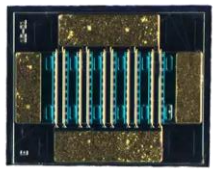
An Improved Extraction Method for the Trapping Time Constants in GaN HEMTs

Inês C. Lopes, Luís C. Nunes, Pedro M. Cabral, José C. Pedro

STATUS QUO

GaN HEMT [1]



Trapping effects cause performance degradation!

- ✓ To understand it, we need **accurate models**.
- ✓ The **trapping dynamics** is analyzed through the **time constants** extracted from the $i_{DS}(t)$ profile.
- ✓ However, I_{DS} **is nonlinear** with respect to the trapping state.

Incorrect results can be obtained.

NEW INSIGHTS

$I_{DS}(t)$ from I-DLTS + I/V Curves → V_{CTRL} → τ

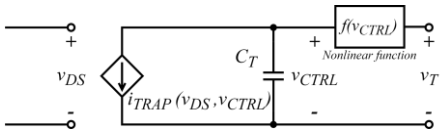
New method to obtain the trapping time constants:

- ✓ De-embed the nonlinearity.
- ✓ Obtain the **equivalent control voltage** (V_{CTRL}), which represents the **trapping state**.
- ✓ Obtain the **time constant** from the new information.

DESCRIPTION

Simulation

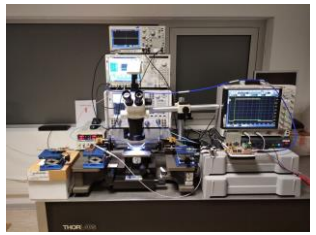
- ✓ Transistor model: **current source**, that depends on v_{GS} and v_{DS}, and v_{CTRL} through the **Jardel's Model**.



Simplified circuit schematic used for modelling the transistor trapping effects.

- ✓ Apply a **voltage step** and compute $i_{DS}(t)$ and $v_{CTRL}(t)$.
- ✓ Calculate the **derivative over logarithmic time** for each variable and obtain the time constants.

Experimental Setup

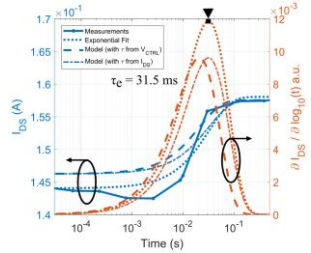


- ✓ Using the **double-pulse technique,** obtain the **I/V curves** for different V_{DQ} and perform I_{DS}**-DLTS measurements**.
- ✓ **Obtain** v_{CTRL} from the i_{DS} measurements and **fit an exponential function** to the measurements.
- ✓ Calculate the **derivative over logarithmic time** for each variable and obtain the time constants.

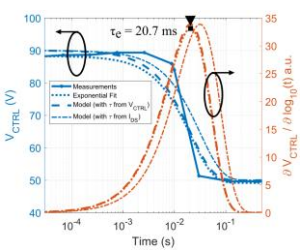
QUANTITATIVE IMPACT

Emission from 90 V to 50 V (V_{GS}=-1 V)

- ✓ Comparison between emission profiles using the **time constants obtained from the measured** $i_{DS}(t)$ **and** $v_{CTRL}(t)$ curves.



Measured and simulated $i_{DS}(t)$ profile.



Measured and simulated $v_{CTRL}(t)$ profile.

- ✓ The model with the **time constant obtained through** V_{CTRL} presents a **better fit** to the measurements.

PROPOSED CONCEPT GOALS

This improved extraction method features:

- ✓ **Extraction of the trapping time constants** in a more **accurate** way.
- ✓ On what the trapping dynamics is concerned, **transistor models** that are more **precise**.

[1] https://www.wolfspeed.com/cg2h80015d/