Paolo Mirone

Tutor: Prof. Andrea Irace

XXIX Cycle - II year presentation

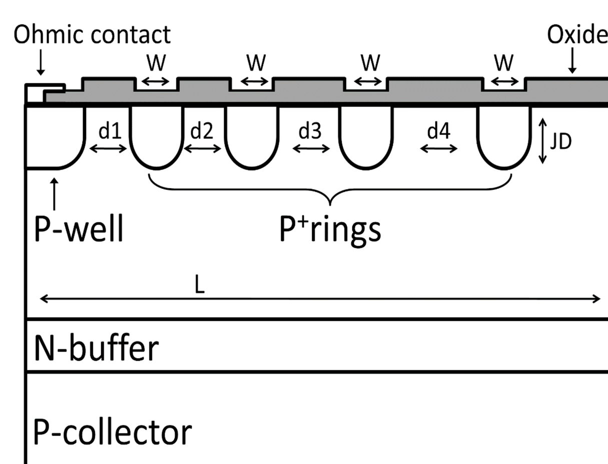
Analysis, development and validation of novel power devices termination

MOTIVATIONS: All semiconductor devices have a **finite size.** The cut of the wafer produces severe damage to the crystal. In the case of power devices, if the sawing is performed through the junction that must support a **high voltage**, the crystal damage creates a **high leakage current** that degrades the **breakdown voltage and its stability** with respect to time. This problem can be addressed by using special junction terminations around the edges of the power devices.
The **termination design** must be realized in order to maximize the breakdown voltage achievement and, at the same time, improve the avalanche stability. In power switching applications with inductive load, such as automotive, the **avalanche robustness** is an harsh requirement, since thermal instability phenomena can lead to catastrophic events. The **Unclamped Inductive Switching test** is commonly used to investigate over-stress conditions in power device. UIS can be used to analyze unstable problem such as **filamentation** problem. The design analysis are realized by means of **TCAD simulations** to reduce costs and time of project closure.

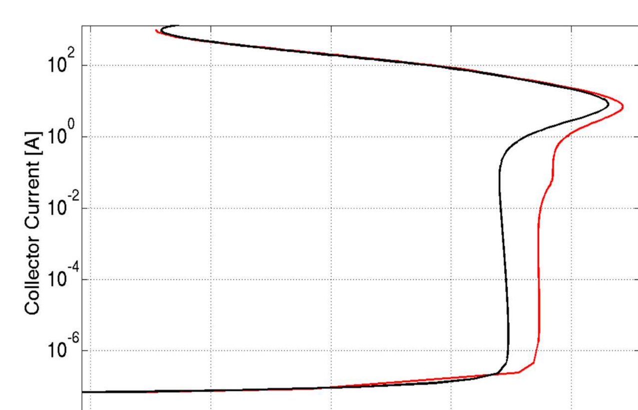
The following steps are needed to realize a power device:

- **Theoretical analysis** of the problem and its solutions
- **TCAD** optimizations and analysis
- **Experimental** validation

TCAD Termination Design

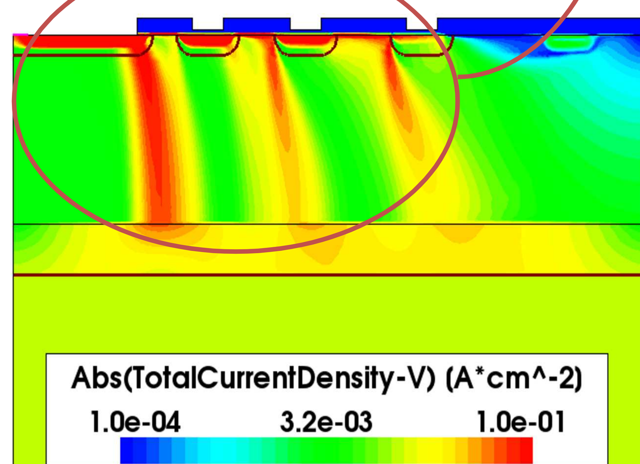


TCAD Simulations



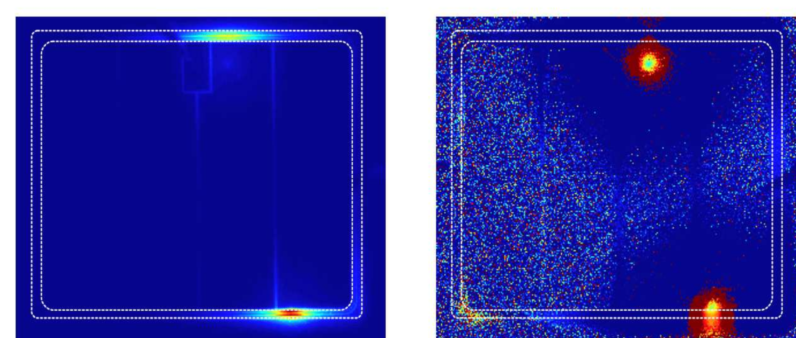
Avalanche I-V curves achieved by two set of design parameters

To optimize the structure design is needed to managing many **parameters** such **as doping profiles** of P/N junctions or **geometrical** dimensions. Each of them impacts on the **Masks** used in the technological process.

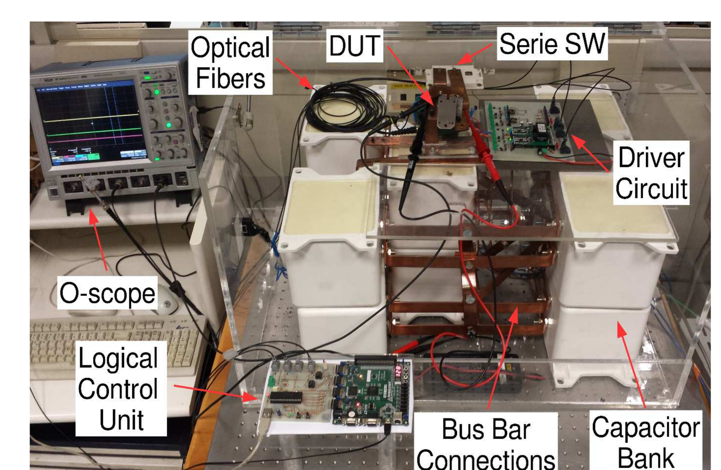


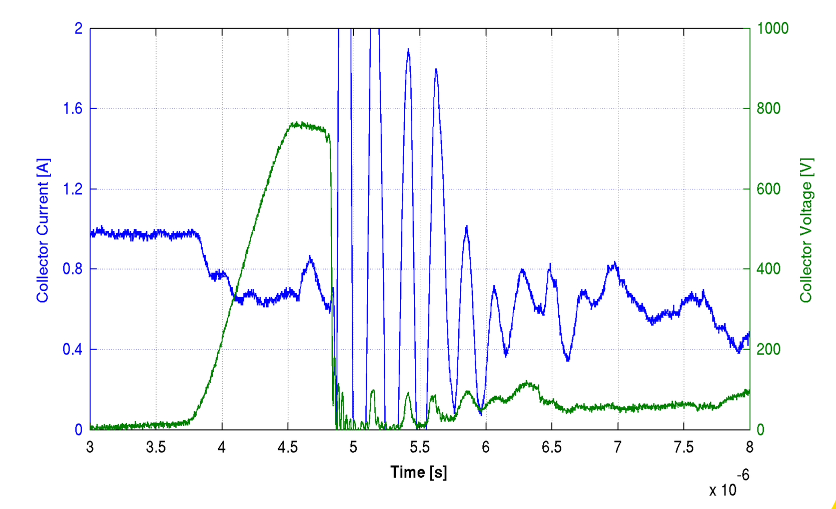
Experimental analysis

Infrared Electrothermal set-up



UIS set-up





Achieved Results

- 2D TCAD design of two novel termination structres for 1200V power diode:
  - One based on RESURF and SIPOS technologies
  - One based on Guard Assisted JTE
- 2D TCAD robustness and stability analysis by means of:
  - Avalanche isothermal simulations
  - UIS test (Electro-thermal simulations)
- Filament analysis in avalanche NDR condition[1]

[1] P.Mirone, L. Maresca, M. Riccio, G. Breglio, A. Irace, "On the avalanche ruggedness of optimized termination structure for 600 V punch-through IGBTs", Microelectronics Reliability, 6 Dec. 2015

All the activity are conducted in association with Vishay

VISHAY

FUTURE DEVELOPEMTS: In the early years of my working I studied the physics behavior of power devices in many design configurations. Then I proposed and analyzed, by means of 2D TCAD simulations, different terminations design for a power device 1200V rated. Further step will be to physically realize, in collaboration with Vishay industry, the proposed structure in order to perform an experimental validation.