THERMAL STABILITY AND PROCESSING OF DIAMOND BASED NANOCOMPOSITES

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Introduction

Nanostructured Al-diamond composites can be classified as a new kind of materials that have the potential for applications in electronic, microelectronic and thermal management packaging and engineering industries. The main benefits of such materials include: high thermal conductivity, low coefficient of thermal expansion (CTE), reduced weight, wear resistance, high strength and stiffness [1 - 5]. The continuing increase in the packaging density has caused significant requirements for materials with high thermal conductivities and closer matching of their coefficient of thermal expansion (CTE). Possible methods for achieving this objective by use of a substrate or chip carrier with higher thermal conductivity have been suggested to draw the heat away from the chip and dissipate into the surroundings.

This work deals with the Al-diamond nanocomposites produced by liquid metal infiltration process. These composites may exhibit thermal conductivity up to 500-600 W/mK. Furthermore, the problems associated with the interfacial reaction have been circumvented by optimizing the process parameters which may not be possible to avoid in other production methods. Therefore it became imperative to fully characterize the nanocomposites produced by the liquid metal infiltration process.
A number of investigations on the Al-SiC composites and other alloys have been carried out previously which had revealed the occurrence of Al_4C_3 precipitates at the interfacial regions [2 - 5]. The microstructure, phases and interfacial reaction were studied to optimize parameters of the infiltration process in order to achieve the production advantages.

Experimental

The diamond particles were produced by the HPHT process and used in the as- received condition. The diamond volume fraction was 60% in the tap packed diamond powder density. The samples were produced by liquid metal infiltration process in the diamond tap packed steel mold. The Al melt was superheated to 800 C and pouring was accomplished within a few seconds at a pressure of 100 MPa in forming gas environment.

Results and discussion

Figure 1 illustrates different phases determined by using Calphad program for the Al-C system.
The formation and stability of Al_4C_3 precipitates was found at different temperatures. Figure 2 shows an example of nanosized diamond particles dispersed in the Al matrix. Evidence for the uniform distribution of the particles was found. This also demonstrated stability of nanosized diamond particles in the Al matrix. Faceting can be seen in the diamond particle without any reaction products formed at the interface. The reinforced nanozised particles can also

significantly enhance the strength of the alloys by impeding the mobility of dislocations.

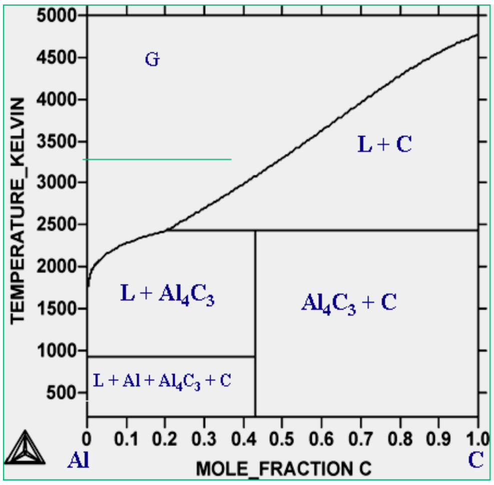

Figure 1 Phase diagram of Al-C system determined by Calphad modeling.

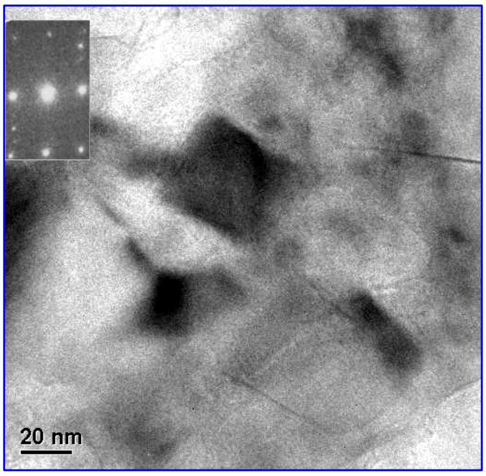

Figure 2 Micrograph showing morphology of nanosized diamond particles in the Al matrix nanocomposite specimen, inset SADP, Z=[123]Diamond.

Figure 3 illustrates the presence of Al_4C_3 particles formed in the Al-diamond specimen. The carbides grew along (011) Al with semicoherent interface. The carbides were very small and found occasionally indicating a negligible influence on the properties of the composite materials. The results are in confirmation with previous work on Al-C_{60} composite materials [4].

Conclusions

It can be stated that stable structure can be achieved in the nanocomposites produced by liquid infiltration process with greater prospects for thermal management applications.

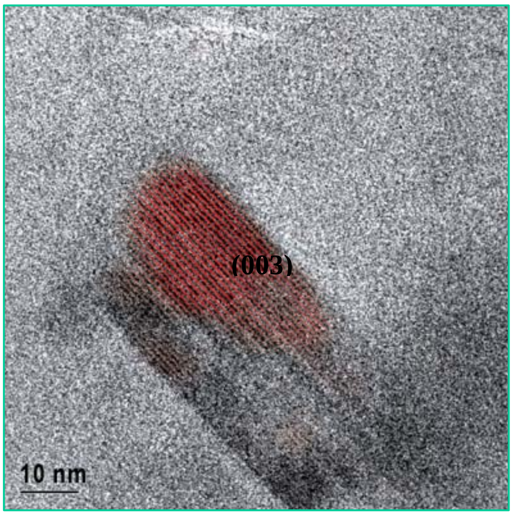

Figure 3 HR-TEM image showing presence of rod-shaped Al_4C_3 precipitates in the nanocomposite sample.

References

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