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Physical properties of metal-matrix composite materials

Both high thermal conductivities and low thermal expansion coefficients (CTE) are required for heat-sink materials as they promote rapid heat dissipation and tolerate thermo-mechanical strains upon thermal cycling. Currently, Cu or Al heat sinks are being used. However, they are not suitable due to the large CTE mismatch with the ceramic and silicon parts in the components. To overcome this issue, we proposed to replace the Cu and Al heat sinks by metal matrix composites (MMCs), more particularly Al and Cu matrix composites reinforced with carbon. The properties in MMCs is often compromised by the absence of effective interfaces, especially in non-reactive systems such as $Al(Al_2O_3)/C$ and Cu/C. However, for a thermally efficient assembly, the interface should allow proper transfer of thermo-mechanical loads between the materials, which is only possible in the presence of chemical bonding. *Ex-situ* and *in-situ* methods can be used to form interfacial metal-matrix zones with optimized physical properties. An *ex-situ* method developed in this study is correlated with the synthesis of a hybrid TiO_x/TiC coating on carbon fibers (CFs) using molten salt synthesis. The molten salt synthesis method is a facile and efficient way for the synthesis of transition metal carbides at low temperatures in a relatively short time. The *in-situ* method is linked with the synthesis of composite materials by alloying the matrix with carbide forming elements which has been investigated using a well-known process used for Al-based composites. The solid-liquid coexistence allows the formation of a liquid phase which enhances the reactivity between the carbide forming element and the carbon reinforcement. For both *ex-situ* and *in-situ* MMC composite materials, the fabrication conditions will be correlated with the microstructures of the interfacial zones and the physical properties of the MMC materials.

Notes:

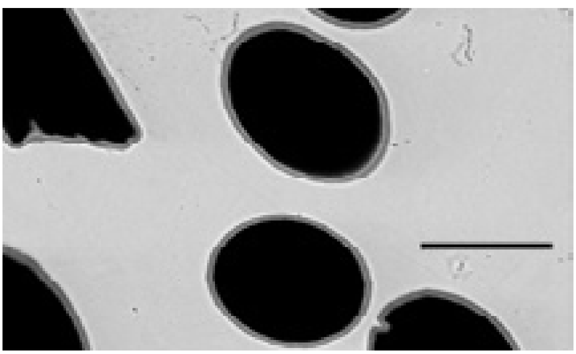

Figure 1: *In situ formation of TiC interfacial zone between carbon fibers and copper matrix (bar equal 10 microns)*

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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