

Explicit Threshold Voltage Based Compact Model of Independent Double Gate MOSFETs

Marina REYBOZ, Thierry POIROUX, Olivier
ROZEAU, Patrick MARTIN & Jalal JOMAAH

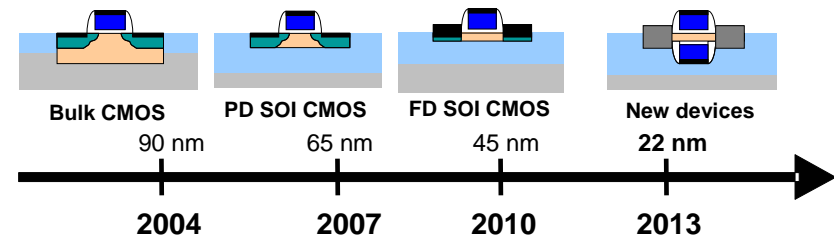
OUTLINE

- **IDG ARCHITECTURE**
- **MODELING DIFFICULTIES**
- **BASIS OF THE MODEL**

1 IDG ARCHITECTURE

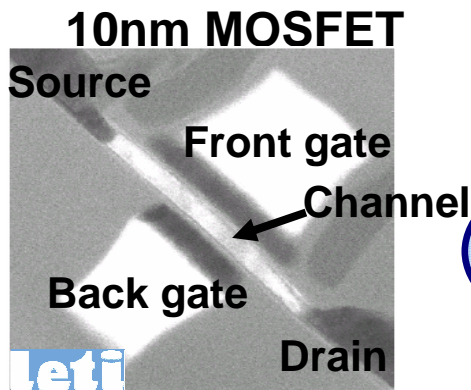
- New Devices

- Classical CMOS technologies + forecasts of the ROADMAP = ?



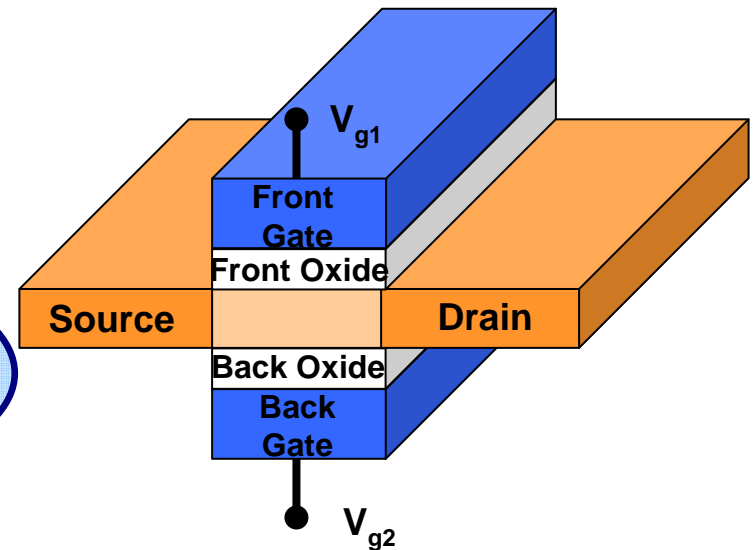
- New devices: **GAA, FinFET, SON & planar DG MOSFET**

- IDG Mosfet



let
PICTURE: IDG MOSFET
M.Vinet et al, SSDM 2004

Design flexibility with a second gate independently driven



SCHEMATIC: IDG MOSFET

- Compact Model

To take advantage of this new device, designers need a model and particularly a compact model to design new circuits.

II MODELING DIFFICULTIES

DRAIN CURRENT

$$I_{ds} = \mu \frac{W}{L} \int_{V_s}^{V_d} Q_{inv} d\phi_{imref}$$

GAUSS THEOREM

$$Q_{inv} = \epsilon_{si} (E_{s1} - E_{s2})$$

BOUNDARY CONDITIONS

$$E_{s1} = \frac{C_{ox}}{\epsilon_{si}} (V_{g1} - \psi_{s1})$$

$$E_{s2} = -\frac{C_{ox}}{\epsilon_{si}} (V_{g2} - \psi_{s2})$$



To calculate I_{ds} , we need **surface potentials**

POISSON EQUATION & ITS FIRST INTEGRATION

$$\frac{d^2 \psi}{dx^2} = \frac{q \cdot n}{\epsilon_{si}}$$

$$E_{s1}^2 - E_{s2}^2 = \frac{2 \cdot q \cdot u_t \cdot n_i}{\epsilon_{si}} \left[\exp\left(\frac{\psi_{s1} - \phi_{imref}}{u_t}\right) - \exp\left(\frac{\psi_{s2} - \phi_{imref}}{u_t}\right) \right]$$



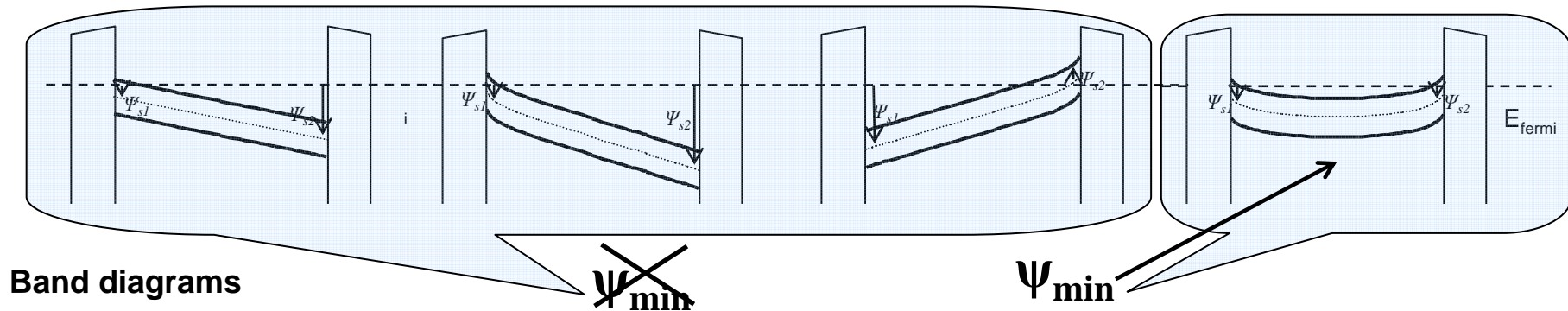
However, we get implicit equations of ψ_{s1} and ψ_{s2}

II MODELING DIFFICULTIES

DIFFICULTIES TO SOLVE IMPLICIT EQUATIONS

- NO EXACT ANALYTICAL SOLUTIONS OF ψ_{s1} AND ψ_{s2}
- DEFINE 2 CASES AND THEN UNIFY THEM

ASYMMETRY → Not always a minimum of potential in the silicon film: 2 CASES



2 OPTIONS

IMPLICIT RESOLUTION

- FLOATING NODES
- GREEN FUNCTIONS
- ...

EXPLICIT RESOLUTION: MAKE PHYSICAL ASSUMPTIONS Simplifications of Poisson equation

→

III BASIS OF THE MODEL

BASIS

Weak inversion

$$Q_{invi} = \alpha \cdot \exp\left(\frac{V_{gi} - V_{th}(V_{gi})}{u_t}\right)$$

$$Q_{inv} = Q_{inv1} + Q_{inv2}$$

Strong inversion

$$Q_{invi} = \beta \cdot (V_{gi} - V_{th}(V_{gi}))$$

We are looking for these equations because we know how to unify them

(BSIM3v3)

BASIC EQUATIONS

PHYSICAL ASSUMPTIONS

$$I_{ds} = I_{ds1} + I_{ds2}$$

$$I_{ds1} = \frac{W}{L} \mu \cdot C_{oxi} V_{gti,eff} \left(1 - n_{i,eff} \frac{V_{dsi,eff}}{2(V_{gti,eff} + 2u_t)} \right) V_{dsi,eff}$$

EXPLANATIONS IN THE POSTER

I sincerely hope you will go to see my poster