Ciro Scognamillo

Analysis of electrothermal effects in electronic devices, circuits, and systems

Tutor: prof. Vincenzo d'Alessandro

Cycle: XXXV

Year: 2019/2020

itee PhD
information technology
electrical engineering

My background

M.Sc. in **Electronic Engineering** – 24th Oct 2019

Ph.D. started in Nov 2019 (XXXV cycle)
Tutor: prof. **Vincenzo d'Alessandro**

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The funding for my Ph.D. was generously donated by the Rinaldi family ***in the memory of prof. Niccolò Rinaldi***.

Research field of interest

Study of **electrothermal** (ET) **effects** in **electronic devices** (with and without packages) and **photovoltaic modules**.

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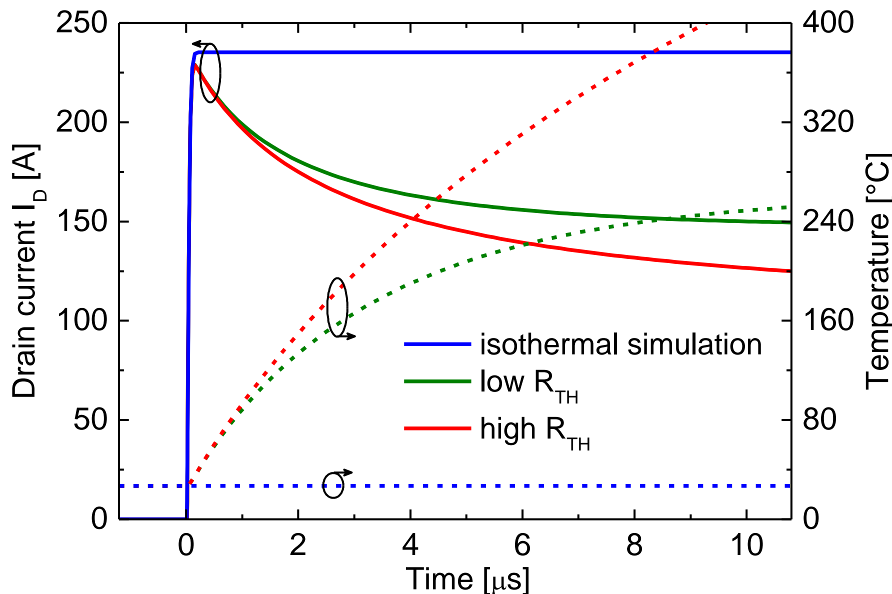
Are ET analyses *really* needed?



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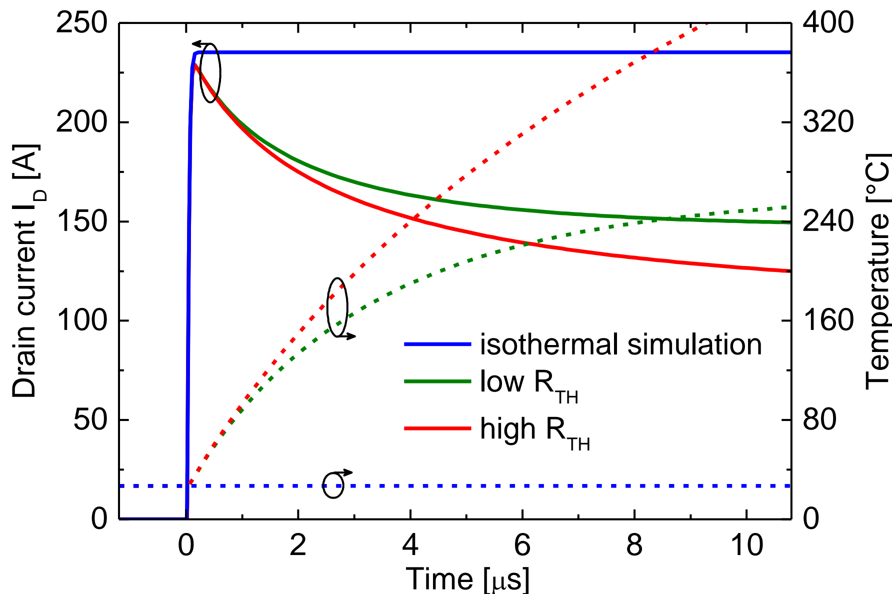


The answer is **YES!** And there is still ***plenty of scope*** for **improving existing methodologies** and **developing new ones!**

Research activity: Overview

Problem:

ET effects hinder the **adoption of new technologies** that may improve the devices electrical performances. On top of that, ET analyses are **time-demanding**, **prone-to-errors**, and **resource-hungry**.

Objective:

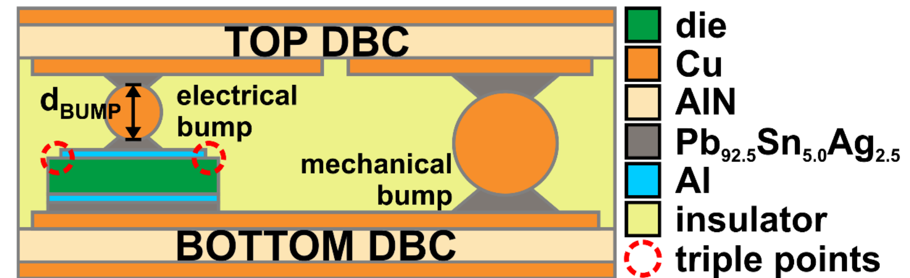
To carry out **highly-efficient ET numerical investigations** in FEM and SPICE-like tools.

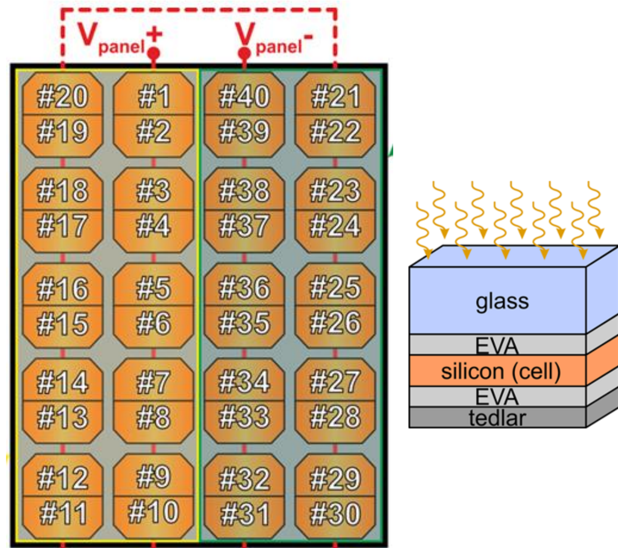
Intended contribution:

To **improve the trade-off** between their **accuracy** and **computational efforts**.

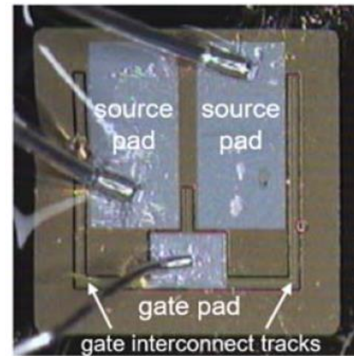
Technologies

Double-sided cooled (*DSC*)
power modules

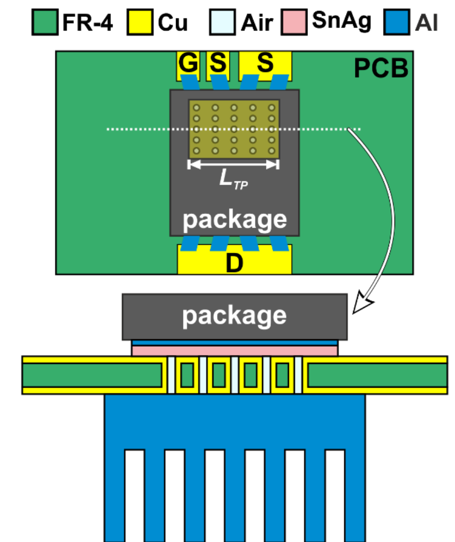




Photovoltaic modules



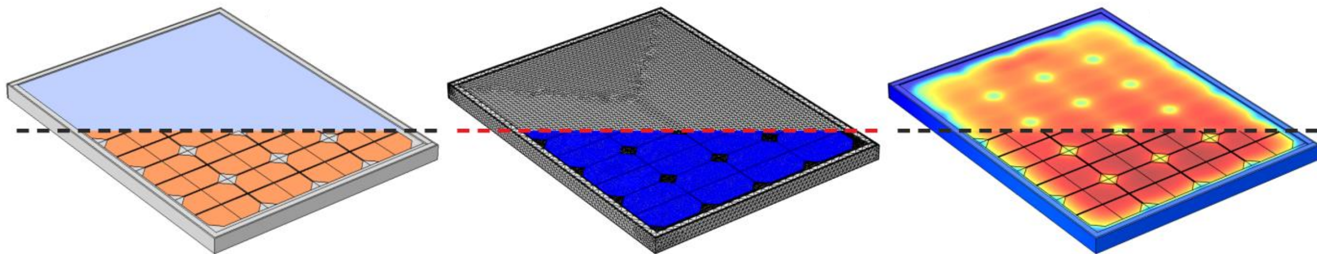
SiC power MOSFETs

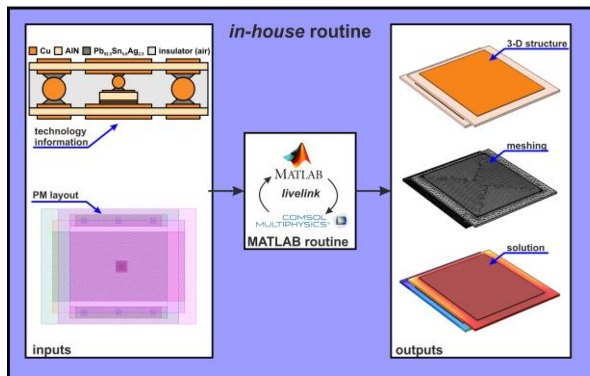


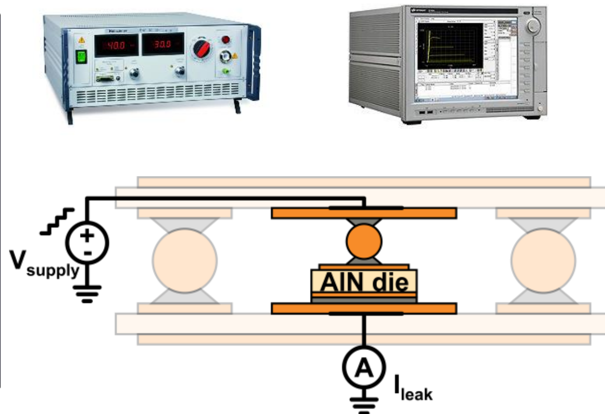
PCB-integrated power circuits

Methodologies

In-house routine for **purely-thermal FEM simulations**

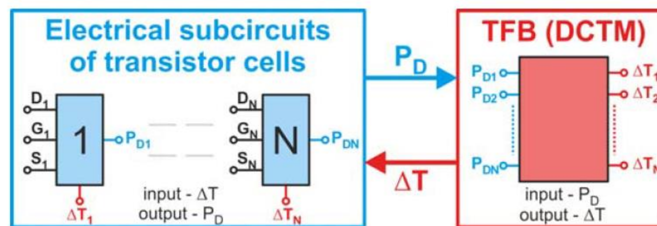






Combined *FEM-experimental* analysis of DSC PMs **electrical ruggedness**

Highly-efficient ET simulations in SPICE-like solvers (**OrCad**)



Products

Journal contributions

[1.j]	A. P. Catalano et al., “Numerical analysis and analytical modeling of the thermal behavior of single- and double-sided cooled power modules,” *IEEE Transactions on Components, Packaging and Manufacturing Technology*, vol. 10, no. 9, pp. 1446–1453, Sep. 2020.
[2.j]	C. Scognamillo et al., “Combined experimental-FEM investigation of electrical ruggedness in double-sided cooled power modules,” *Microelectronics Reliability*, 113742, 2020.
[3.j]	V. d’Alessandro et al., “Circuit-Based Electrothermal Simulation of Multicellular SiC Power MOSFETs Using FANTASTIC,” *Energies*, vol. 13, no. 17, 4563.
[4.j]	A. P. Catalano et al., “Using EMPHASIS for the thermography-based fault detection in photovoltaic plants,” *Energies*, 2020. (*under review*).

Book chapter contribution

[1.b]	A. P. Catalano et al., “Optimum module design III: Electrothermal,” in *SiC Power Module Design: Performance, robustness and reliability*, A. Castellazzi and A. Irace, IET, ch. 5. ISBN: 978-1-78561-907-6. (*in press*).

Conference contributions

[1.c]	A. P. Catalano et al., “Evaluation of vertical mechanical displacement in SiC-based power modules,” *Proc. International Symposium on Advanced Power Packaging (ISAPP)*, Oct. 2019.
[2.c]	C. Scognamillo et al., “Influence of bumps height on electric field in double sided cooling power modules,” *Proc. International Symposium on Advanced Power Packaging (ISAPP)*, Oct. 2019.
[3.c]	R. Trani et al., “Optimum thermal management design for compact PCB-based high frequency GaN assemblies,” *Proc. International Symposium on Advanced Power Packaging (ISAPP)*, Oct. 2019.

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Conference contributions

[4.c]	C. Scognamillo et al., "3-D FEM investigation on electrical ruggedness of double-sided cooling power modules," *Proc. IEEE International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems (EuroSimE)*, Jul. 2020.
[5.c]	A. P. Catalano et al., "Stress-induced vertical deformations in state-of-the-art power modules: an improved electro-thermo-mechanical approach," *Proc. IEEE International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems (EuroSimE)*, Jul. 2020.
[6.c]	A. P. Catalano et al., "Optimization of thermal vias design in PCB-based power circuits," *Proc. IEEE International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems (EuroSimE)*, Jul. 2020.
[7.c]	A. P. Catalano et al., "Experimental validation of analytical models for through-PCB thermal vias," *International Workshop on Thermal Investigations of ICs and Systems (THERMINIC)*, Sep. 2020.
[8.c]	C. Scognamillo et al., "Numerical analysis of the thermal impact of ceramic materials in double-sided cooled power modules," *International Workshop on Thermal Investigations of ICs and Systems (THERMINIC)*, Sep. 2020.

Summary of activities

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	**0**	**0.8**	**8**	**0**	**8.8**
Bimonth 2	**0**	**0**	**10**	**0**	**10**
Bimonth 3	**4**	**0.8**	**7**	**0**	**11.8**
Bimonth 4	**9**	**8.6**	**5**	**0**	**22.4**
Bimonth 5	**3.6**	**0**	**6.4**	**0**	**10**
Bimonth 6	**5**	**1.2**	**4.5**	**0**	**10.7**
Total	**21.6**	**11.4**	**40.9**	**0**	**73.7**
Expected	**30 - 70**	**10 - 30**	**80 - 140**	**0 – 4.8**	

Ad-hoc courses

- *Matlab Foundamentals*, 20/02/20–23/03/20
- *Scientific Programming and Visualization with Python*, 27–28/02/20
- *Topics on Microelectronics*, 08–10/09/20

Conferences

- *International Conference on Thermal, Mechanical and Multi-Physics Simulation and Experiments in Microelectronics and Microsystems (**EuroSimE**)*, online conference, 6–28 Jul 2020. Two contributions presented.
- *International Workshop on Thermal Investigations of ICs and Systems (**THERMINIC**)*, online conference, 14 Sep–9 Oct 2020. Two contributions presented.
- *European Symposium on Reliability of Electron Devices, Failure Physics and Analysis (**ESREF**)*, online conference, 4–8 Oct 2020. One contribution presented.

Thank you for your kind attention

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Possible future research activities