SOLUTIONS COMMUNICANTES SECURISEES
PÔLE DE COMPETITIVITE MONDIAL

SUPER SWITCH

Design Of New High Voltage Superjunction Power Switches

> OBJECTIVES

The objective of this project is to fabricate Deep Trench SuperJunction power devices (diodes and MOSFETs) in the «600 - 1200 Volts» voltage range. The major challenge is to carry out 1200 V SuperJunction devices. Indeed, in this voltage range, such devices do not exist in the power devices market because their manufacturability is too complex and requires a high degree of accuracy in the charge balance control. The solutions suggested in this project (deep trenches and boron doping by diffusion, Ion Implantation -II- or Plasma Immersion Ion Implantation -PIII-) will probably allow to overcome this technological difficulty. On the other hand, the 600 V SuperJunction devices technological process will be then also simplified.

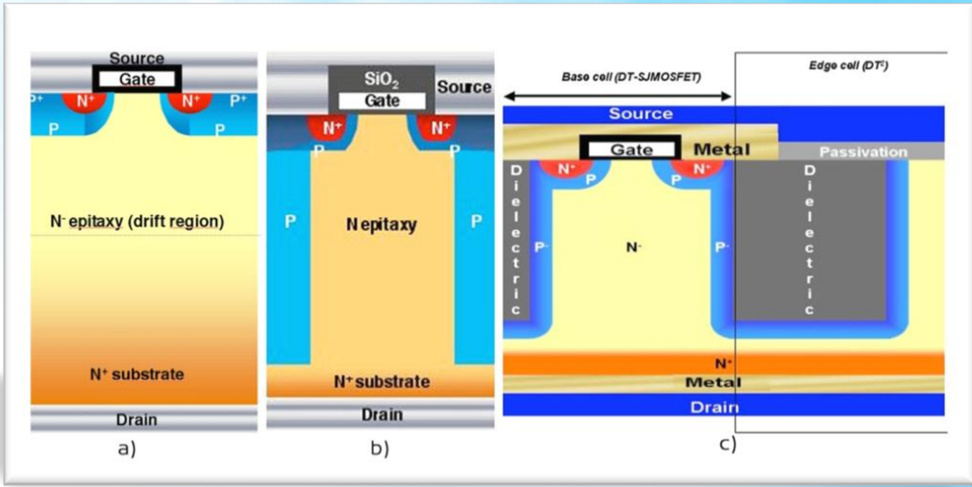
> ADVANTAGES

Compared to conventional power devices, the advantages of these Superjunction power devices are :

- drastic improvment of performance in terms of breakdown voltage, on-state voltage, maximal current, conduction and switching losses (and, consequently, switching frequency),
- reduction of size and weight,
- and, consequently, reduction of the global cost.

Furthermore, the reduction of the technological cost will be important when compared to the conventional technological processes proposed to manufacture Superjunction devices.

Schematic cross-sections of :
a) a conventional VDMOSFET,
b) a SuperJunction (SJ) MOSFET,
c) a Deep Trench SuperJunction MOSFET (DT-SJMOSFET) and its termination (DT^2).



> APPLICATIONS

There are numerous power electronics applications (electrical traction, industrial drives, distribution network management, electrical household appliances, transportations and portable units) using a large variety of power devices. The drastic performance improvement of these power devices is a main factor for the safeguard of the energy. Then, in all these applications, it is essential to improve the energy conversion chain in terms of energy saving, cost, size, weight and reliability.

> DELIVERABLES

- Design and optimization of the termination of power devices called Deep Trench Termination (DT^2).
- Design and optimization of the Deep Trench SuperJunction Diode (DT-SJDiode).
- Design and optimization of the Deep Trench SuperJunction MOSFET (DT-SJMOSFET).

F.E.D.E.R. dgcis Région PACA CONSEIL GENERAL BOUCHES-DU-RHÔNE CONSEIL GENERAL DES ALPES-MARITIMES Var CONSEIL GENERAL Hautes Alpes PAYS D'AIX MARSEILLE PROVENCE METROPOLE NICE COTE AZUR Ville de Rousset Gap

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> TECHNOLOGICAL INNOVATIONS

Some technological process steps have to be studied in order to obtain performant and robust structures:

- 1) The deep etching step can be performed by deep reactive ion etching (DRIE) avalaible at LAAS-CNRS or by electrochemical etching available at GREMAN. To achieve p-columns of 1200 V DT-devices, thin (3 to 6 µm) and deep trenches (100 µm) are needed. The challenge will be to adapt the two etching methods to reach such aspect ratios while controling a perfect verticality of the trenches sidewalls. These etching processes will be compared in terms of performance, repetability and cost.
- 2) The doping process step can be performed by boron diffusion from a heavily doped polysilicon deposited by LPCVD, available at LAAS-CNRS, or by Ion Implantation and Plasma Immersion Ion Implantation at IBS and GREMAN. Once again, the two methods will be adapted to reach a quasi-perfect control of the diffused or implanted dose of p-columns. This is necessary to ensure an optimal breakdown voltage of the SuperJunction devices. These doping processes will be compared in terms of performance, repetability and cost.
- 3) The dielectric deposition into deep trenches is also a key process step: our previous work showed the excellent properties of BenzoCycloButene (BCB), but BCB is also known to be thermally limited to temperatures below 350°C; therefore its robustness in power electronics applications should be studied. Other dielectrics (for instance: Polyimide PI) or dielectric combinations (for instance: BCB with diamond powder) will be also investigated. They should allow the filling of thin and deep central cells trenches to ensure mechanical resistance, as well as the filling of wide and deep termination trenches.

> TARGET MARKETS

Energy and transport are in the middle of the sustainable development paradoxes: both are essential to the development and to the socio-economic growth but their current evolutions go together with unacceptable risks for humanity, i.e. the exhaustion of the nonrenewable natural resources and the environmental pollution. Moreover, 89% of the energy resources of planet come from fossil origin and the major increase in the world demand of primary energy is mainly covered by energies with high environmental effects: oil (75%) and nuclear energy (18%) versus only 6% for renewable energies. The research and development in the fields of green renewable energies are one of the main targets for the future of humanity. The yield improvement of the energy chain (creation of energy, transport of energy, successive transformations, consuming system) absolutely needs a yield improvement of each part of it. The transport sector consumes 25% of world energy and uses more than half of the oil produced in the world. Consequently, the research orientations related to the use of alternative energies for road transport (hybrid and electric vehicles) are of the most importance, but it will also be vital in the future to modify the ways of life associated to the use of private vehicles and the consumption of energy.

> PARTERNSHIP

- Project leader : Laboratoire d'Analyse et d'Architecture des Systèmes du CNRS - Toulouse
- Industrial partners : Ion Beam Services
- Research partner : Laboratoire de l'Intégration du Matériau au Système (Institut Polytechnique de Bordeaux), Groupe de Recherche En Matériaux, microélectronique, Acoustique et Nanotechnologies (Université François Rabelais de Tours).

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