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Microstructural evolution of nanocrystalline tungsten-25% rhenium-hafnium carbide composite synthesized by spark plasma sintering technique for FSW tool application

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Development of nanocrystalline tungsten-25% rhenium alloy reinforced with hafnium carbide is a challenging task as these alloys are difficult to synthesize by conventional methods. The problem of these difficult to alloy elements can be addressed by using a unique combination of mechanical alloying and spark plasma sintering (SPS) techniques via powder metallurgy route. Rhenium was added to a lower ductile-to-brittle transition temperature and to increase recrystallization temperature of tungsten. SPS is a rapid consolidating technique which prevents grain growth. These tool materials can withstand high temperatures and harsh conditions in joining application such as Friction Stir Welding (FSW) of steel and titanium alloys. FSW is a green process which does not emit fume and toxic fumes during the process. Sintering was carried between 1500-1800°c. Mechanically alloyed and spark plasma sintered alloy and composite were characterized by optical microscopy, field emission scanning electron microscopy (FESEM) and X-ray diffraction. Microstructural investigation of consolidated specimens was initially carried out by conventional etching and metallography techniques. Optical micrographs showed no visible signs of grain boundary etching. Spark plasma sintered samples were further electrochemically etched in one molar concentrated solution of NaOH. The positive terminal of the low voltage direct current power supply was connected to the sample. The negative terminal was connected to a steel plate acting as a cathode. Both electrodes were placed in the tank face to face with a gap of 6 to 10 centimeters between them. The voltage was kept constant at 5 volts during the etching process. The sample was etched for a short time interval from 1 to 5 seconds and microstructural analysis was conducted after each etching step. The results of the FESEM images confirm microstructural revelation of these difficult to etch alloy and composites.

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