Elaboration of nanoporous copper films and thermocompression for assembly in power electronics

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Amphitheatre at the Maison du Doctorat Jean Kuntzmann, 110 rue de la Chimie, 38400 Saint Martin d'Hères

Jury :

Olivier DEZELLUS, Professor (Assistant), LMI Université Claude Bernard Lyon 1, Reviewer
Joël ALEXIS, Professor, École Nationale d'Ingénieur de Tarbes , Reviewer
Anne KAMINSKI-CACHOPO, Professor, IMEP-LAHC Université Grenoble Alpes, Examiner
Jean-Yves HIHN, Professor, UTINAM Université de Franche-Comté, Examiner
Jean-Michel MISSIAEN, Professor, SIMaP Université Grenoble Alpes, Thesis supervisor
Rémi DAUDIN, CNRS Researcher, SIMaP Université Grenoble Alpes, Co-supervisor, invited
Rabih KHAZAKA, Research Engineer, SAFRAN Tech, invited

Abstract : In order to reduce greenhouse gas emissions in the aerospace industry, manufacturers are looking to electrify the various engines used in aircraft, starting with the secondary engines (landing gear, etc.). To achieve this objective, the performance of power electronic modules must be improved, in particular by improving the quality of the assembly between the various components and substrates. This is the background to this thesis. We propose an innovative all copper interconnection assembly technique to improve electrical, thermal and mechanical performance. The technique involves interposing a nanoporous Cu film of a few tens of µm between the electronic components and the substrates, followed by thermocompression at a temperature close to 300°C. In this study, both the preparation of the porous Cu films by selective dissolution of binary alloys and the assembly by thermocompression are investigated, for the films obtained by selective dissolution and also for films obtained by electrodeposition under hydrogen bubbles by our colleagues at UTINAM. In terms of selective dissolution, films made from Mn Cu alloys gave the best results. After optimising the production of porous films, thermal and mechanical analyses and microstructural observation of thermocompression assemblies revealed better adhesion of electrodeposited films. Shear strengths up to 25 MPa were achieved. We have shown that this difference is due to the difference in microstructure between the films obtained by dissolution, which have grain sizes in the order of 100 nm and internal cohesion ensured by a 3D interconnected network of solid ligaments, and the electrodeposited films, which have grain sizes in the order of 1 µm with poor cohesion. This facilitates densification and contact formation with electrodeposited films.