Towards Contact Resistance Modeling

- Channel doping (S/D doping)
- New device geometries
- New channel materials
- Schottky height, doping concentration
- Contact area
- Objective

Objective
- Impact of interface area scaling as device shrinks.
- Significant increase of contact resistivity is observed when the metal-semiconductor junction area reaches to the certain limit (sub-10nm).

TB Fitting Model for Metal Wire Conductance

- Ballistic Metal Conductance
- Tight-binding method is employed for an accurate full quantum mechanical description of the electronic structure of pure metal.
- Fit the metal wire conductance from effective mass with TB results.

Specific Contact Resistivity 101

- Metallization for Metal Wire Conductance
- Metal-Si Contact Modeling in EM
- Low field I-V Linearity of M-Si Contact Model

Doping Effect in Si Contact Pad

- Highly doped Si contact pad in used, and [100] transport direction.
- Fixed N_Si=1x10^20 cm^-3 and A=1x10^-16 m^2 (parabolic non-ideality)
- Excluded Si region from scaling effect while downsizing contact region.

Schottky Barrier Height between M-Si Contact

- Transport receives spatial current spreading at contact and in Si
- Increased Schottky barrier height reduces current density (one order of magnitude for 0.5V)
- Barrier height can be varied through alloy magic

Metal Interconnect Scaling Effect

- Lower Schottky barrier indeed provide lower resistivity.
- Contact resistivity is almost constant while downsizing across sectional area of metal interconnect.
- Metal conductivity decreases linearly as while downsizing.
- No scaling effect is found within the ballistic transport regime in InSi structure.

Summary and Conclusion

- Contact resistance is becoming a critical factor in on-state performance of devices.
- Industry is in need of quantitative nano-scaled contact models.
- Mode mismatch plays a role at the nano-scale.
- Simple effective mass model calibrated against more complex DFT+ tight-binding DOS.
- Modeled simple 2-D / 3-D M-Si junction structure.
- Fit ballistic conductance of pure metal (Cu) wire in EM with TB.
- Conclusions:
  - Contact resistivity is almost constant while downsizing across sectional area of metal interconnect.
  - Surface roughness of metal wire and grain boundary distribution are expected to cause the conductivity degradation.