

Atomistic Tight-binding Modeling of III-Nitride

Materials and Field Effect Transistors

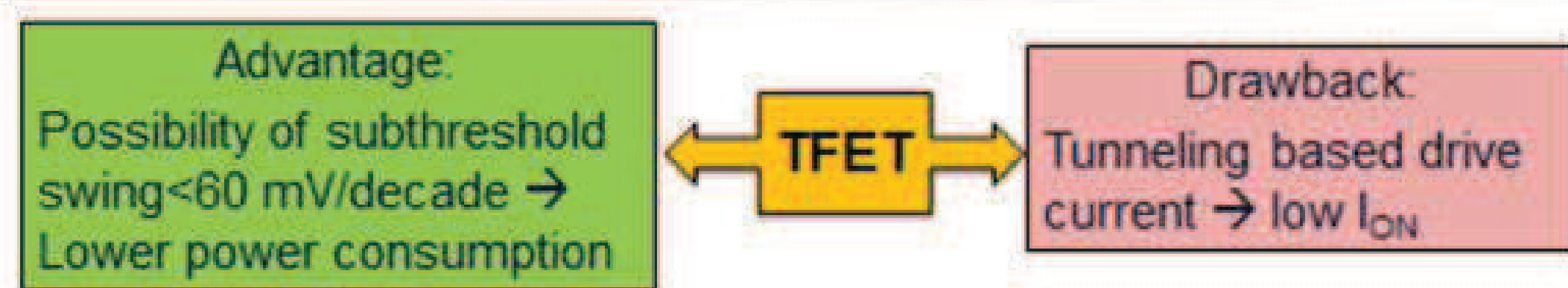
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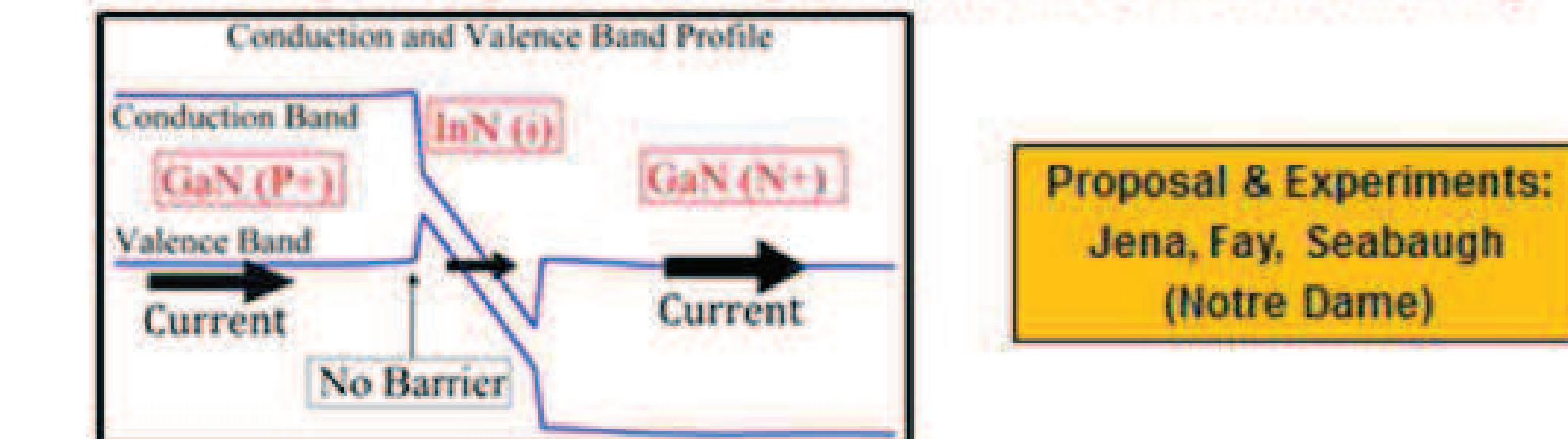
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III-Nitride as a prospective TFET



Tunneling rate increase in III-Nitride TFETs

- Large polarization field → small tunneling length.
- Small effective mass (e.g., bulk InN ~ 0.20 m_0)
- Tunneling through low bandgap material → efficient tunneling



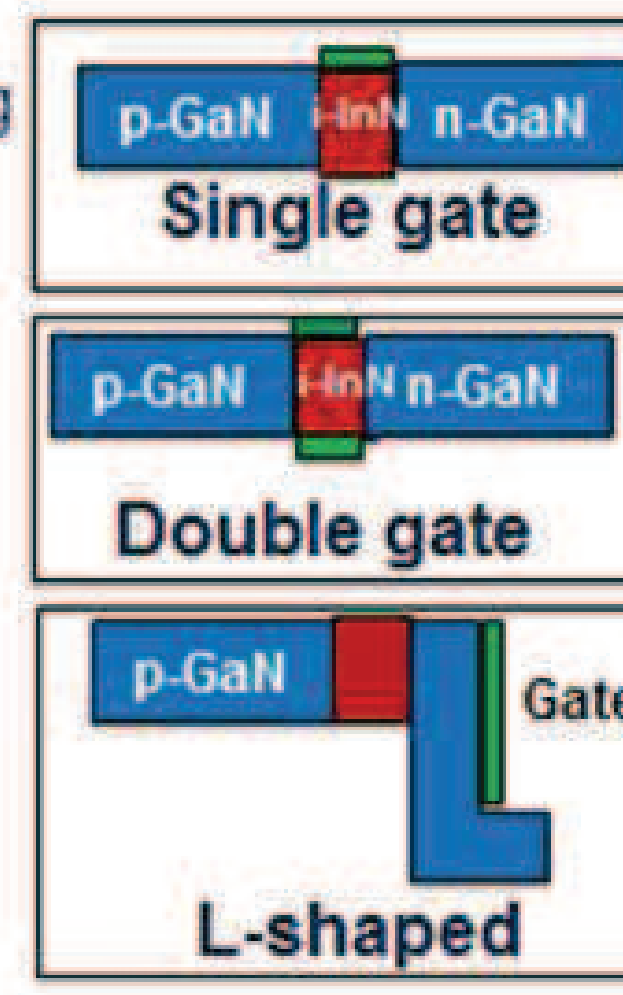
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Design issues in III-Nitride TFET

- Geometry for best gate control: Single gate vs Double gate vs L-shaped
- Polarization engineering for efficient tunneling
- Optimized doping density
- Effective oxide thickness
- Effect of InGa alloy
- Effect of strain
- Role of non-idealities: defects, dopants
- Effect of scattering mechanisms



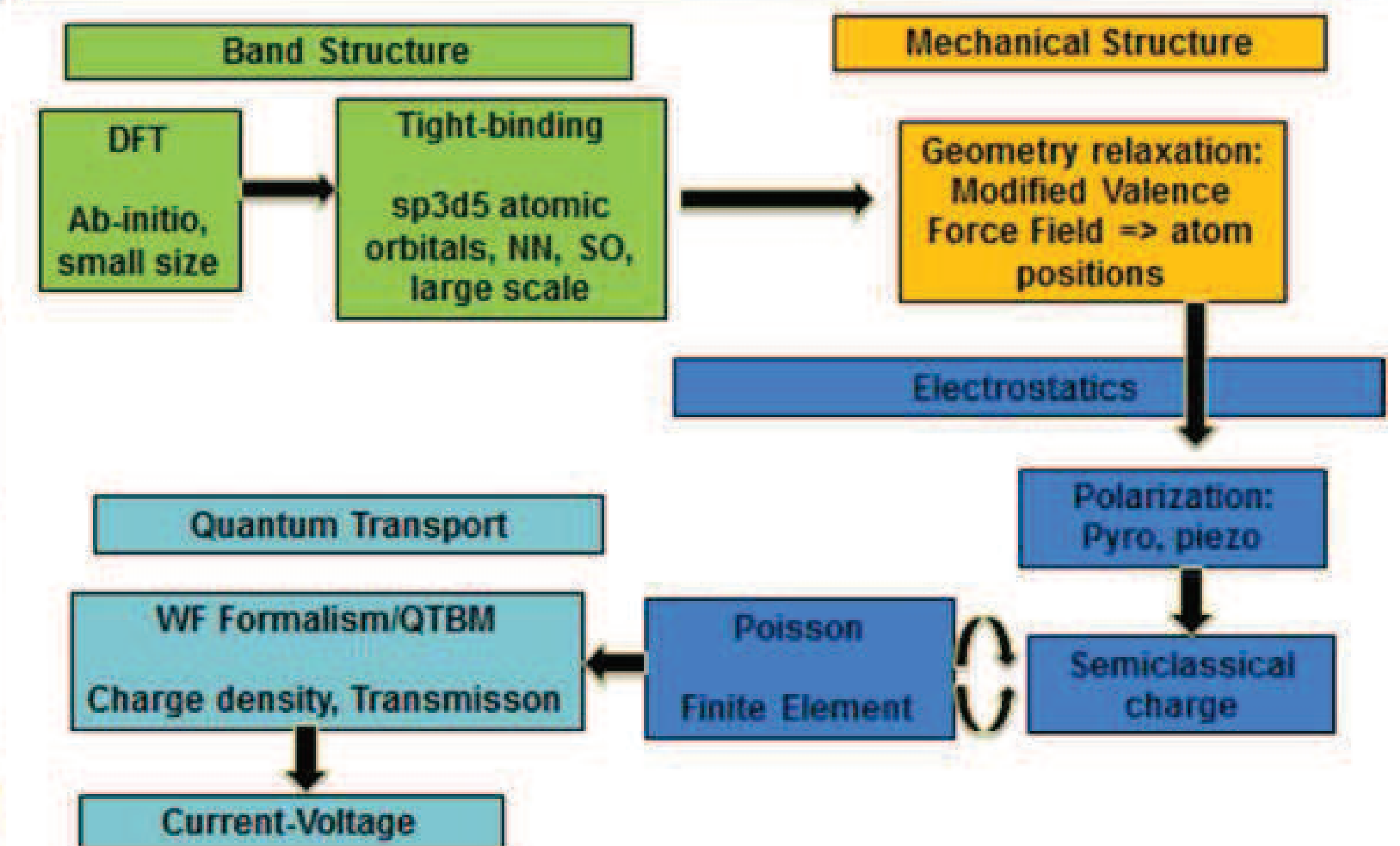
Atomistic Quantum Transport needed to address design issues.

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Components of Atomistic Simulations

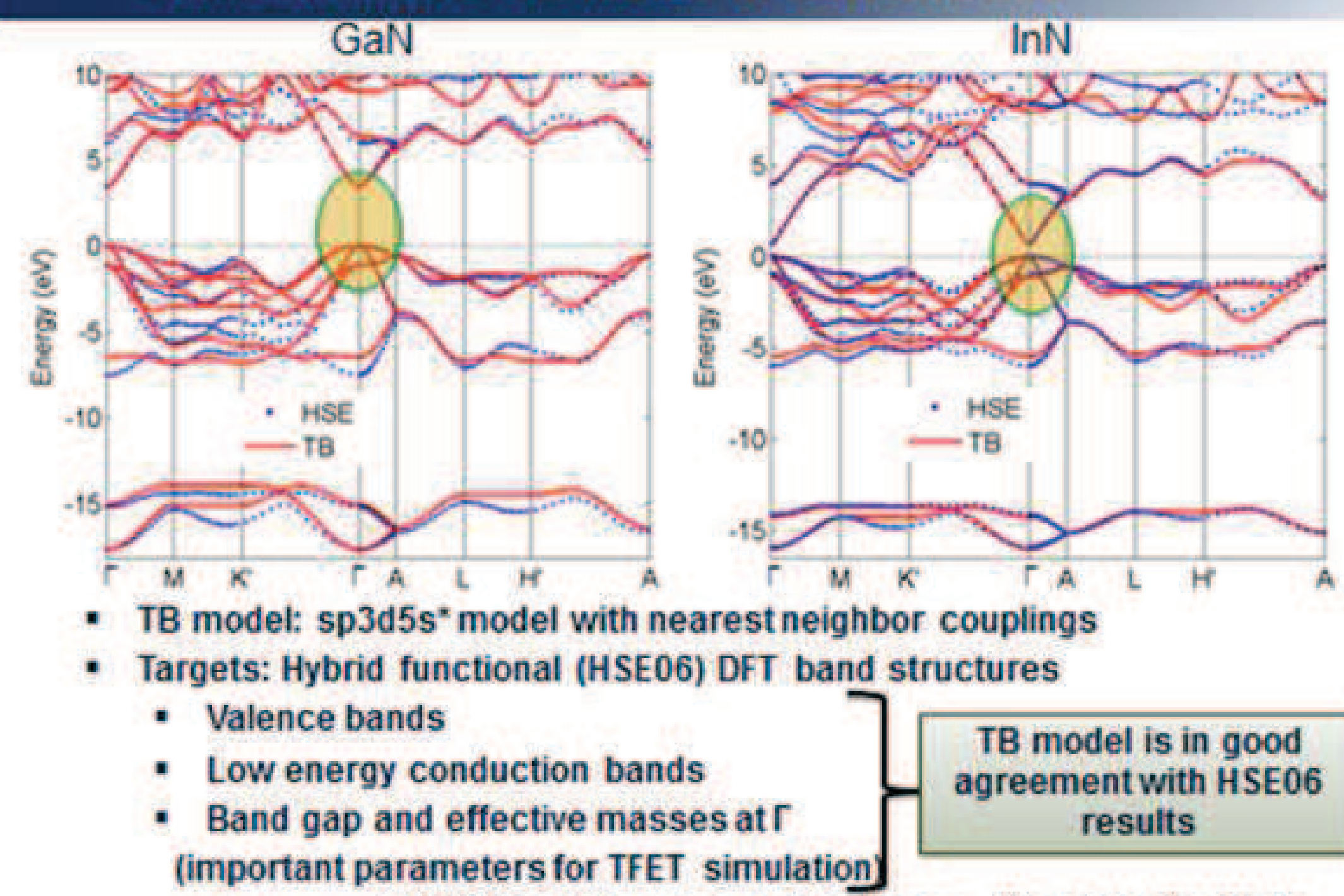


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Band Structure: TB model of GaN and InN

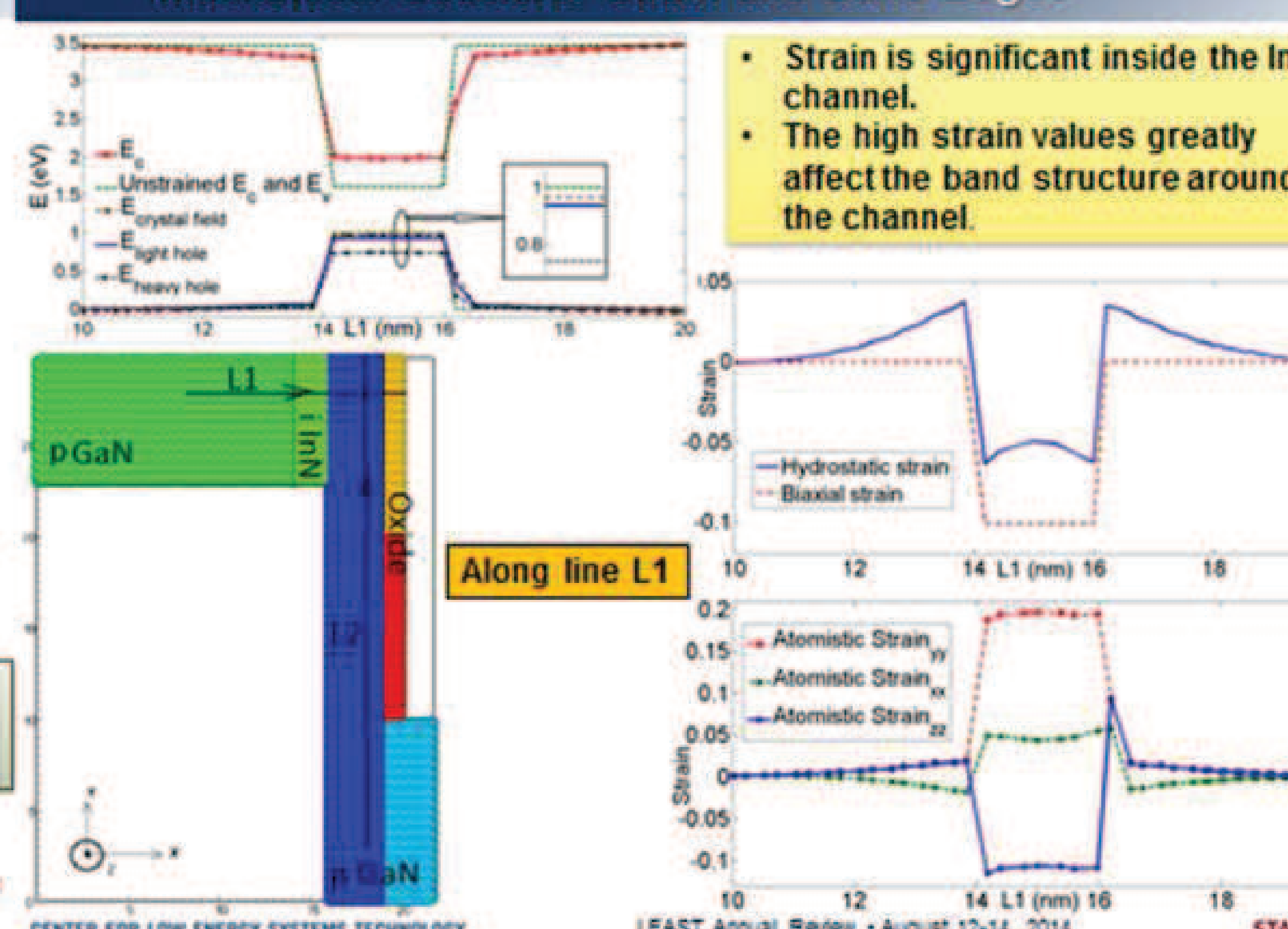


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Mechanical Structure: Strain and Band Edges

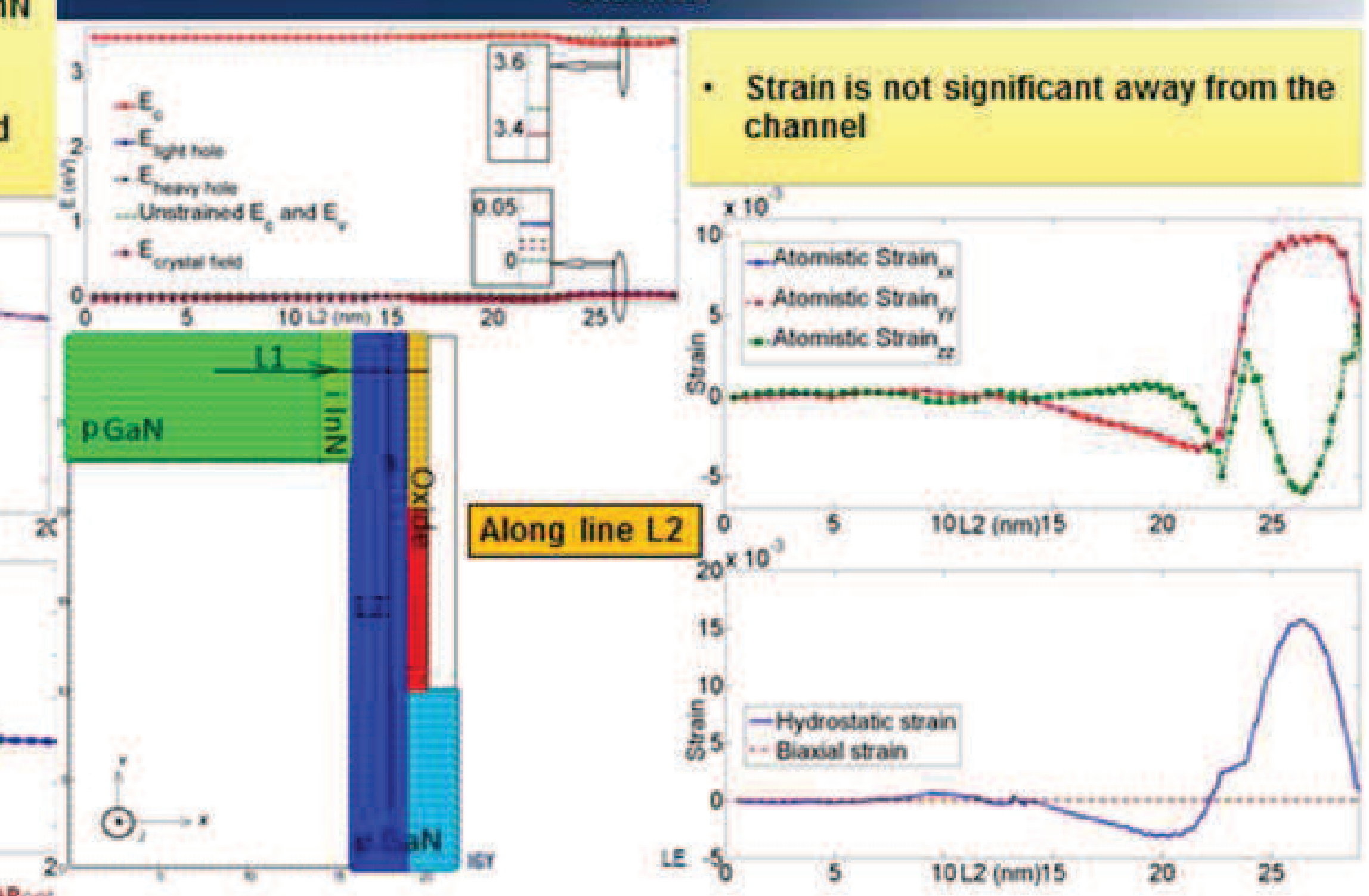


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Strain and Band Edges in the device away from the channel

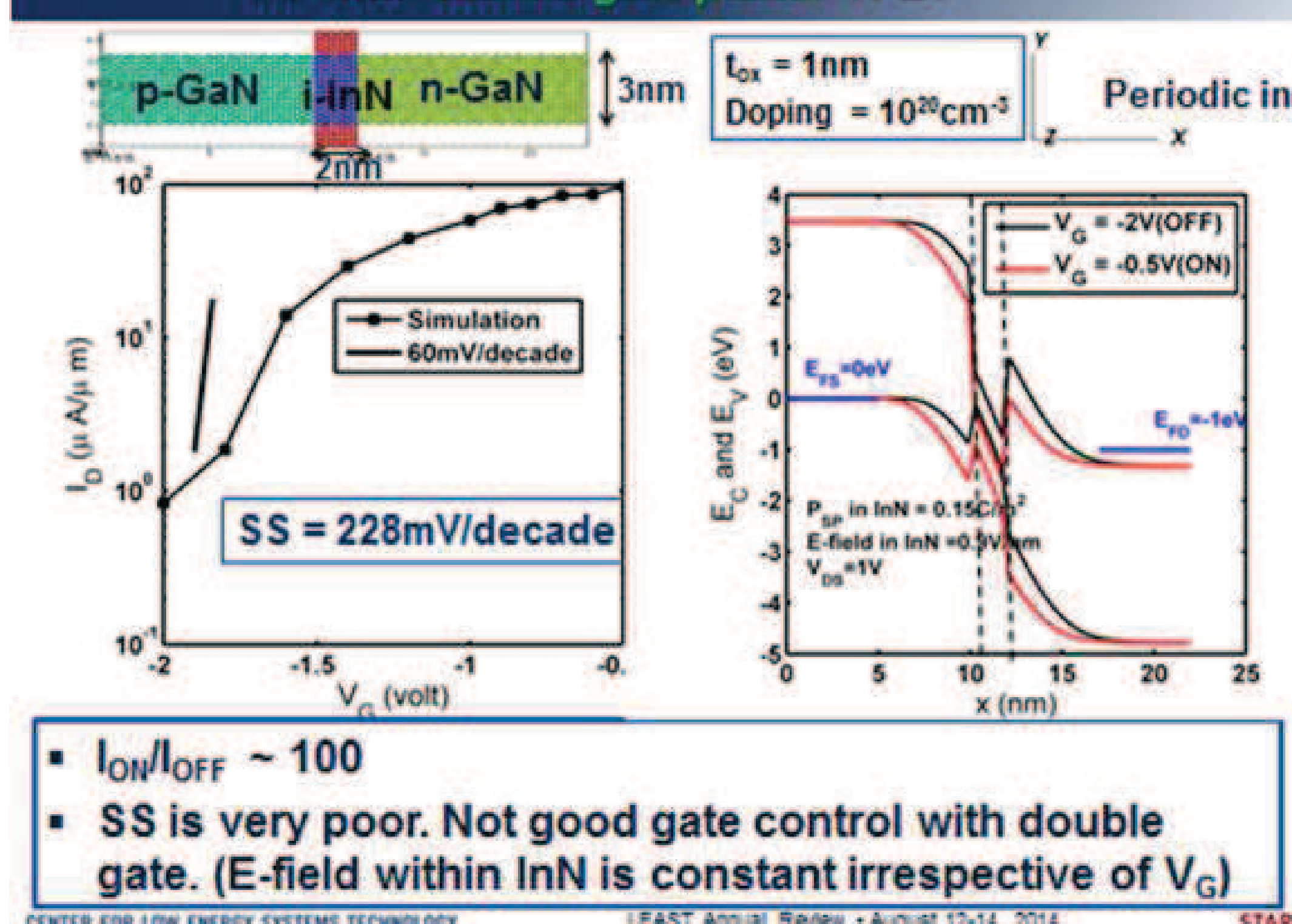


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I-V from double gate planar TFET

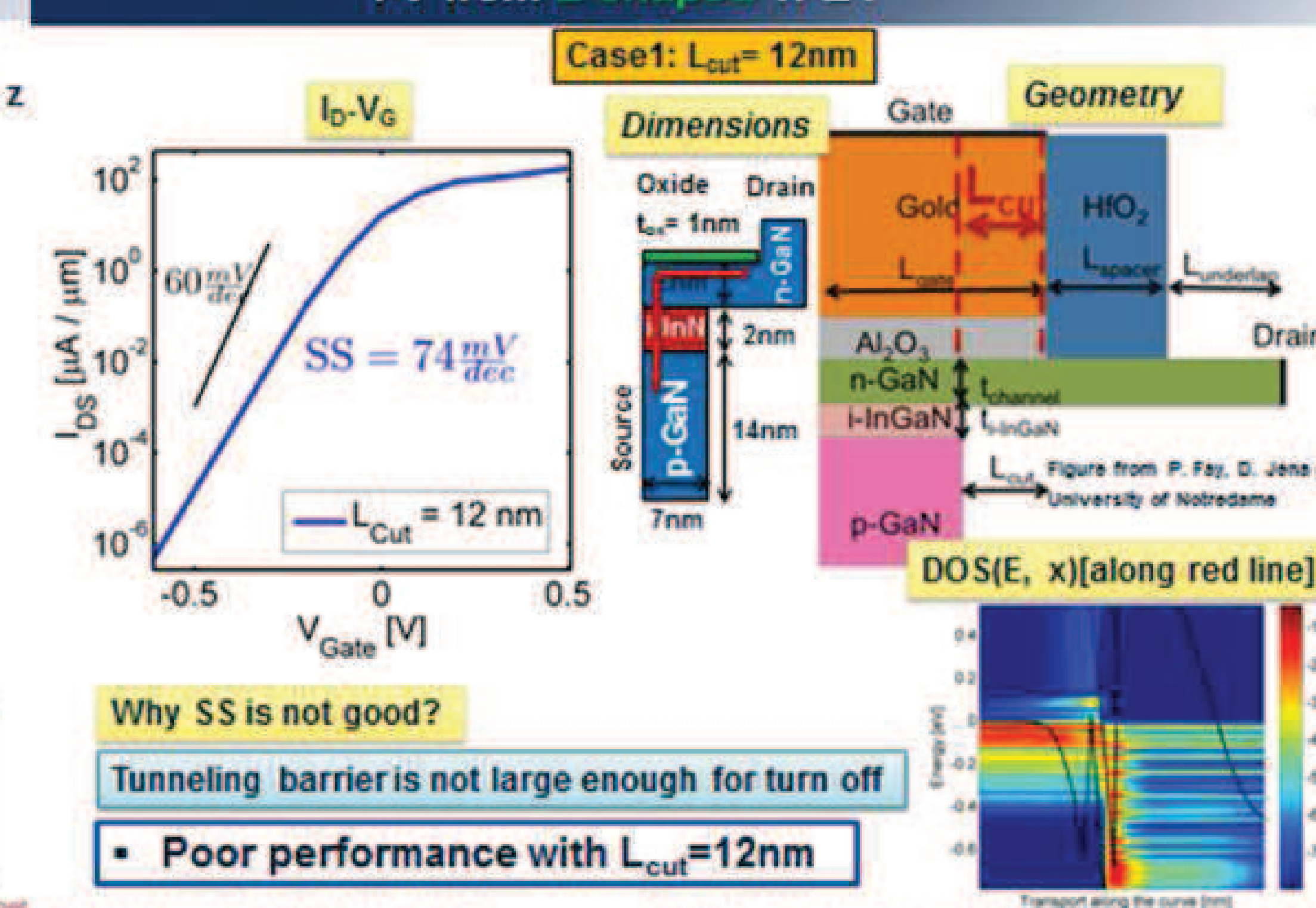


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I-V from L-shaped TFET

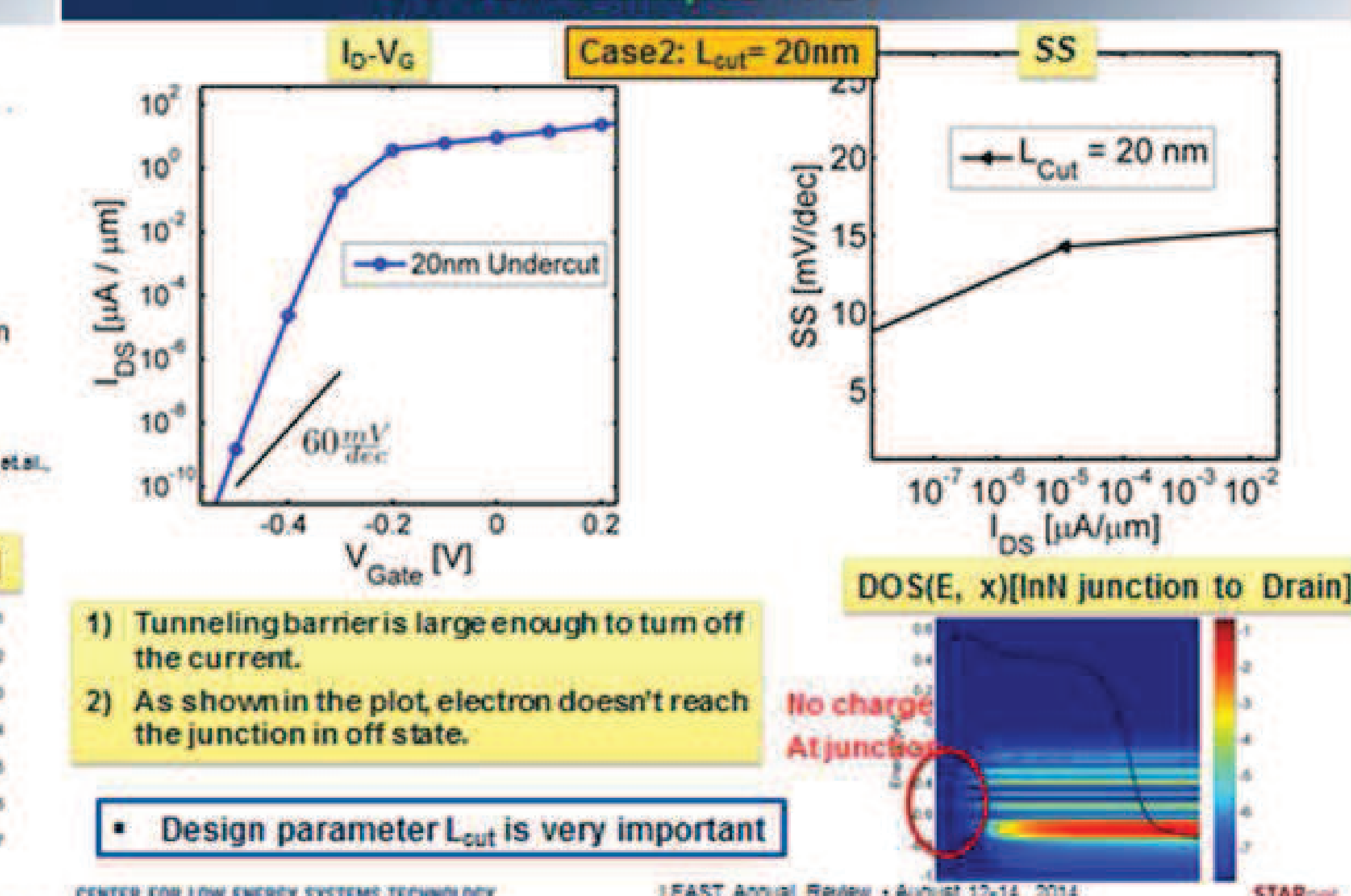


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I-V from L-shaped TFET

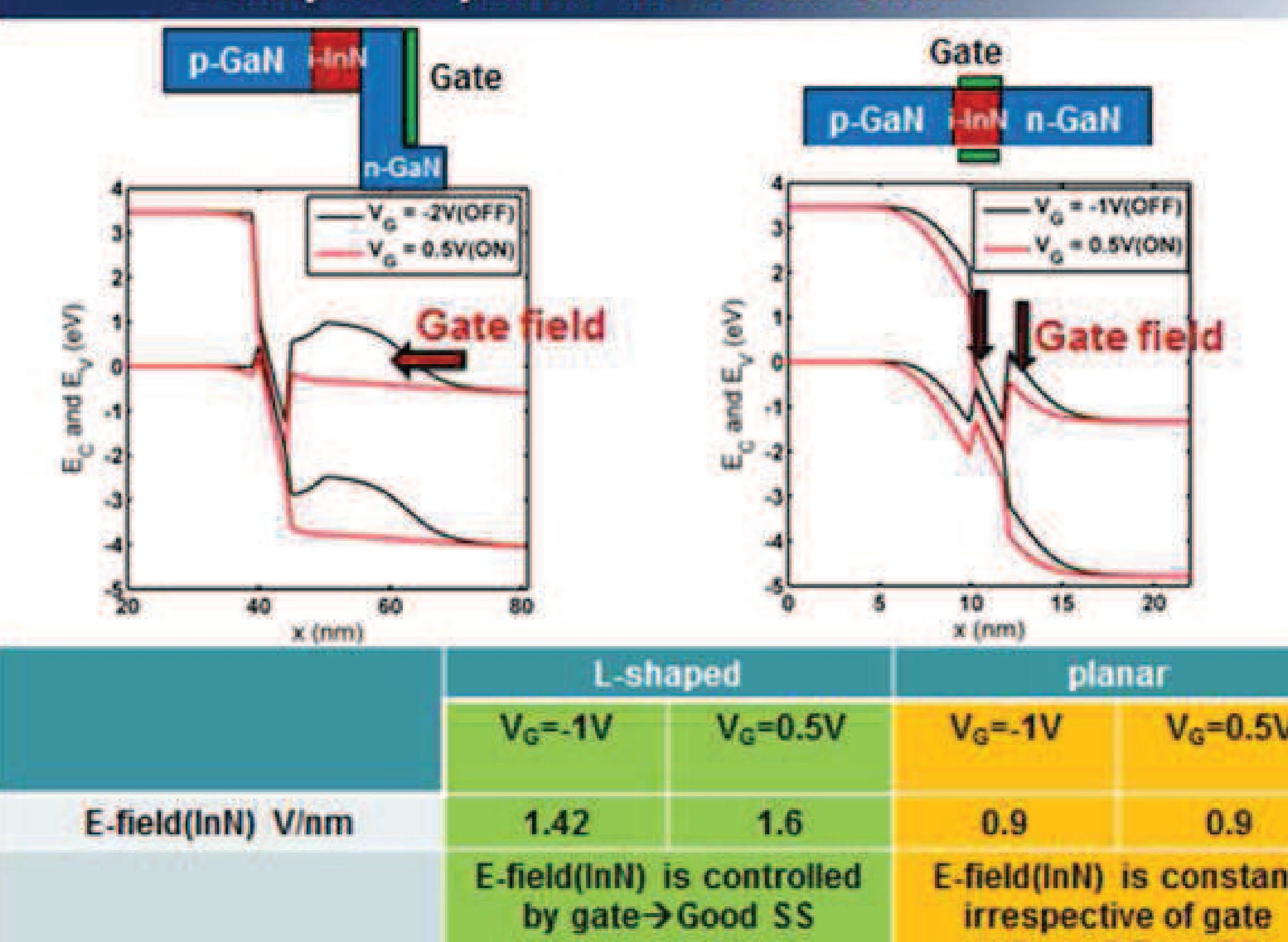


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L-shaped vs planar TFET: Gate control

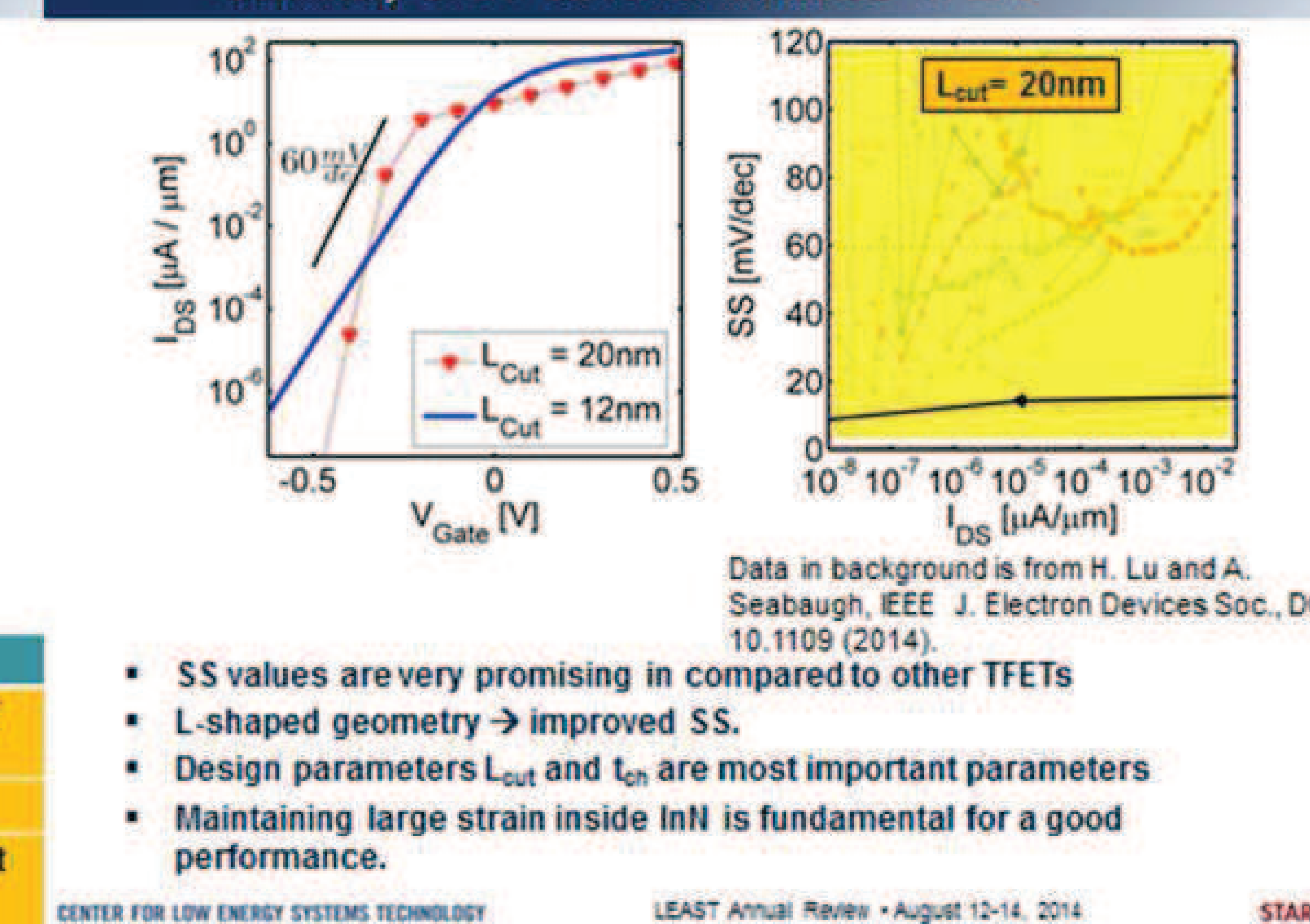


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Summary of I-V curve for III-Nitride TFETs



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Conclusion

L-shaped vs planar geometry:
L-shaped provides better electrostatics. Scopes for improved SS

Design engineering:
Optimization of design parameters (L_{cut} , t_{ch} etc.) is critical.

Effect of strain:
Piezoelectric strain modifies band structure in the channel, hence possibility to control tunneling

Future Work:

- Model inhomogeneous/atomistic polarization in the device.
- Study how strain modifies bandgap, effective mass etc., and hence, contributes to tunneling.
- Role of InGa alloy in TFET performance.
- Role of deep acceptor levels