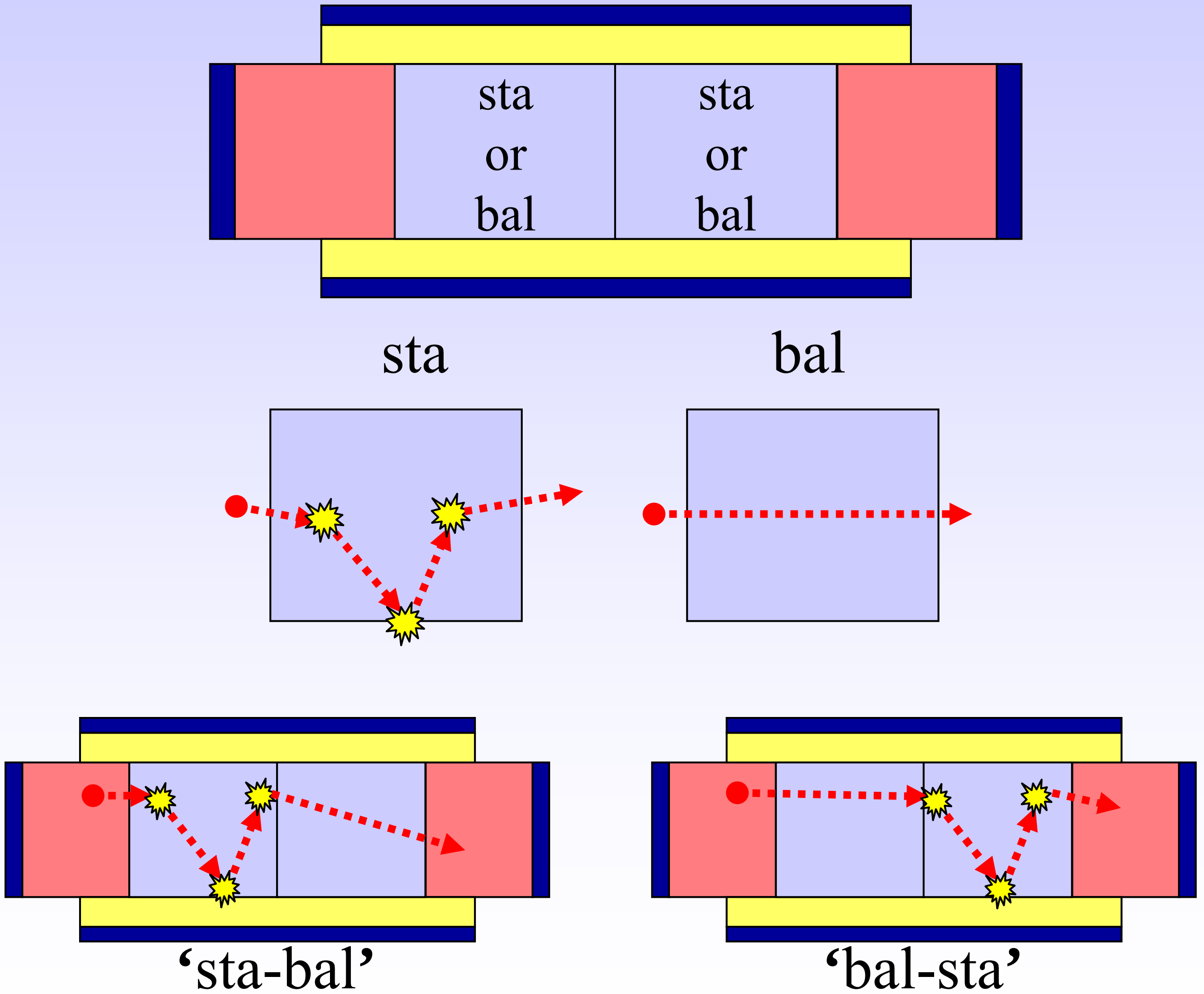
B_{int} as a function of V_{DS} for different V_{GS}



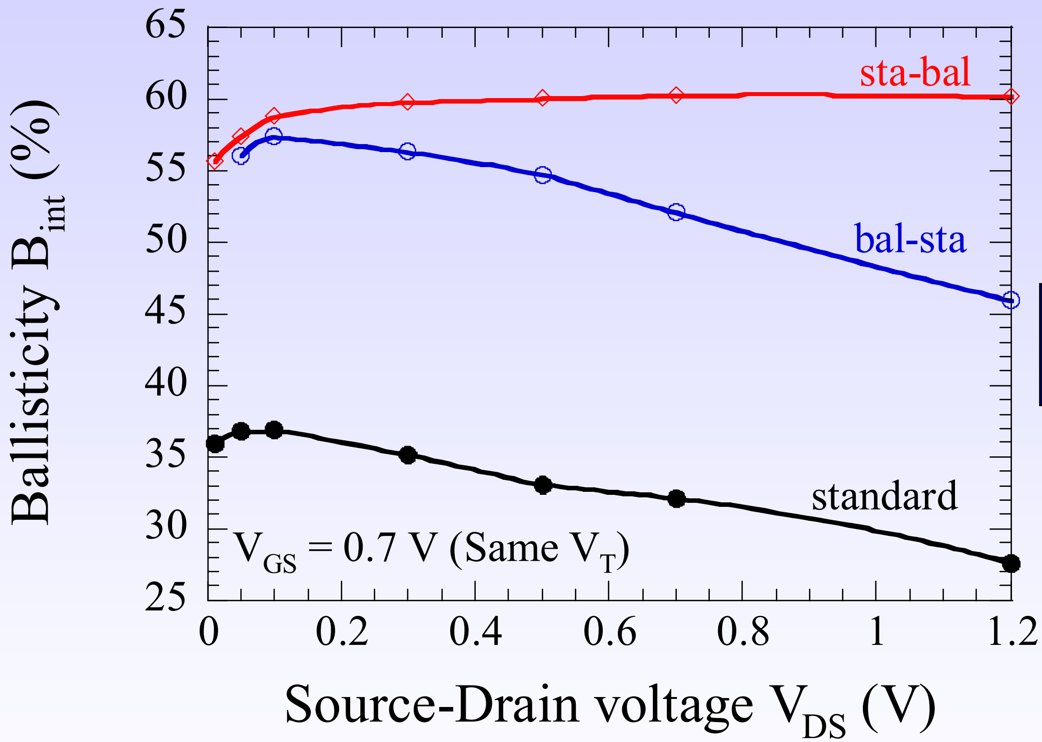
➡ B_{int} decreases when V_{GS} increases

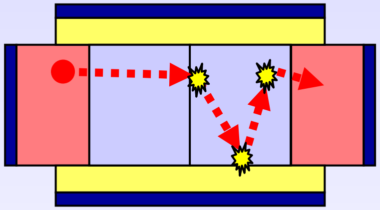
➡ B_{int} decreases when V_{DS} increases

‘Sta-bal’ and ‘bal-sta’ architectures



B_{int} (V_{DS}): 'sta-bal' vs. 'bal-sta'





➡ B_{int} decrease is due to scatterings in the 2nd half of the channel

Higher phonon scattering rate > driving field

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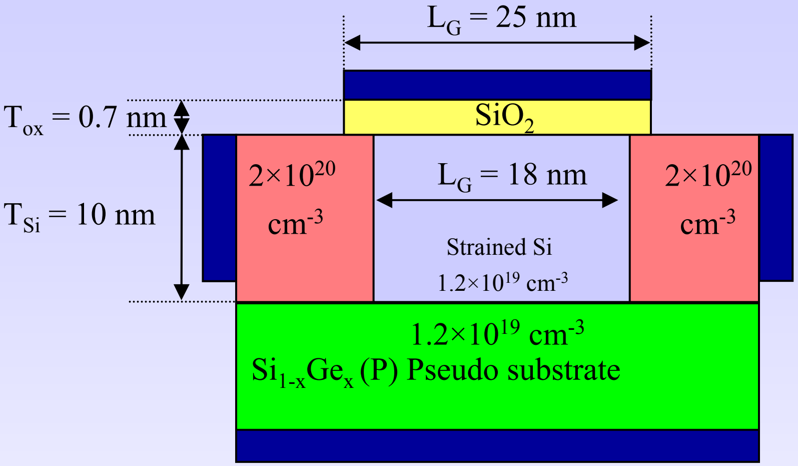
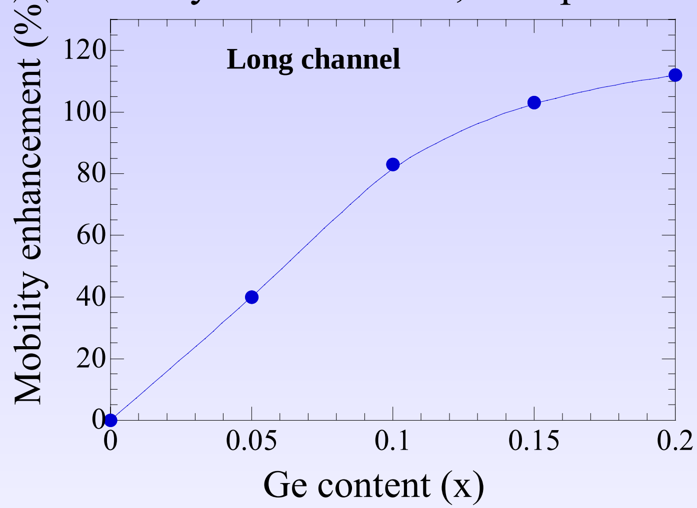
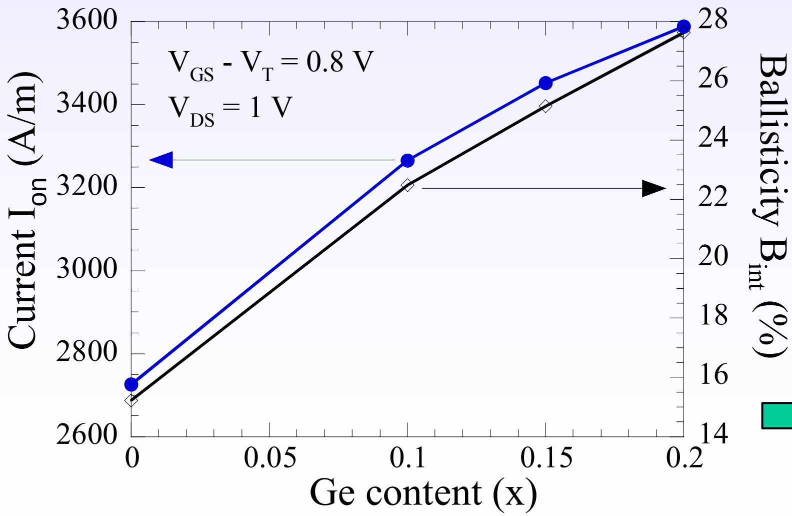
Studied strained SGMOS



V. Aubry-Fortuna *et al.*,to be published



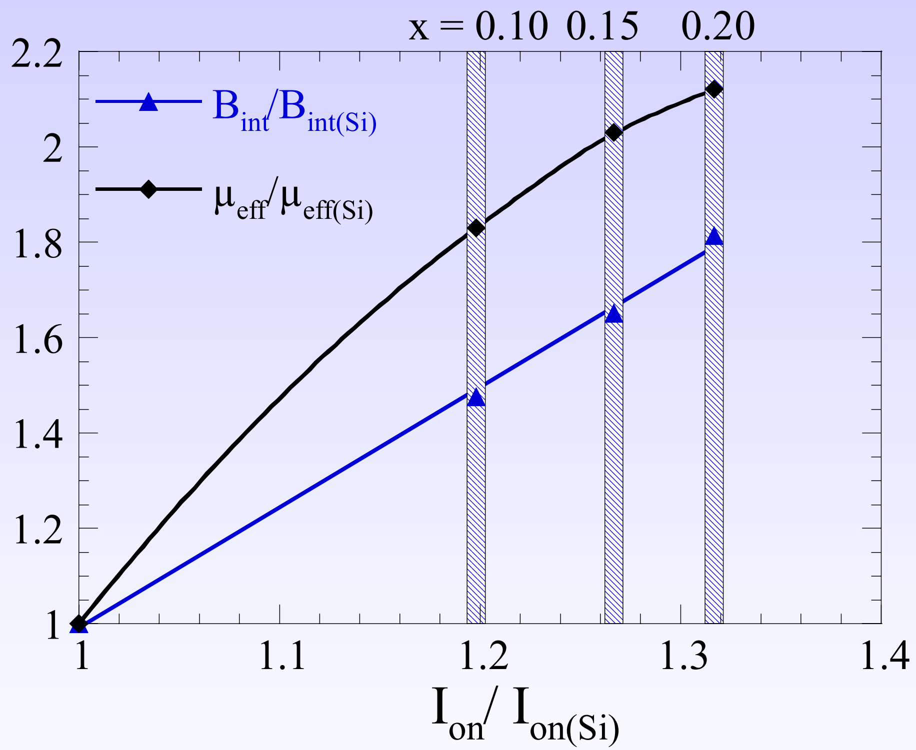
‘x’ increase
⇒ Strain increase
⇒m_t population increase
⇒ μ_{eff} enhancement



➡ μ_{eff} saturation for x > 0.15

➡ I_{on} and B_{int} increase similarly

$I_{on}(B_{int})$ vs. $I_{on}(\mu_{eff})$



B_{int} more relevant than μ_{eff} to account for I_{on}

($B_{int}(I_{on})$ linear for $B_{int} \in [\ 15\%, 30\%]$)

Conclusions

- ☑ Connections between B_{int} and:
  - channel length
  - strain
  - bias
- ☑ High quasi ballistic influence for $B_{int} < \approx 20\ \%$
- ☑ B_{int} more relevant than μ_{eff} to account for I_{on}

 Role of MOS architecture (*cf.* paper)

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