Physical Compact Modeling

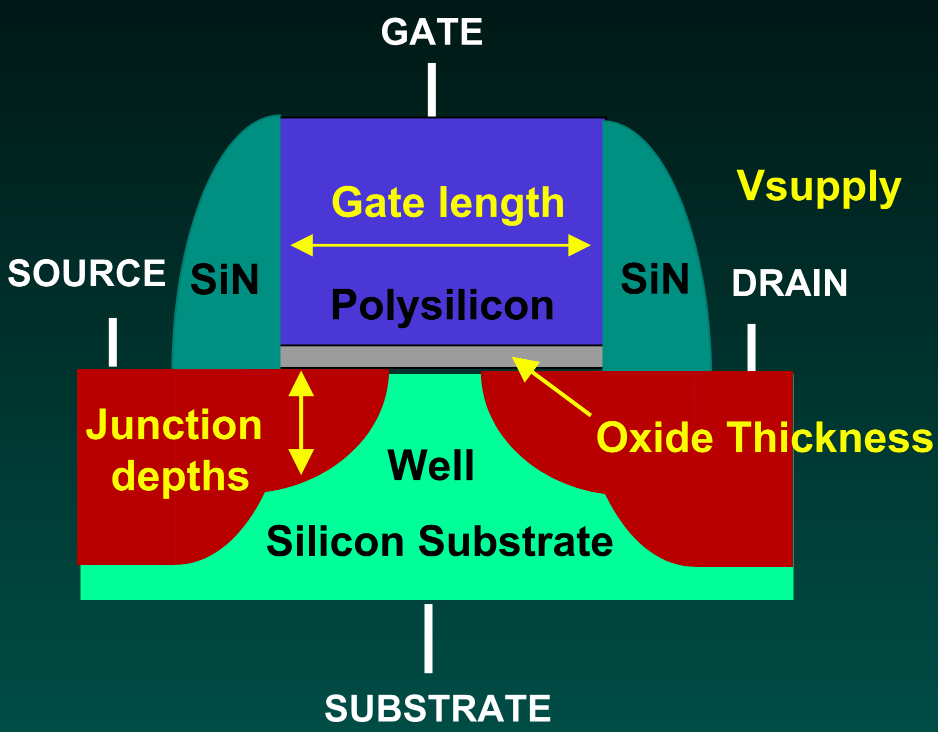
Shiuh-Wuu Lee

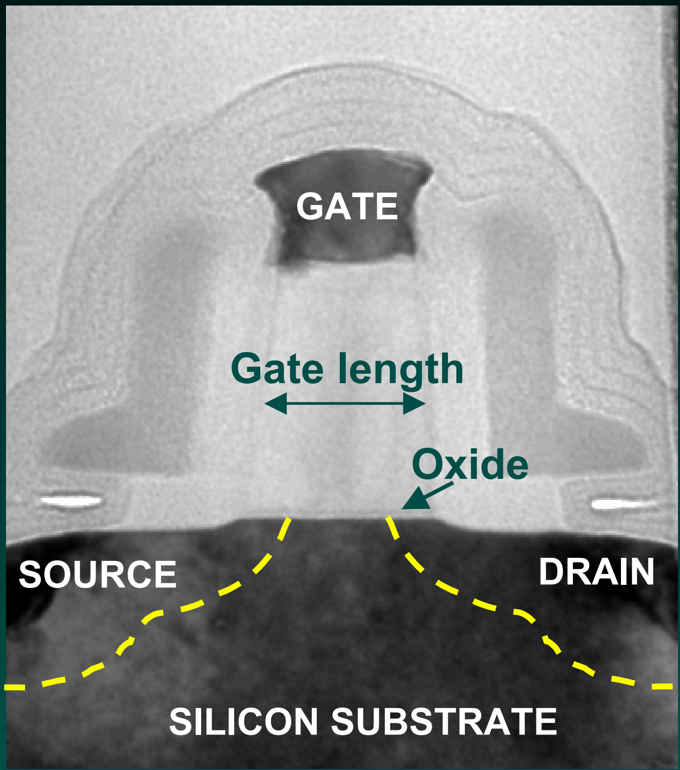
Technology CAD Division
Intel Corporation

Outline

- Three Main Areas of Physical Compact Modeling
- Roles and Requirements of Compact Models
- Scenarios of Compact Model/Simulator Usage
- Issues
- Conclusions

Compact Transistor Modeling

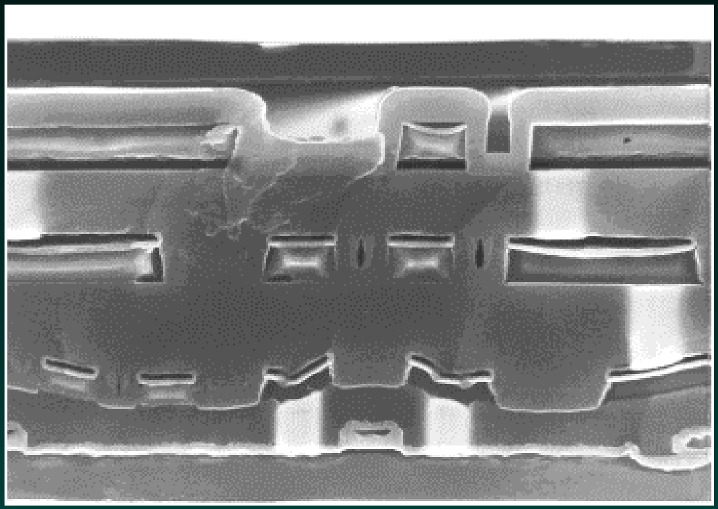




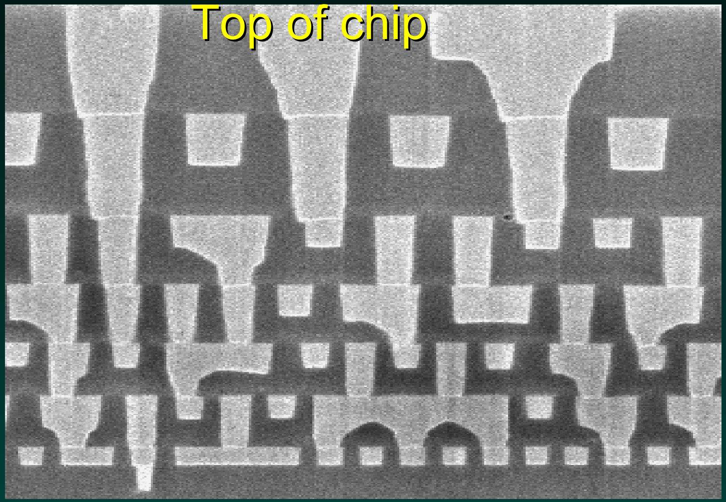
- Aggressive scaling of device dimensions & Vcc, complex doping profiles, and GHz operation

Compact Interconnect &
Passive Component Modeling

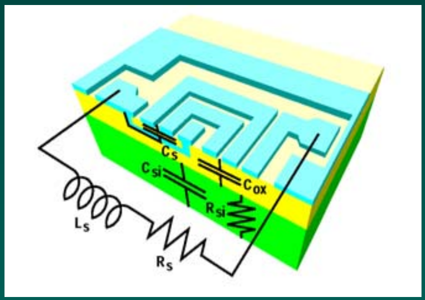
0.5 μm Interconnects

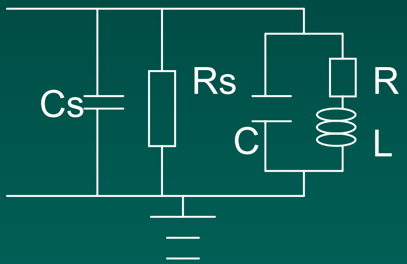


0.09 μm Interconnects



Spiral Inductor → **Equivalent circuit**

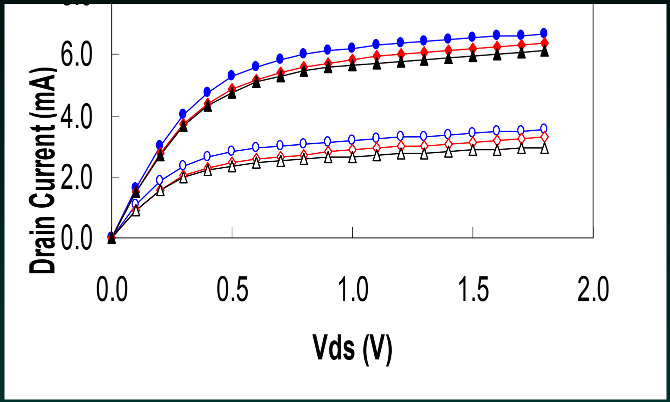




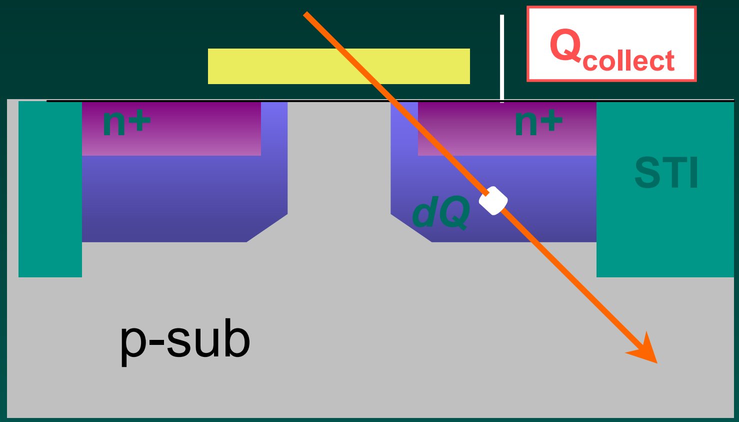
- **Interconnect metal pitch scaling, increased aspect ratio, complex ILD composition, GHz operation**
- **RF components**

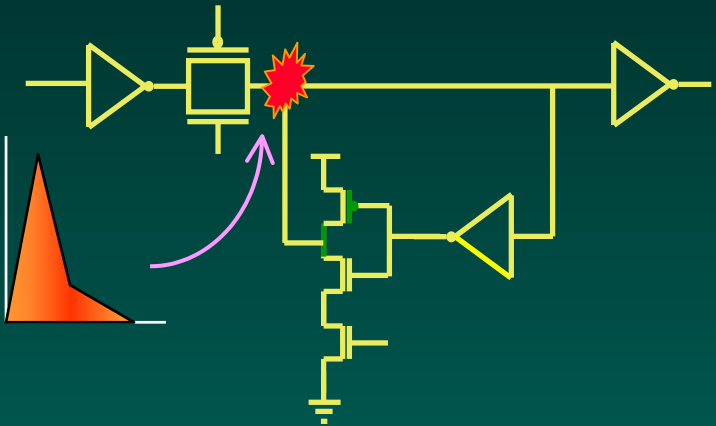
Compact Reliability Modeling

- Hot Carrier Device Degradation



- SER





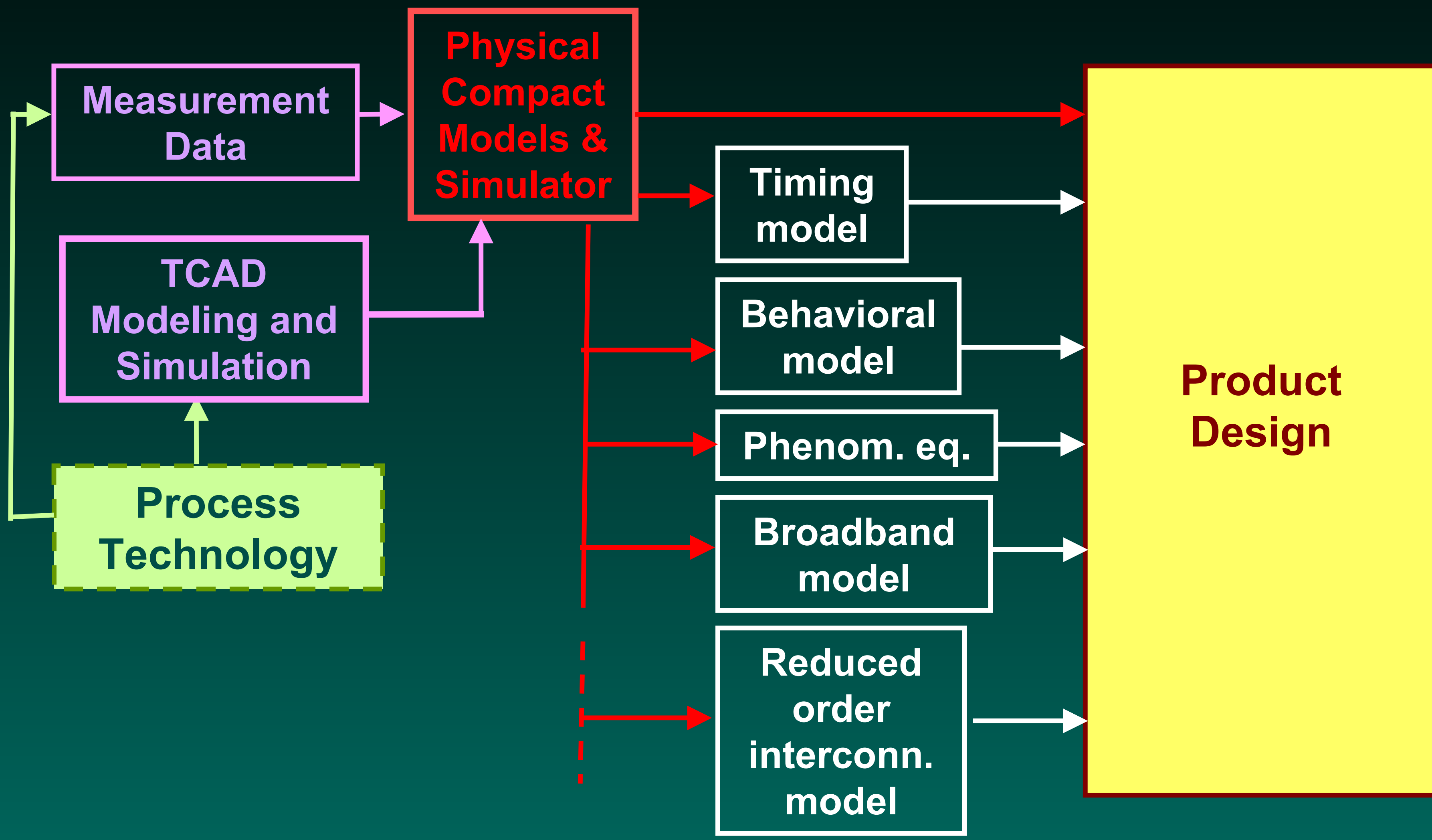
- EM
- Oxide Wear Out

- Reliability has become a technology limiter and should no longer be an after-thought

Outline

- Three Main Areas of Physical Compact Modeling
- Roles and Requirements of Compact Models
- Scenarios of Compact Model/Simulator Usage
- Issues
- Conclusions

Physical Compact Models – Link Between Technology and Design



- **Technology Definition and Design Exploration**
  - Contain a wide range of physical phenomena
  - Remain physical over a wide range of process conditions to support "what if" experimentation
  - Extendable with quick incorporation of new device physics
  - Tight link to TCAD process/device simulators
- **Synchronized Design with Technology Development**
  - Quick and accurate model characterization
  - Physical modeling in re-targeting and of process corners
  - Scalable
  - Robust and cpu efficient
- **Manufacturing**
  - E-test based monitoring on process shift & process variation

Outline

- Three Main Areas of Physical Compact Modeling
- Roles and Requirements of Compact Models
- Scenarios of Compact Model/Simulator Usage
- Issues
- Conclusions

- **Proprietary models in proprietary simulators**
  - Optimum simulation accuracy & performance
- **Industry-standard models in proprietary simulators**
  - Communication vehicle with external partners
  - Filling gaps in proprietary models
- **Industry-standard models in EDA vendor simulators**
  - Leveraging EDA simulators and industry-standard models to eliminate the need of internal development
- **Proprietary models in EDA vendor simulators**
  - Optimum simulation accuracy while leveraging EDA vendor simulators

Outline

- Three Main Areas of Physical Compact Modeling
- Roles and Requirements of Compact Models
- Scenarios of Compact Model/Simulator Usage
- Issues
- Conclusions

- **University research on compact modeling diminished dramatically during recent years.**
  - Modeling concepts
  - Supply of new blood for the industry
- **Laborious and error prone in model implementation**
  - Industry-standard models in proprietary simulators
- **Difficulties in user support**
  - Proprietary models in EDA vendor simulators

Conclusions

- **Scaling of physical dimensions approaching its limit.**
- **Technology evolution that meets Moore's law requires novel breakthroughs in device & interconnect.**
- **New compact models will be needed at a ever-faster pace to support technology definition, design exploration, product design and manufacturing**
- **This requires:**
  - Broadened industry-university partnership
  - Standardized environment for model delivery and implementation
  - Improved methodology for supporting proprietary & industry-standard models in EDA tools