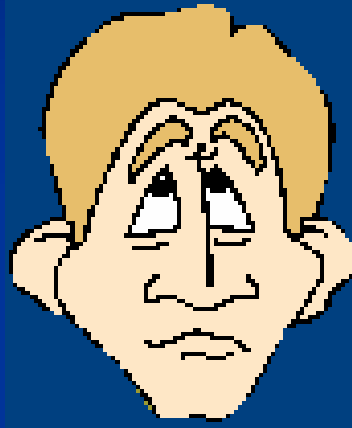


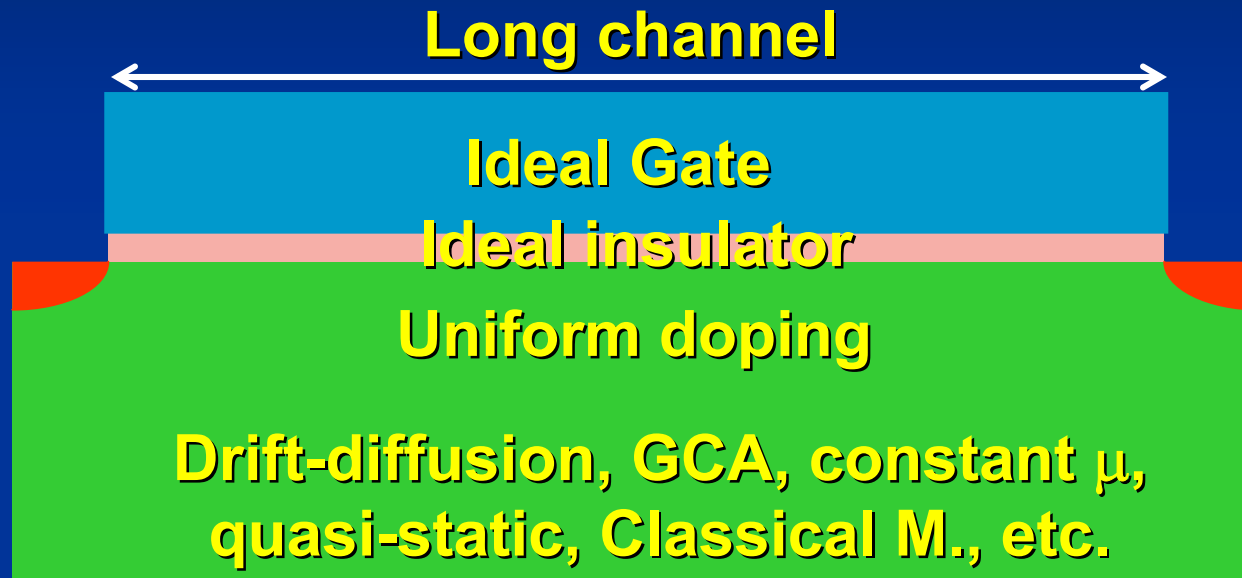
$Q_i$ -based?

$\phi_s$ -based?



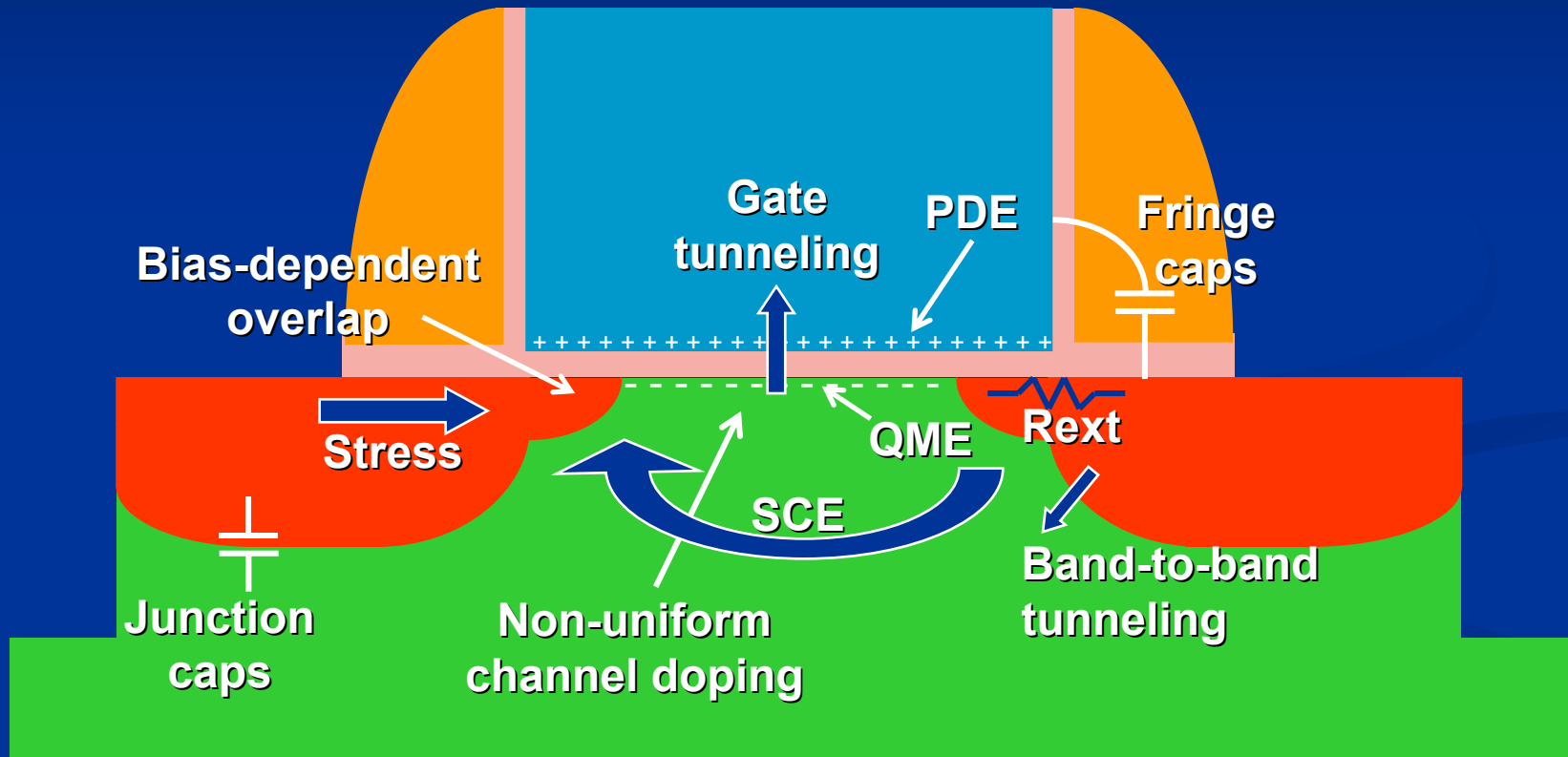
**How critical is the core  
model choice?**

# Relatively easy to model this



This is what the core model deals with

# But we need to model this...



# MOSFET Model Requirements (to be production worthy)

**Must have**

1. Physically sound core model
2. Completeness: SCE, NCE, QME, PDE, RSCE,  $I_g$ ,  $I_b$ ,  $C_{ov}$ ,  $R_{ext}$ ,  $C_j$ , NQS, noise, etc.
3. Efficiency

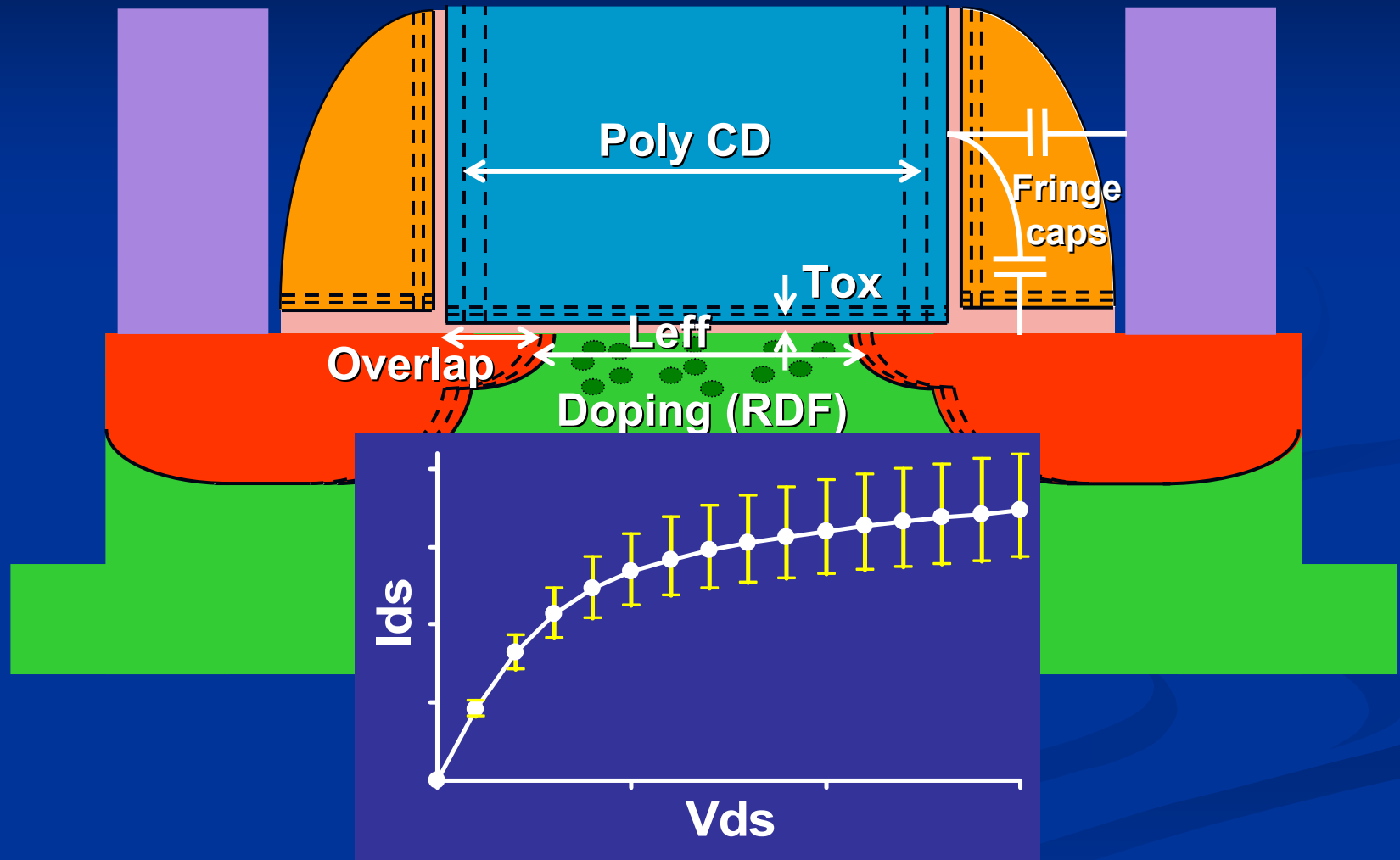
**Nice to have**

4. Small (<100) set of model parameters
5. Scalability
6. Simple, intuitive code

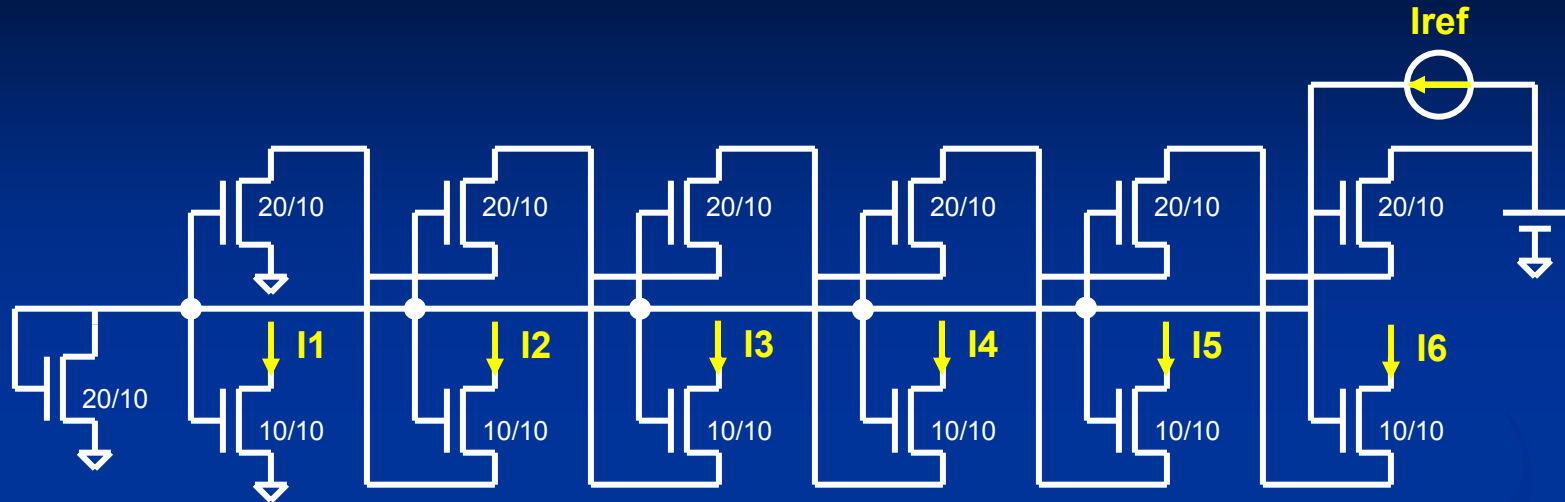
# Model Accuracy vs. Reality

**How critical it is to achieve  
model perfection for real  
applications?**

# Reality: process variations



# Example 1: R2R Ladder Circuit



**Circuit should produce:**

$$I_{ref} = 2 I_1 = 4 I_2 = 8 I_3 = 16 I_4 = 32 I_5 = 64 I_6$$

**Model requirement:**

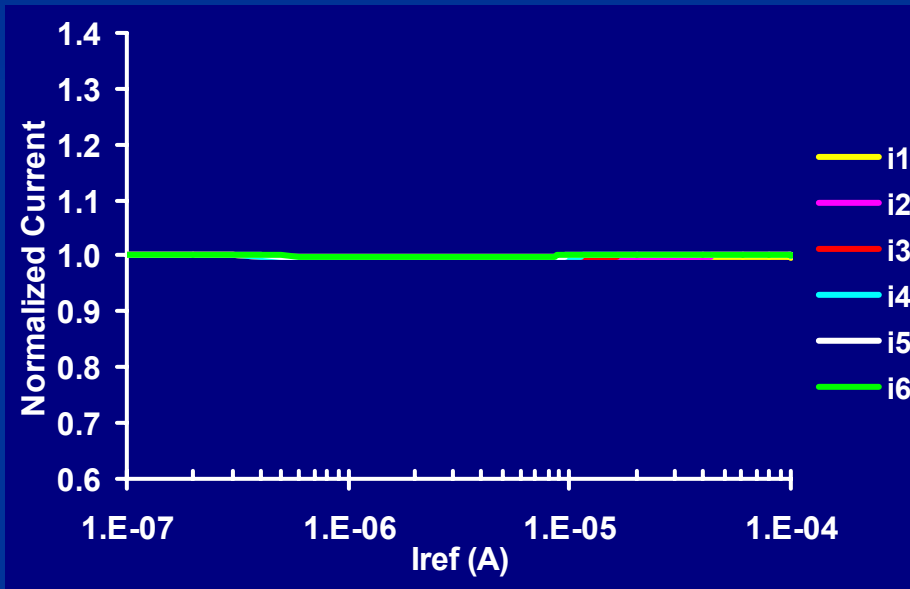
- Correct linearization of  $\mu \cdot Q_{inv}$   
(Klaassen, IEICE Trans. Electron., June '04)

**Real devices requirements:**

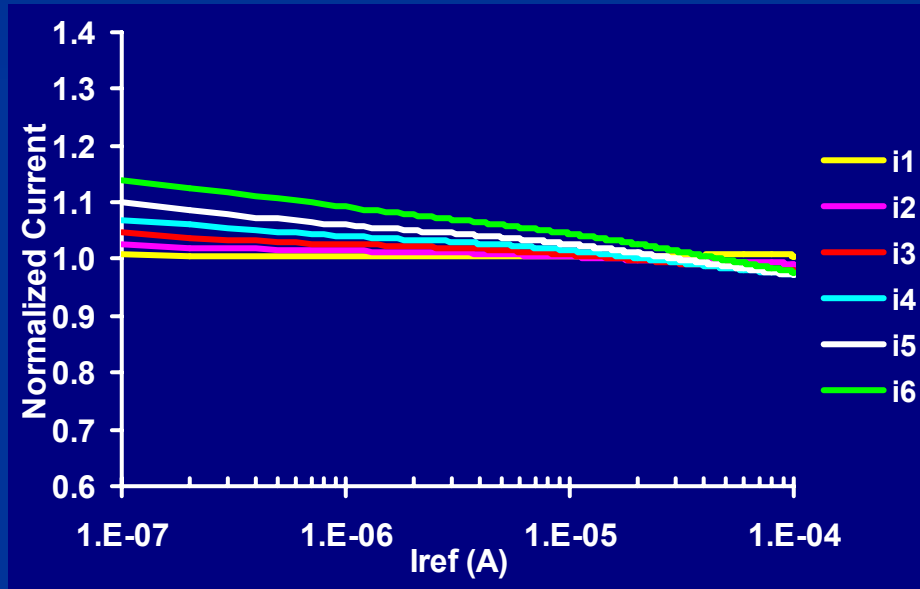
- Long channel, uniform lateral doping, no gate leakage.
- Devices must be identical (no process variations).

# Model Influence on R2R

“Ideal”  
Constant  $\mu$ , no  $I_g$ , etc.

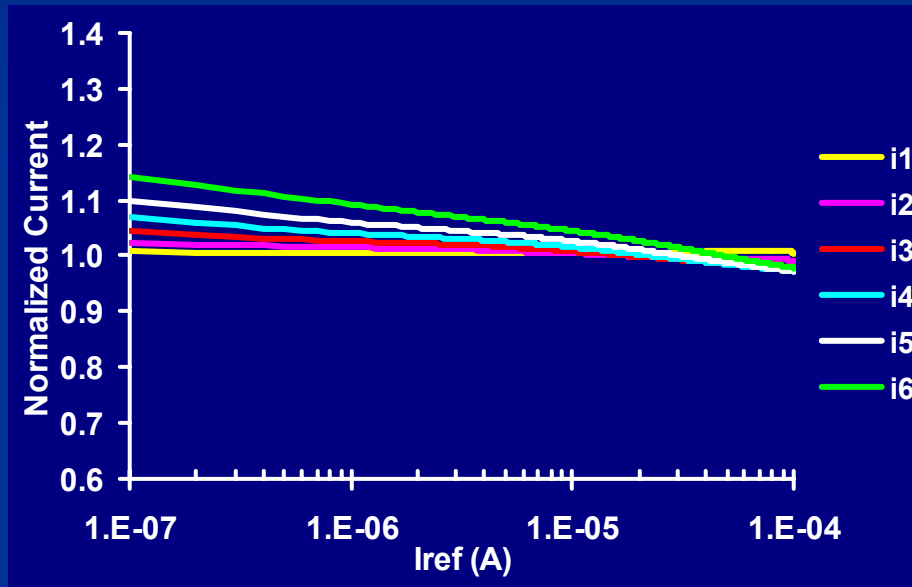


Full model  
(uniform doping)

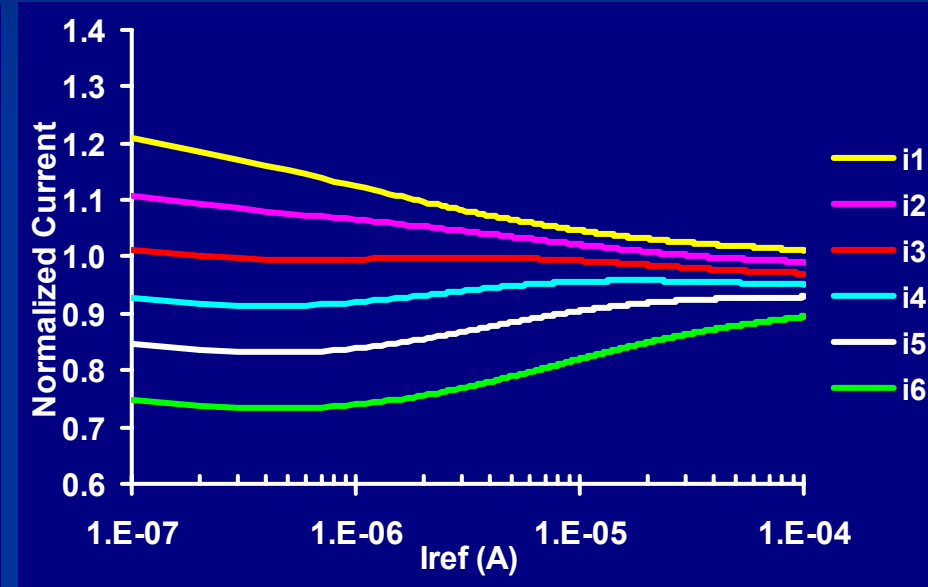


# Influence of Non-Uniform Channel Doping

## Flat-well



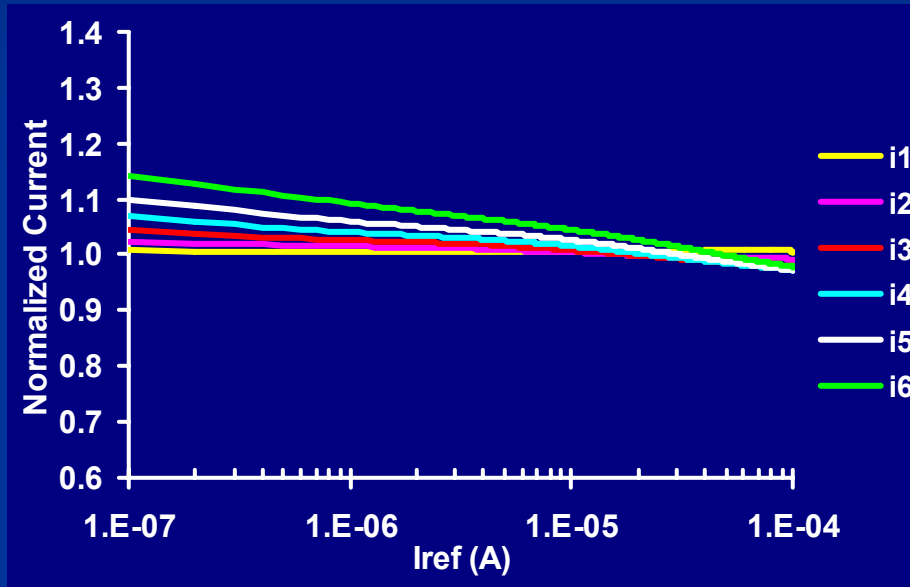
## Halo



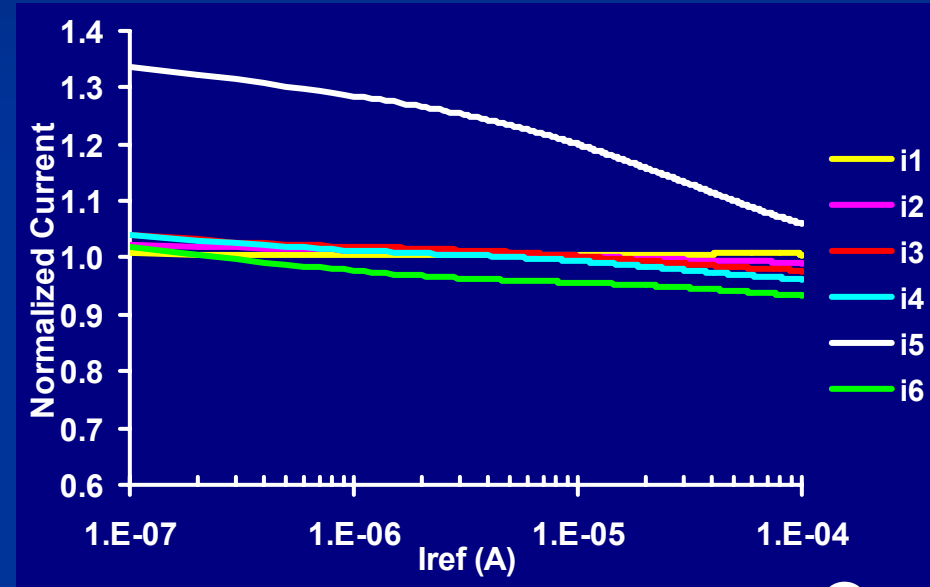
Large mismatch due to long-channel DIBL of halo devices

# Process Variation Influence

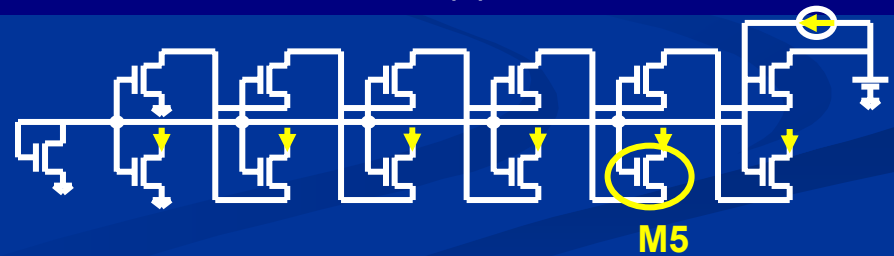
## Identical Devices



## Vt of M5 changed by 3%



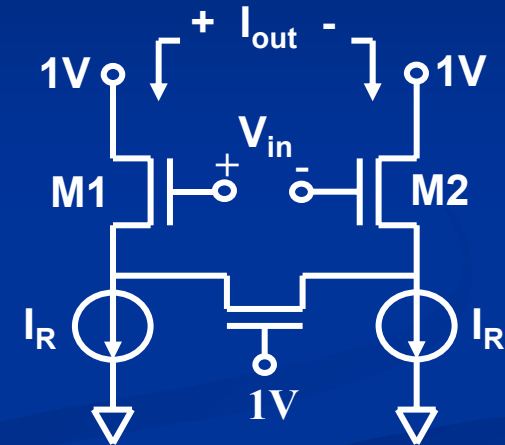
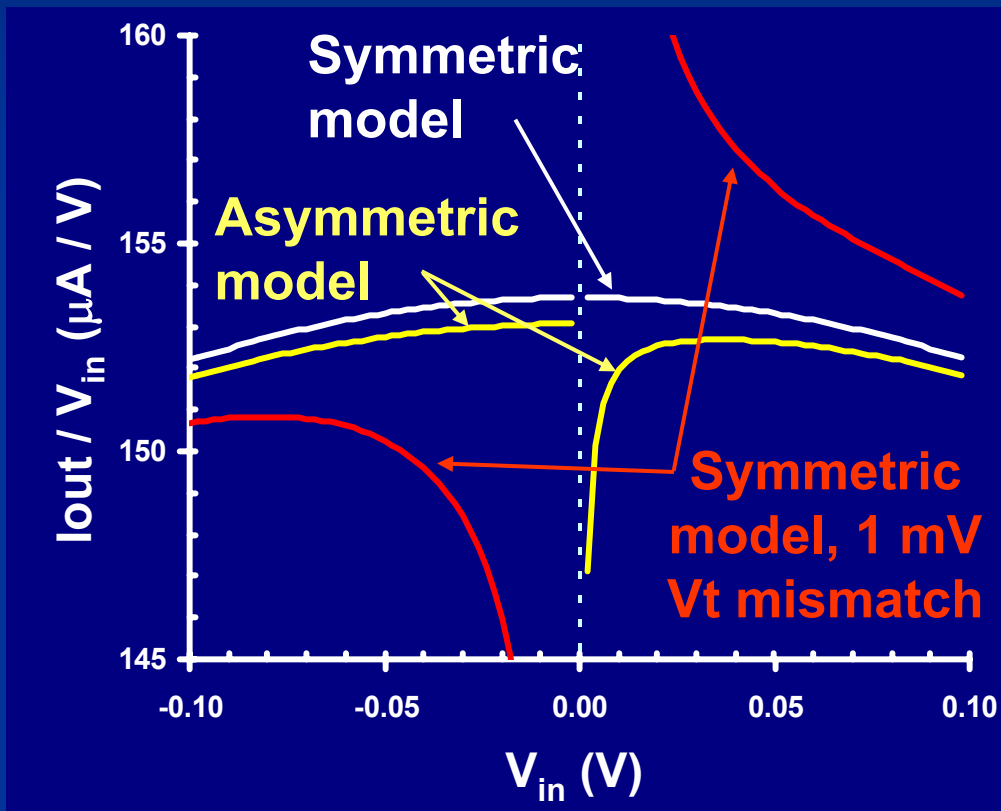
Large mismatch due to  $V_t$  variation



# Example 2: V-I Converter

Proposed as symmetry test,

D. Klaassen, IEICE Trans. Electron., June 2004



Model symmetry may not be so critical (at least for this circuit)