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Thermal and thermomechanical properties of graphite flakes and carbon fibers reinforced aluminum matrix composites

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Today, the microelectronics industry uses higher functioning frequencies in commercialized components. These frequencies result in higher functioning temperatures and, therefore, limit a component's integrity and lifetime. Until now, heat-sink materials were composed of metals which exhibit high thermal conductivities (TC). However, these metals often induce large coefficient of thermal expansion (CTE) mismatches between the heat sink and the nonmetallic components of the device. Such differences in CTEs cause thermomechanical stresses at the interfaces and result in component failure after several on/off cycles. To overcome this issue, one solution is to replace the metallic heat sink materials by a metal matrix composites (MMCs), specifically, carbon-reinforced aluminum matrix (Al/C) which exhibit optimized thermomechanical properties. Moreover, due to his low density, 2.7 g/cm^3, Al has a high specific thermal conductivity (TC divided by density) and low cost which are great advantages in terms of the fabrication of mobile electronic devices for automobile or aeronautic industries. Carbon fibers (CF) and graphite flakes (GF) were preferred to diamond particles because of their low coefficient of thermal expansion (CTE), high thermal conductivity (TC), and a good machinability. These reinforcements will allow developing composite materials that fulfill the requirements related to the field of power electronics. However, the anisotropic thermal properties of these reinforcements may generate a strong influence of the reinforcement orientation on the macroscopic thermal properties of the MMC. Moreover, the oxide layer on Al particles inhibits Al-C reactivity. Therefore, the areas of research discussed in this work are: Orientation optimization of anisotropic reinforcements by a microstructural design Development of composite materials with mixed reinforcement (GF+FC) to evaluate the influence of the combination of the two reinforcements on the thermomechanical properties; Elaboration of composite materials by liquid phase sintering in order to optimize the interfacial properties and densification of composite materials with high carbon content.

Recent Publications

1. Constantin L, Fan L, Mortaigne L, Lu Y F and Silvain J F (2018) Laser sintering of cold-pressed powder without binder. Materialia, 3:178-181.
2. Chamroune N, Caillault N, Lu Y F and Silvain J F (2018) Effect of flake powder metallurgy on TC of graphite flakes reinforced AlMMC. Journal of Materials Science. 56:3.
3. Azina C, Roger J, Joulain A, Mortaigne B, Lu Y F and Silvain J F (2018) Solid-liquid co-existent phase process: Towards fully dense and thermally efficient Cu/C composite materials. Journal of Alloys and Compounds 738.
4. Guillemet T, Heintz J M, Mortaigne B, Lu Y F and Silvain J F (2017) Formation of Co nanodots on diamond surface to improve heat transfer in Cu/D composites. Advanced Engineering Materials 1700894.
5. Xiong W, Liu Y, Zhou Y S, Li D W, Jiang L, Silvain J F and Lu Y F (2016) Laser-direct assembly of aligned CNT in 3D for multifunctional device fabrication. Advanced materials 28:(10).

Biography

Jean-Francois Silvain is a Senior Researcher at ICMCB-CNRS and an Adjunct Professor of Engineering at UNL-Lincoln, USA. He has obtained his Bachelor's degree at Poitiers University in 1980 and PhD degree at Poitiers University in 1984, both in Material Science. He was a CNRS Research Fellow at the University of Nancy, France from 1987 to 2002. He has joined the ICMCB-CNRS in 1992. He has over 30 years of experience in composite materials processing and characterization at micro/nano scales. His main field of interest is the processing and the characterization of ceramic and inorganic multi materials ranging from metal matrix composite to functionally graded materials with the aim to develop materials with adaptive physical and/or mechanical properties. .

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