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Influence of thermal aging and microstructure evolution on the adhesion of an Ag sintered joint in a multilayer system.

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The development of modern power electronic modules is strongly linked to the need for massive electrification of transportation systems in order to limit gaseous emissions, known to be harmful to the environment. Power modules are made up of a stack of various materials ensuring, among other things, energy conversion (chip), electrical conductivity, passive cooling and insulation. As such, the technology experienced a major turning point with the arrival of wide gap chips (SiC and GaN). In fact, those allow increased performance compared to Si. However, these performances have few drawbacks among which is a substantial increase in the operating temperature. In this context, the solutions for assembling the chips in the system need to be re-evaluated and, currently, the main research effort is focused on the sub-micrometer paste sintering technology of Ag and Cu. The sintering conditions, strongly constrained by the electronic components to be integrated, do not allow total densification of the joint during the elaboration of the module. In operating conditions, the temperature generated by the module generates mechanical stresses resulting from differences in thermal expansion coefficients between the various layers of materials constituting the stack. In the case of sintered Ag, the relationship between properties (mechanical and thermal) as a function of porosity rate is now fairly well established. Despite a noticeable evolution in the porosity of the sintered Ag during thermal aging, this occurs at constant density.

The nanoporous sintered Ag system is relatively well studied but the impact of changes in the microstructure at the interface or close to the interface between the Ag and the substrates during thermal aging as a function of the initial porosity is still relatively poorly known. In particular, questions remain as to the influence of thermal aging on the evolution of the porosity of the Ag close to the interface (including the role of thermal stresses) and the repercussion on the evolution of the film-substrate adhesion and the impact on transport properties.

In this context, the proposed thesis will focus on an idealized Ag/Cu system, fairly representative of a real system. It will include i) the study of interfaces and their microstructural evolution during thermal aging depending on the production conditions, coupled with ii) the study by laser shock of the impact of these evolutions on the adhesion of the joint porous.

This PhD program includes both experiment/modeling aspects in a multidisciplinary mechanical/material field. In particular, the doctoral student will have to master digital tools for image analysis and shock wave propagation. The candidate may come from a mechanical and/or materials background with a sensitivity to modeling and experimentation.