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Microstructure and high temperature deformation behavior of the $Mo-ZrO_2$ alloys

Chaopeng Cui [a,*], Yimin Gao [a], Shizhong Wei [b,c,**], Guoshang Zhang [b], Yucheng Zhou [c], Xiangwei Zhu [b]

[a] State Key Laboratory for Mechanical Behavior of Materials, Xi'an Jiaotong University, Xi'an 710049, China
[b] School of Materials Science and Engineering, Henan University of Science and Technology, Luoyang 471003, China
[c] Engineering Research Center of Tribology and Materials Protection, Ministry of Education, Henan University of Science and Technology, Luoyang 471003, China

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ABSTRACT

The $Mo-ZrO_2$ alloys were prepared by a hydrothermal synthesis and a powder metallurgy process. The grain size, density and hardness of the alloy sintered compacts were investigated. The deformation behavior of the alloy at high temperature was studied by using a Gleeble-1500D thermal simulated test machine. The strengthening effect of zirconia particles was found during the deformation process of the alloy at high temperature. The result shows the mechanical properties of the $Mo-ZrO_2$ alloys were obviously improved due to the uniform distribution of the small second phase. After adding ZrO_2, the hardness of the alloys has increased by 40%, and the high temperature strength of the alloy was increased. At the temperature of 1400 °C, the strength of the alloys was increased by 35% compared with that of the pure molybdenum. The ZrO_2 particles can effectively improve the deformation resistance, resulting in increase of the mechanical properties of the $Mo-ZrO_2$ alloys.

1. Introduction

The melting point of molybdenum is as high as 2620 °C, and molybdenum can keep good mechanical strength at high temperature. The molybdenum has good dimensional stability at high temperature due to its small linear expansion coefficient; The thermal conductivity of molybdenum is relatively high, which is several times higher than that of many high temperature alloys. Thus, molybdenum alloys are widely used in aerospace, electronic communication and electrical equipment as refractory metal above 1000 °C [1–5]. However, when the temperature is at or above 1600 °C, the strength of pure molybdenum will sharply decrease with brittle fracture behavior, which would limit its application [6,7]. Many researchers found that the high temperature properties of molybdenum alloys could be improved by introducing alloy elements or second phase particles [8,9]. Then many kinds of molybdenum alloys with high-temperature mechanical properties were developed. Thus, the application range of molybdenum became wider.

Elements Ti and Zr were added to molybdenum, called TZM alloy, which had solid solution reaction with elements and formed oxides and carbides at the same time [5]. TZM alloy has better performance than pure molybdenum. Later, after adding lanthanum oxide and alumina, the mechanical properties of molybdenum can be enhanced by controlling the grain size and the distribution of the second phase particles in the alloy [3,5,6]. In this paper, the $Mo-ZrO_2$ alloys were prepared by a hydrothermal process and a powder metallurgy method [10]. The high temperature mechanical properties of the sintered compacts were tested. The effect of the second phase on the microstructure and mechanical properties of the alloys was investigated.

2. Material and methods

2.1. Material preparation

The precursor powders of ZrO_2 and MoO_3 were prepared by the

* Corresponding author.
** Corresponding author. School of Materials Science and Engineering, Henan University of Science and Technology, Luoyang 471003, China.
E-mail address: ccp273206157@163.com (C. Cui).

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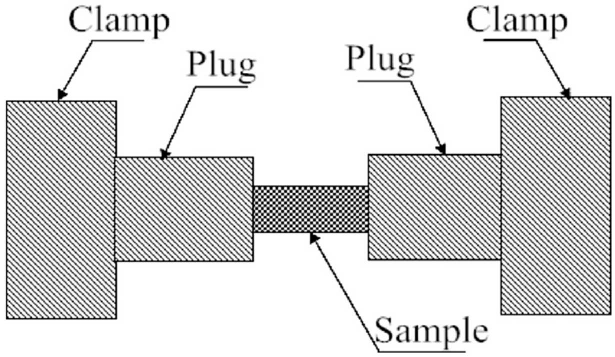

Fig. 1. Schematic diagram of thermal simulation compression experiment device.

hydrothermal method. The mixed powders of ZrO_2 and MoO_3 can be obtained by calcination. The composite powders of Mo and ZrO_2 could be obtained by two stage reduction processes, and the Mo-ZrO_2 alloy was prepared by powder metallurgy technology.

The pressure value was 280 MPa, holding 5 min (by cold and static pressing (CIP)). The samples with size of Ø8mm × 12 mm were sintered at 2000 °C under H_2 atmosphere.

2.2. Experiment procedure

The deformation behaviors of the sample at the temperatures of 900 °C, 1100 °C, 1200 °C, 1300 °C, and 1400 °C were studied respectively on a Gleeble-1500D thermal simulated test machine, under the following conditions: heating rate: 10 °C/s, holding time

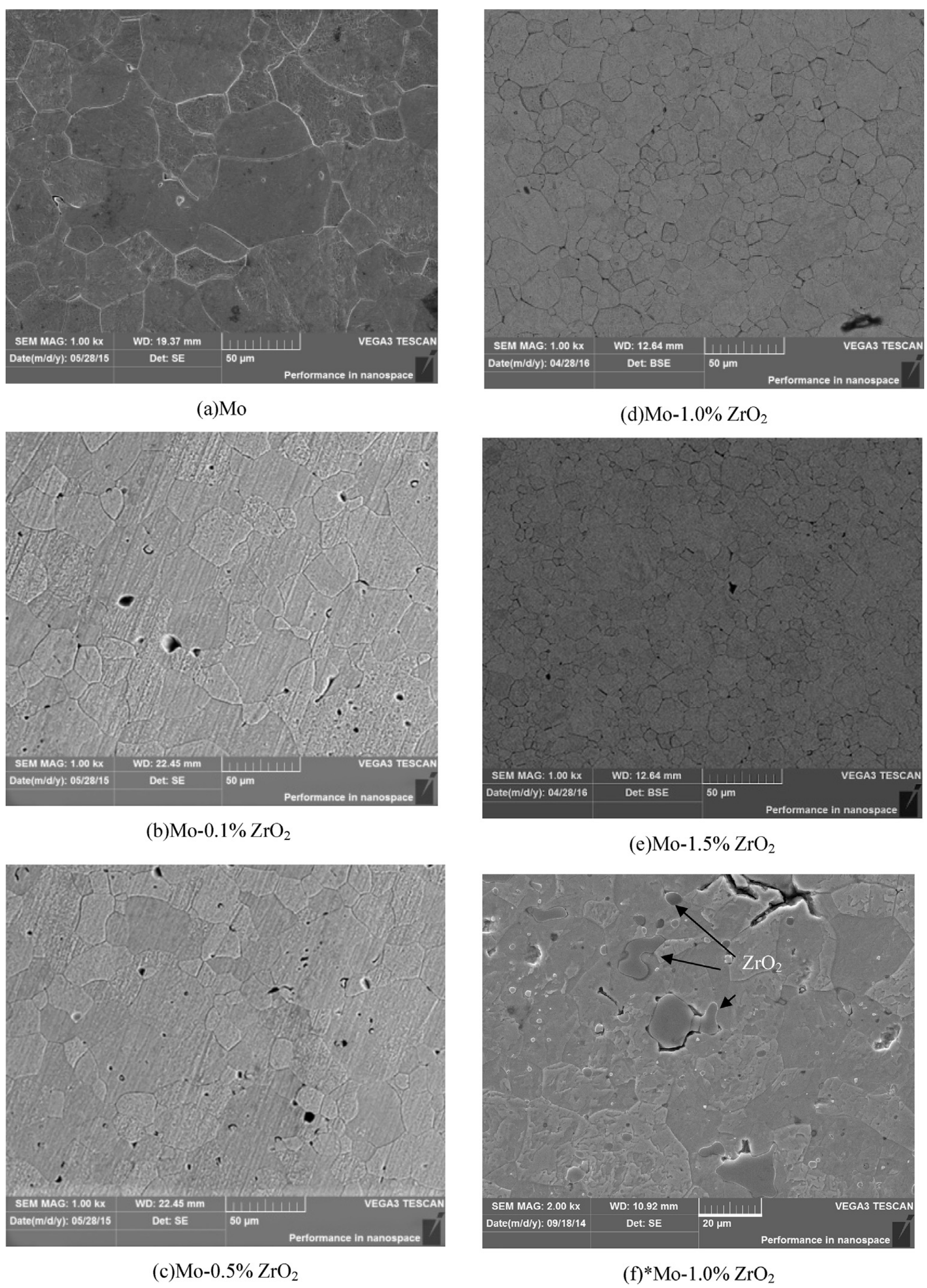

Fig. 2. Microstructure and morphology of molybdenum alloy sintered compact.