UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

itee PhD information technology electrical engineering

DIETI UNINA

PhD Vincenzo Terracciano

# Innovative Approaches to Power Device Design and Semi-Physical Modeling

Tutor: Andrea Irace

Co-Tutor: Vincenzo d'Alessandro

Cycle:XXXVIII

Year: First

itee PhD information technology electrical engineering

# My background

- MSc degree: *Electronic Engineering*
- Research laboratory: *OPTO-POWER LAB*
- PhD start date: *01/11/2022*
- Scholarship type: *ITEE*
- Partner company: *Vishay Semiconductor*

# SUMMARY OF STUDY ACTIVITIES

| Ad hoc PhD courses | MSc Courses |
|---|---|
| - *How to boost your PhD*<br>- *Academic Entreprenuership* | -*Electrodynamics of continuos media*<br>(mathematical eingeenering) |

Summer School:**China-Italy Joint Laboratory on Advanced Manufacturing (CI-LAM)**
Summer School Chair: **Giovanni Breglio**

CI-LAM China - Italy Joint Laboratory on Advanced Manufacturing
中意先进制造联合实验室

UNIVERSITÀ DEGLI STUDI DI BERGAMO
UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II
Tsinghua University

Conferences:

**International Conference on Silicon Carbide and Related Materials (ICSCRM), *Sorrento Italy 2023*.**

ICSCRM2023 INTERNATIONAL CONFERENCE ON SILICON CARBIDE AND RELATED MATERIALS
SORRENTO / ITALY 17-22 SEPTEMBER 2023

**29th International Workshop on Thermal Investigations of ICs and Systems (THERMINIC), Budapest Ungary 2023.**

THERMINIC

# POWER SEMICONDUCTOR PHYSICS

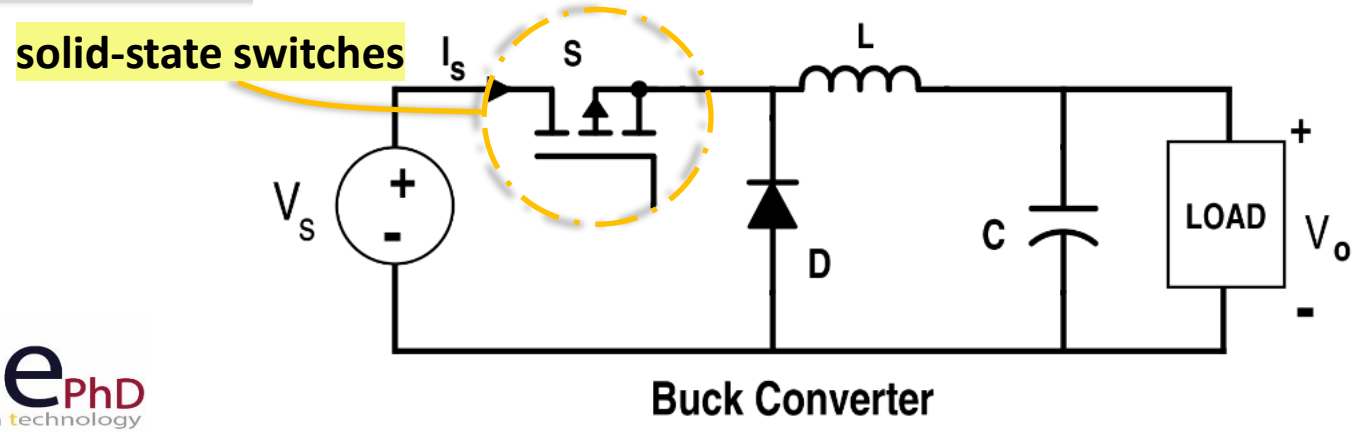
- ***Power Semiconductor Physics*** is concerned with the study of the physical principles and properties of semiconductors used in **power electronic devices**, such as **wide-bandgap** semiconductor devices.
- These power devices are crucial for **electrical energy conversion** and include components like diodes, transistors, and rectifiers.
- In power electronics systems, power devices are used as **solid-state switches**.

## *IDEAL SWITCH*

1) To conduct infinite current
2) Block infinite voltage
3) Switch at infinite frequency with zero power loss

## *REAL SWITCH*

1) Low on-state resistance ($R_{ON}$)
2) High breakdown voltage (BV)
3) Small switching loses




Buck Converter

# RESEARCH ACTIVITY[1]

## RESEARCH ACTIVITY PROBLEM

### REAL SWITCH

1) Low on-state resistance ($R_{ON}$)
2) High breakdown voltage (BV)
3) Small switching loses

### TRADE-OFF

$R_{ON}$ ↓ BV ↑

## APPROACHES TO IMPROVE THIS TRADE-OFF

1) Employ semiconductors with **superior properties** for power switching, such as **wide-bandgap (WBG) materials**
2) Involves innovation in **device architecture**

**PAPER**

***"SiC GAA MOSFET Concept for High Power Electronics Performance Evaluation through Advanced TCAD Simulations"***

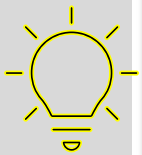
# RESEARCH ACTIVITY[2]

## RESEARCH ACTIVITY PROBLEM

To realize a **compact model** in the form of a **SPICE-compatible subcircuit** describing the **electrical and electrothermal behavior** of a particular SiC diode: **Merged PiN Schottky (MPS)**. In addition, the model has to take into account of the detrimental **snapback mechanism**, which can lead, where we have multiple cells in parallel, **to current-focusing**. Through a **compact model**, it would be possible to reduce both the **time** and **complexity of a TCAD simulation**, as in the case of **TCAD electrothermal simulations**.

## APPROACHES TO REALIZE THESE MODELS

The approach is based on a **comparison** of **Sentaurus TCAD simulations** and the **SPICE simulations**, while specifically for **electrothermal analysis** we exploited the **thermal equivalent of Ohm's law (TEOL)**



**PAPERS**

I ***"A Geometry-Scalable Physically-Based SPICE Compact Model for SiC MPS Diodes Including the Snapback Mechanism"***

II ***"A Simple Electrothermal Compact Model for SiC MPS Diodes Including the Snapback Mechanism"***

# Products

| | |
|---|---|
| [P1] | **SiC GAA MOSFET Concept for High Power Electronics Performance Evaluation through Advanced TCAD Simulations** |
| [P2] | **A Geometry-Scalable Physically-Based SPICE Compact Model for SiC MPS Diodes Including the Snapback Mechanism** |
| [P3] | **A Simple Electrothermal Compact Model for SiC MPS Diodes Including the Snapback Mechanism** |

# Thank You For Your Attention