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Effects of the temperature of hot isostatic pressing treatment on Cr–Si targets

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Abstract

Commercial as-hp (hot pressing) treated Cr–Si targets are used throughout this study, with three different compositions: Cr20–Si80, Cr35–Si65 and Cr50–Si50. To evaluate the effects of microstructure and properties of as-hp treated Cr–Si targets by hot isostatic pressing (HIP) SEM, XRD and porosity inspections were performed. The experimental results showed that the 1373 K, 1750 MPa, 4 h HIP treated with three different Cr–Si targets had suppressed porosities successfully. The most efficient was Cr50–Si50 target subjected to HIP treatment. Porosity decreased about 60% after HIP treatment, and both the nitrogen and oxygen concentrations of the targets were slightly increased after HIP treatment. This was especially true for the single silicon in Cr–Si targets such as Cr20–Si80 and Cr35–Si65. The aim of this paper is to discuss these methods and finding suitable temperatures for the HIP for Cr–Si targets.

Keywords: A. Hot pressing; A. Hot isostatic pressing; B. Porosity; Cr–Si targets

1. Introduction

Most targets could be made by casting, because the metals have low melting points and good toughness. However, some activated or brittle elements such as chromium and silicon are not suitable for casting, because they are easily oxidized and cracked during the process. To make the Cr–Si targets in powder metallurgy; it is better to produce them by hot pressing. Hot pressing (HP) is putting the powder in a die and applying force with vertical (or horizontal) pressure heads. The heaters around the die would be turned on in a vacuum or with atmosphere [1–4]. The products made by hot pressing would still be porous or coarse, and the size is limited. For finer and larger targets, we can apply advanced method, like hot isostatic pressing.

Hot isostatic pressing (HIP) is the application of high pressure equally on all sides of an object. HIP is a material pressing technique in which high isostatic pressure is applied to a powder part or compact at elevated temperature to produce particle bonding. This process usually results in the manufacture of a fully dense body. During this process, the compact is subjected to equal pressure from every side [5–7]. HIP is used for dense high performance ceramics, to remove porosity from castings, the consolidation of PM materials and surface coatings, diffusion bonding and improvement of weld integrity [8–12]. As shown in Fig. 1, HIP equipment was from a Flow Autoclave Pressure System, Inc. This HIP equipment provided an uniform rapid cooling (URC) system and a quick heating which result in very short cycle time and high productivity.

In this study, three different HIP temperatures are utilized, including 1323 K, 1373 K and 1423 K. The processing pressure and soaking time for the HIP treatment were 175 MPa and 4 h, respectively. Porosity test, nitrogen and oxygen concentration test, X-ray diffraction analysis and microstructure inspection were used to evaluate the effects of HIP treatment at different temperatures for as-hp treated Cr–Si targets.

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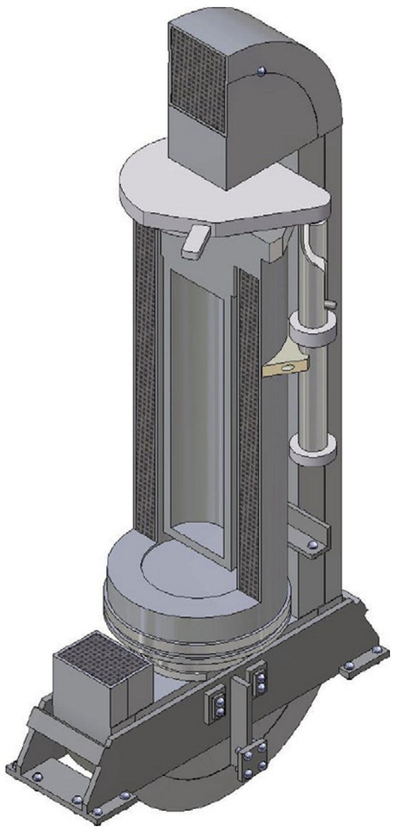

Fig. 1. Schematic diagram of HIP equipment.

2. Experimental

Both chromium and silicon are rapidly oxidized, and powder metallurgy is usually used to make targets out of such materials, especially in hot pressing. To achieve better quality targets, we should use some advanced methods, such as hot isostatic pressing. HIP involves the application of high pressures and temperatures through the medium of a pressurized gas, such as argon or nitrogen, to remove internal pores and voids, thus increasing density and upgrading properties. HIP consolidates powders of metals, ceramics, or carbides into fully dense, complex parts with net or near net shapes.

The aim of this paper is to discuss the methods and to find a suitable temperature of HIP for Cr–Si targets. In this study, the HIP pressure was maintained at 175 MPa, the soaking time 4 h and the three different temperatures were 1323 K, 1373 K and 1423 K. Commercial HP treated Cr–Si targets were used throughout this study, and they had three different compositions: Cr20–Si80, Cr35–Si65 and Cr50–Si50. To evaluate the effects of microstructure and properties of the Cr–Si target by HIP process, SEM, XRD and porosity inspections were performed.

3. Results and discussion

3.1. Porosity test

The porosity test followed the ASTM C373 standard. During HIP plastic flow, power law creep, grain boundary sliding in the particles and bulk diffusion in the particle contacts may

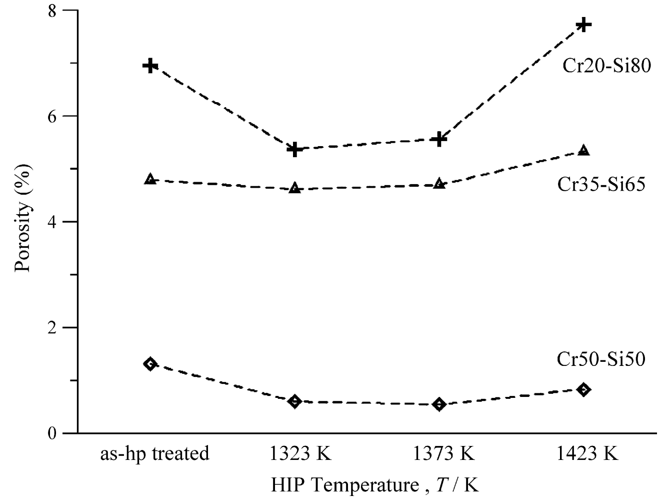

Fig. 2. Comparison of the porosities of as-hp treated and after HIP treatment at different temperatures for different compositions of Cr–Si targets.

contribute to the densification [2]. Fig. 2 represents the porosity of Cr–Si targets after HIP treatment at different temperatures. It shows the porosity was significantly reduced before 1423 K HIP treatment. The porosity of Cr50–Si50 target was reduced down to 40% after HIP treatment at 1373 K. The minimum amount of porosity of Cr20–Si80 target was obtained for samples after HIP treatment at 1323 K. When the temperature of HIP was increased from 1373 K to 1423 K, the porosity rapidly increased. Because the silicon exists singly inside the Cr20–Si80 and Cr35–Si65 targets, the new pores would emerge by diffusion and adsorption of silicon elements.

3.2. Concentration of nitrogen and oxygen

Figs. 3 and 4 show the concentration of nitrogen and oxygen inside the Cr–Si targets for different compositions after HIP treatment. The results show the silicon element was singly existed in the Cr20–Si80 and Cr35–Si65 targets, and the concentrations of impurities would rise up after HIP treatment. There was still residual air inside the vessel before heating, and

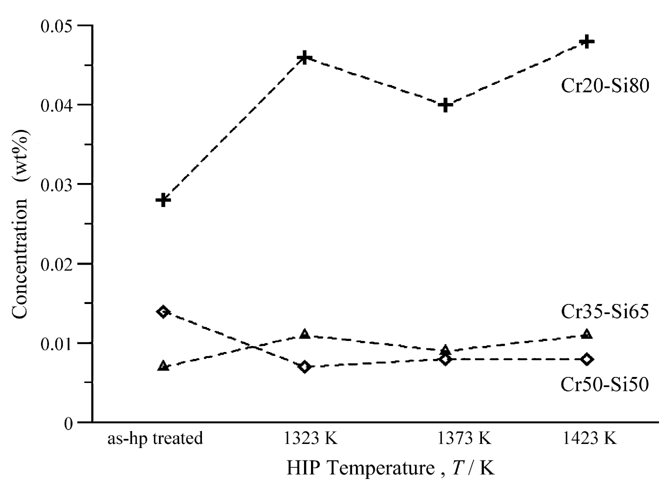

Fig. 3. Comparison of the nitrogen concentration of as-hp treated and after HIP treatment at different temperatures for different compositions of Cr–Si targets.