



Characterization of multi-element alloy claddings manufactured by the tungsten inert gas process

J.H. Chen^a, P.N. Chen^a, C.M. Lin^a, C.M. Chang^a, Y.Y. Chang^b, W. Wu^{a,*}

^a National Chung Hsing University, Department of Materials Science and Engineering, Taichung 402, Taiwan, ROC

^b MingDao University, Department of Materials Science and Engineering, Chunghua 52345, Taiwan, ROC

ARTICLE INFO

Article history:

Received 2 October 2008

Accepted in revised form 20 February 2009

Available online 6 April 2009

PACS codes:

46.55.d

62.20.Qp

81.40.Pq

42.81.Bm

06.60.Vz

81.20.Vj

Keywords:

TIG cladding process

Microstructure

Wear

Hardness

ABSTRACT

Multi-element alloy filler method and the tungsten inert gas (TIG) cladding process were used to fabricate Fe–Co–Cr–Ni–Mo_x multi-element alloy claddings, and the microstructure and wear properties of the claddings were studied.

In the absence of Mo, the claddings formed a face-centered-cubic (FCC) solid-solution phase. When the Mo concentration was increased, the claddings comprised not only the primary FCC phase but also a phase with the characteristics of a eutectic mixture of the FCC phase and σ phase. The microhardness of the claddings increased from 210 to 465 HV upon the addition of Mo due to the formation of the σ phase. Claddings with higher microhardness showed better wear performance due to precipitation strength and solid solution strength.

© 2009 Elsevier B.V. All rights reserved.

1. Introduction

Advances in alloy technology are very important for industries as well as the general public. Carbon steel and stainless steel are used widely in the civil industry, while Al-, Ni-, Co- and Fe-based alloys are often used in industries such as aerospace and nuclear energy industries. These commercial and industrial alloys are mainly composed of one or two base metal element and other solute elements.

Recently, a novel alloy system, “multiple-element systems,” was developed by Yeh et al. [1–3]. This alloy system consists of multiple elements without any matrix elements, and it contains at least five elements whose concentrations range from 5 to 35 at.%. Due to the high mixing entropy, the formation of complex structures consisting of many intermetallic compounds is suppressed, and instead, a solid solution containing multiple elements is formed. Some of these alloy systems exhibit useful mechanical properties, high thermal stability, high wear and oxidation resistance, and high corrosion resistance [1–5]. These properties make multiple-element system attractive in the field of surface treatment. Typically, multiple-element alloys are manufactured by adding metallic elements such as cobalt, chromium, molybdenum, nickel, and vanadium to the ingot; conventional casting

and the thin film deposition process are used for their manufacture. However, since some metallic elements like molybdenum and cobalt are expensive, the manufacturing cost is high, thus limiting its use. If the alloy systems could be manufactured using surface treatment, a smaller quantity of base metal elements would be required, thus lowering the cost. When selecting a surface treatment process for bulk materials, it is important to consider their corrosion resistance, mechanical properties, and wear resistance.

The tungsten inert gas (TIG) process is a surface treatment process with the following advantages: high deposition rate, high maneuverability, large-scale availability, low cost, and compatibility with a wide range of materials. It has been reported that the TIG process can be effectively used for surface treatment when appropriate fillers are used [6–9]. In this study, the TIG process was used for cladding a multiple-element alloy onto a low-carbon steel matrix, and a multi-element filler was used in the process. After cladding, the microstructure, hardness, and wear resistance were systematically investigated.

2. Experimental procedures

Low-carbon steel plates with a rectangular shape (length: 12 cm; width: 8 cm; and thickness: 2 cm) were used as the base material in the TIG process that was employed in the experiments. Fig. 1 shows the TIG process; the welding path and the positions at which the microstructure observation, hardness test, and wear test were carried

* Corresponding author. 250 Kuo Kuang Road, Taichung 402, Taiwan, ROC. Tel.: +886 422840500; fax: +886 422857017.

E-mail address: d9466112@mail.nchu.edu.tw (W. Wu).

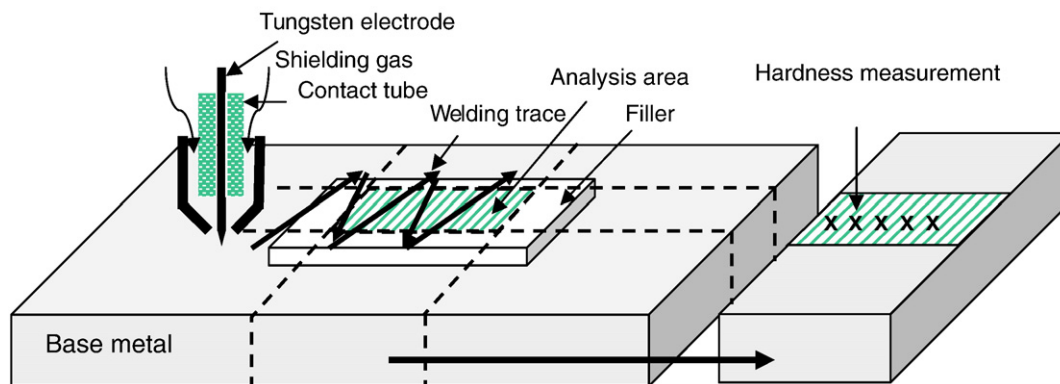


Fig. 1. Diagram of the TIG cladding process and the positions at which hardness was measured.

out are also shown in this figure. Fillers prepared from powder mixtures with an equi-atomic ratio of Cr, Co, and Ni and different amounts of Mo were used as the cladding alloy. In all the experiments, a 3.2-mm W-ThO₂ electrode was used. The operating current and voltage were 220 A and 16 V, respectively. Ar was used as the protective gas, and its flow rate of 15 l/min. The travel speed of the nozzle was 30 mm/min, and the oscillation speed was 300 mm/min. It is worth noting that the filler does not include Fe. Fe was formed when the low-carbon steel melted along with the matrix. Microstructures of the specimen were prepared by sectioning the cladding in the transverse direction and polishing and etching it with 0.3- μ m Al₂O₃ and aqua regia, respectively. The microstructures were imaged using scanning electron microscopy (SEM), and their chemical compositions were analyzed by employing X-ray energy dispersive spectrometry

(EDS). X-ray diffraction (XRD) analysis was performed to identify the structural phases. Vickers indentations were obtained using a microhardness tester at a load of 294.3 N to determine the bulk hardness. Abrasive wear tests to estimate wear resistance were also carried out using a dry sand wheel apparatus. Specifications for the abrasive wear tests were as follows: load: 130 N; sand-flow rate: 350 g/min; wheel rotation rate: 200 rpm; and total wheel revolutions: 3000. The specifications of the test sample were as follows: length: 75 mm; width: 25 mm; and height: 12 mm.

3. Results and discussion

Fig. 2(a) shows the as-clad surface, and Fig. 2(b) shows the lateral section of the as-clad multi-element alloy coating. Fig. 2(b) reveals

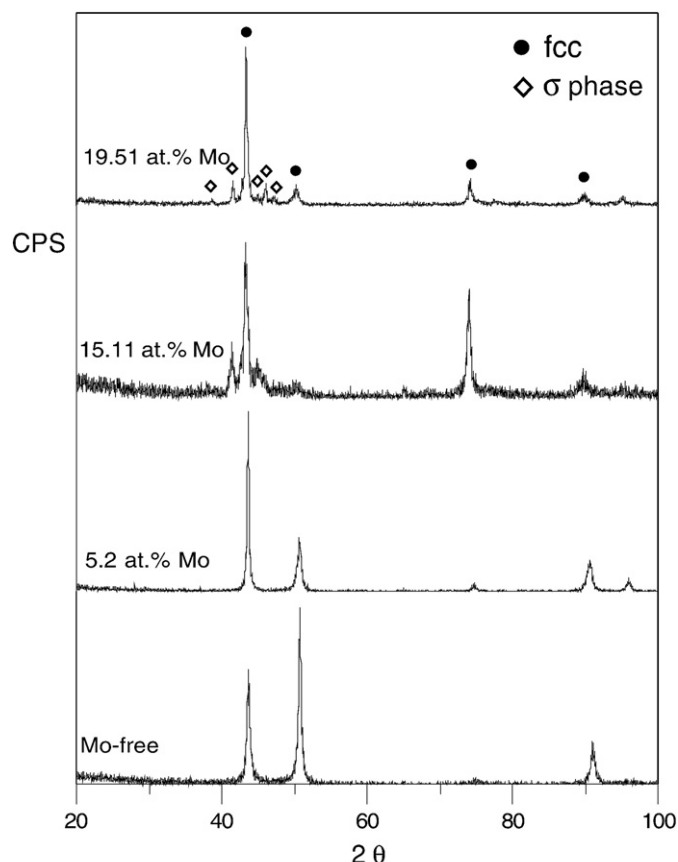
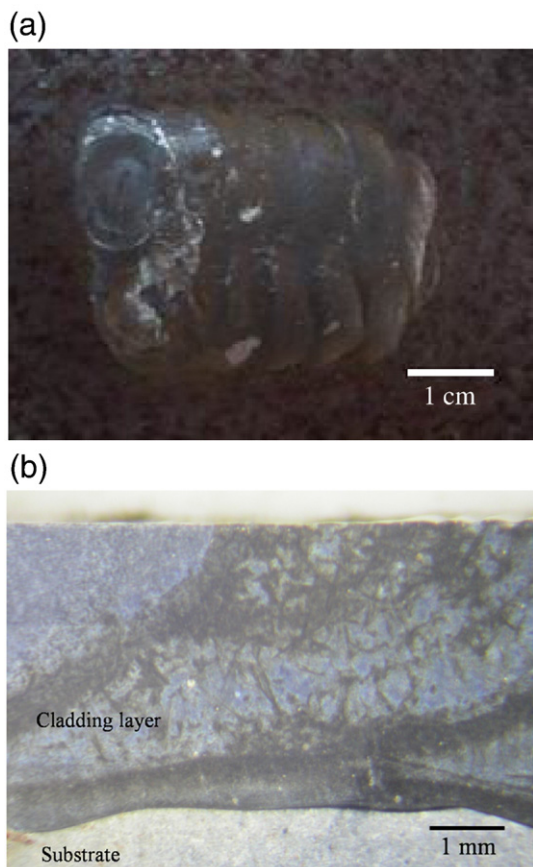


Fig. 3. XRD patterns of the multi-element alloys at different Mo concentrations.

Fig. 2. (a) As-clad surface of the multi-element alloy cladding; (b) OM photograph of the overall cross-section of the as-clad multi-element alloy coating.

Download English Version:

<https://daneshyari.com/en/article/1659908>

Download Persian Version:

<https://daneshyari.com/article/1659908>

[Daneshyari.com](https://daneshyari.com)