Emerging Devices: RFETs and OPBTs

Ghader Darbandy
NanoP, TH Mittelhessen University of Applied Sciences, Gießen, Germany

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Outline

- **Reconfigurable FETs (RFETs)**
  - Fabricated SB Si NW Devices
  - Characteristics, and Simplified Design

- **Organic Permeable Base Transistors (OPBTs)**
  - Conventional Lateral OFETs
  - Vertical OFET, and OPBTs

- **Conclusion**
SB Si NW RFETs

- Namlab, TU-Dresden:
  - Dynamically **switching** between n- and p-type **polarity**.
  - Different logic **computations** use the **same hardware**.
  - Number of **devices** can be reduced by **50%**.

RFET structure and TCAD

RFET Characteristics

- Modify effective mass, the band gap, and thus barrier height [1].

\[ T_{n,p} \propto \frac{e^{-4} \sqrt{2m_{n,p}^*}}{3q\hbar E} \phi_{n,p}^{1.5} \]

- Symmetric characteristics
- on/off > 1e7
- Dynamical reconfigurable

Theoretical limit of unipolar I-V

- Electron and hole contributions of an ambipolar SGT.

- Ideal unipolar (e/h) I-V can be achieved by DG/SG RFET.
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Lateral OFETs

- Planar or staggered OTFTs.
- Impressive investigations.
- Less development of $f_T$.
- Short $L_{ch}$ is NOT feasible with low cost technology.

- An alternative to increase $f_T$ mainly with short $L_{ch}$.
- Different kind of Vertical OFETs are reported.

Vertical OFETs

- The current flows perpendicular to the substrate.
- Thickness control down to 100nm with low-cost.

An issue was/is combination of lateral/vertical $L_{ch}$.

An alternative is OPBTs.

OPBTs

- Three parallel electrodes separated by two OSCs.
- Active length=$T_{OSC}$ => controllable in nm range (low cost).
- Stable, reliable and repeatable characteristics are proved.

Record-high $f_T = 40$ MHz at $\mu_{Ver}=0.06$ cm$^2$ V$^{-1}$ s$^{-1}$

A large room for further DC / $f_T$ improvements.

**OPDBTs**

- **Optimization** of $C_{\text{par}}$
- $\mu_{\text{Lat}} = 25 \implies \mu_{\text{Ver}} = 0.06$ (cm$^2$ V$^{-1}$ s$^{-1}$).
- **Engineering** of $R_C$.

$\Box f_T \geq 1\text{GHz}$ is realistic/achievable

($L_{ov} < 1\mu\text{m}, R_C \leq 100\Omega\text{cm}, \mu \geq 10$).

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Conclusion => **Compact Model**

- **Si NW RFETs:**
  - Dynamically switching polarity, number of devices down to 50%, technology design for **hardware security** (secure circuits).

- **OPBT:**
  - Great DC and record-high $f_T$ and room for further improvements

- **Developing Compact Models:**
  - Novel **applications, circuit,** and **system** design!