Dispersion Control of Nanodiamond in Metal Matrix nNanocomposites by Backpressure Pressing

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Detonation nanodiamond synthesized by explosives has unique characteristics: nanosized single crystal (4.3±0.3 nm), capability of ultra-dispersion in gas and liquid, solid lubricating ability, good biocompatibility etc., in addition to well-known characteristics of diamond: high modulus and high strength, and high thermal conductivity. One of the promising applications is nanocomposites containing detonation nanodiamond, which would have many applications especially in engineering field. The detonation nanodiamond usually forms the strongly-agglomerated secondary particles, and the strong aggregates cause the nanocomposites with ununiformly dispersed nanodiamond and consequent poor mechanical properties. Conventional plastic forming process with large deformation, such as extrusion and rolling and forging, break the aggregates down to smaller size. However such processes cannot be successfully done without capsuling the nanocomposites; furthermore the plastic deformation volume given and obtained size are limited in the processing.

To control nanofiller dispersion in metal matrix nanocomposites, back-pressure pressing method is proposed. This method is plastic forming process with backpressure, which can give large deformation repeatedly to the nanocomposites without capsuling by 3 punches controlled precisely from different directions. Gas-atomized pure aluminium powder and purified detonation nanodiamond of 10% by volume are mechanically mixed at 200 rpm for 2 hours and are consolidated by spark-plasma sintering at 723K. The backpressure pressing is carried out at 573K to control the nanodiamond dispersion in the aluminium-based nanocomposites. Then the repeat number of backpressure pressing applied is 1 and 5 and 9 times. The microstructural observation is made by TEM and optical microscope, and the results show that the nanodiamond aggregates are broken and the nanodiamond dispersion is further improved, as the repeat count increases. Indentation measurement is made to determine the modulus and mechanical strength of the aluminium-based nanocomposites with controlled nanodiamond dispersion, and the effect of the controlled nanodiamond dispersion is discussed.