

DRT: Thesis SL-DRT-21-0387

RESEARCH FIELD

Solar energy for energy transition / Technological challenges

TITLE

Multiphysical design of high-voltage power semiconductor modules for renewable energy conversion

ABSTRACT

Research and development around silicon carbide (SiC) power semiconductors provides samples that can withstand voltages up to 15kV. These devices switch at very high speeds (e.g. 120kV / μ s for a 10kV SiC MOSFET or 180kV / μ s for a 15kV SiC IGBT). Overall, the performances of these semiconductors are exceptional, and drastically reduces the switching losses compared to Silicon equivalents. The implementation of these switches is on the other hand very delicate and calls upon methodologies of multiphysics design in transversal disciplinary fields. It is, from the scientific literature addressed a number of scientific and technological obstacles that we can list:

- Minimization of parasitic inductors of power modules (<5nH)
- Integration of EMC shielding to collect disturbing impulse currents
- Cooling of SiC chips so the size is very small compared to a Si equivalent
- Management of partial discharges and dielectric materials
- Influence of dV / dt on the aging of materials (in DC, at 50Hz, and in pulse)
- Reflection phenomena (electromagnetic wave)

The proposed work consists of studying and proposing a power module architecture integrating innovations making it possible to address the implementation of SiC chips up to 10kV.

The teams from the CEA in Toulouse specialists in high power 3D packaging will provide their skills in assembly technologies for the production of complex power modules. The CEA teams at INES campus (Nat. Inst. of Solar Energy) located at the Bourget du Lac (Savoie) will provide their high voltage measurement and prototyping means as well as their knowledge in power module design (finite element simulation). Researchers from G2ELAB in Grenoble in cooling of power modules and dielectric science will use their knowledge as well as their experimental platforms.

LOCATION

Département des Technologies Solaires (LITEN)
Service d'Intégration des Réseaux Energétiques
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