The effect of processing parameters on the synthesis of an aluminium–titanium nanocomposite by high-pressure torsion

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Abstract

Although a number of SPD processing techniques is now available, high-pressure torsion (HPT) is an especially attractive, because it leads to exceptional grain refinement. It was widely used to process various metals and their alloys. Recently, a new approach was set to fabricate a metal matrix nanocomposite (MMNC) by HPT processing two or more various commercial metal disks. This investigation was initiated to evaluate the potential of HPT process to synthesis of new Al-Ti MMNC. A series of different Al-Ti composites, with a different ratio of Al to Ti and with a different number of joining plates was used. A disks of commercial Al-1050 and Ti99.5% alloys were stacked together and then processed by HPT through 10 up to 50 under two compressive pressures of 1.0 and 6.0 GPa. The microstructure was studied with the use of Scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Mechanical properties were evaluated in microhardness and tensile tests. Structural observations showed that the microstructure of these joints strongly depends on the number of processing disks in stack, their thickness and HPT parameters. In the samples where the mixing of metals occurred, the formation of an multi-nano-layered structure in the whole volume of the disks was observed. Further investigations with the use TEM revealed that each nano-layer is built of nano-grains having sizes of about 20 nm. XRD and selected area electron diffraction (SAED) analysis confirmed the formation of various intermetallic Al-Ti phases in the layered structures. The experiments also showed a significant improvement in microhardness when compared to both Al-1050 and Ti99.5% alloys in initial state and after HPT processing. The results demonstrate that HPT offers a great opportunity to produce novel nanostructured Al-Ti metal matrix composites with unique mechanical properties.