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Sintering Behavior and Mechanical Properties of Mo-TZM Alloyed with Nano Titanium Carbide

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Abstract

Molybdenum alloys are used in a number of commercial, defense, nuclear, and aerospace applications that take advantage of their high melting temperature, good creep resistance, and decent mechanical properties at elevated temperature. Titanium-Zirconium-Molybdenum (TZM) alloys are the most commercially important Mo alloy as they possess substantially higher strength than pure molybdenum while still maintaining strong mechanical performance at elevated temperature. High density components of these alloys are of interest for high performance defense and aerospace applications, however obtaining high relative densities by sintering has proven difficult. Here we report nano-titanium carbide addition as an effective method of improving TZM sintered density as well as increasing alloy hardness and flexural strength. Pure TZM was sintered by Field Assisted sintering Technique (FAST) to over 98.5% density at 2000°C under 55 MPa applied pressure, while density was improved to >99% using TiC addition. TiC addition was found to result in reduced grain size and improved hardness of as-sintered alloys, including over a 95% reduction in grain size and 75% increase in hardness for TZM with 10 vol% TiC addition.

Introduction

The combination of a ductile-to-brittle transition temperature (DBTT) below or near room temperature¹, high melting temperature, good creep resistance², high electrical conductivity³, high strength at elevated temperatures^{4,5}, and low thermal neutron cross section⁶ make molybdenum alloys highly attractive for use in the nuclear, defense⁷, and aerospace industries⁸. In the nuclear industry, molybdenum is of particular interest for use as a structural component in gas cooled reactor applications (GCR) and in accelerator applications^{6,9}. The most commercially important molybdenum alloy is known as TZM and consists of Mo alloyed with small quantities of titanium and zirconium (generally below 0.1 wt%) in order to gain advantage of solid solution strengthening and second phase precipitation strengthening mechanisms while still maintaining

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