

Aim of the project

The project deals with the reliability of innovative substrates used in power modules (IGBTs, MOSFETs, etc.). Conventional substrates are realized using ceramic insulators which have very good dielectric and thermal exchange properties. For these reasons, ceramic substrates are the state of the art. Ceramic substrates are, however, costly and fragile. Therefore, recently, substrates realized using epoxy resin loaded with microparticles having high thermal conductivity (chiefly aluminum nitride and oxide) were introduced. These epoxy-based substrates are less performant than state-of-the-art ceramic substrates, but are interesting due to their lower costs and mechanical properties. Indeed, Infineon (the project leader) gained experience with the design of these substrates, but has limited understanding regarding the performance of dielectric properties over time under stress. The project is aimed at shedding light on this topic.

Activities

The project is aimed at characterizing the evolution of dielectric properties of substrates subjected to thermal aging. Of particular interest is the inception of partial discharges at triple points. Triple points can be associated to different permittivities of substrates and coatings or can be created by thermal aging (i.e., delaminations in proximity of high voltage conductors). Different substrates technologies will be indicated by the project leader (Infineon) while another partner (Serigroup) will realize the model substrates that will be aged. Preliminary to thermal aging, thermo-gravimetric analysis (TGA) of the different materials will be carried out to determine the most appropriate aging temperatures.

Thermal aging will be carried out in cycles. Between each cycle, diagnostic tests will be performed to measure the evolution of the dielectric properties of the substrates (electrical insulation systems) and of the materials. Diagnostic tests will consist of breakdown and partial discharge tests carried out using different voltage waveforms (sinusoidal voltages, square wave voltages, unipolar and bipolar). Other diagnostic quantities will be investigated as the permittivity and the bulk electrical conductivity of substrates and coatings. Chemical analysis of the material will also be carried out using the Fourier Transform InfraRed (FTIR) technique