

# Fabrication and Cyclic Oxidation of $Y_2O_3/CeO_2$ -Modified Low Temperature Aluminide Coatings

Zhang Haijun, Sun Jianfeng



Heilongjiang University of Science and Technology, Harbin 150022, China

**Abstract:** With  $Y_2O_3/CeO_2$  powder, instead of part of  $Al_2O_3$ , acting as filler,  $Y_2O_3/CeO_2$ -modified aluminide coatings were produced on Ni based using a conventional pack-cementation method at 600 °C for 10 h. For comparison, a normal aluminide coating was also produced using pure  $Al_2O_3$  acting as filler. Effect of  $Y_2O_3/CeO_2$  in the pack on the alumina phase transformation and cyclic oxidation resistance in air at 1000 °C was investigated. The results indicate that  $Y_2O_3$  and  $CeO_2$  have different effects on  $\theta$ - $\alpha$  phase transformation:  $Y_2O_3$  suppresses the growth of the  $\theta$ -alumina but  $CeO_2$  promotes the  $\theta$ - $\alpha$  phase transformation. However, compared to the normal aluminide coating, the addition of  $Y_2O_3/CeO_2$  significantly improves the cyclic oxidation resistance due to the formation of adherent alumina scale, especially the later. The effects of  $Y_2O_3/CeO_2$  on alumina phase transformation and cyclic oxidation resistance were discussed.

**Key words:** aluminide; cyclic oxidation; reactive element effect

The addition of reactive element (RE), such as Y, Ce, and La, or reactive-element oxide (REO), such as  $Y_2O_3$ ,  $CeO_2$ ,  $La_2O_3$ , can improve the oxidation resistance of alloys, which was referred to as “reactive element effect” (REE)<sup>[1]</sup>. Various theories to elucidate the REE have been put forward but still are in dispute<sup>[2]</sup>. A large number of research has developed this effect of REO addition into the aluminide coating through depositing on the surface of alloy by various techniques before aluminization<sup>[3-6]</sup>. However, these methods not only complicated their technologic steps, but also added to the difficulty in preparation of these modified coatings. It was well known that the filler  $Al_2O_3$  particles could be entrapped into the outer layer of aluminide coating<sup>[7,8]</sup>. By considering this phenomenon, Zhou et al.<sup>[9]</sup> developed a much simpler technologic process to add  $Y_2O_3$  particles into the aluminide coatings by the  $Y_2O_3$  microparticles instead of part of  $Al_2O_3$  as filler at 1000 °C. Zhao<sup>[10]</sup> further investigated the effect of  $Y_2O_3$  content in the filler on microstructure and hot corrosion resistance of aluminide coating produced at 1050 °C. However, such a high temperature treatment

inevitably restrict the applications of aluminide coatings due to grain growth of the substrate materials, which has a detrimental effect on the mechanical properties of workpieces. Therefore, reducing pack cementation temperature is required for the widespread application of the aluminide coatings<sup>[4-6]</sup>. Recently, Sun et al.<sup>[11]</sup> successfully added  $CeO_2$  nanoparticles into the chromizing coatings using the same methods at low temperature. Meng et al.<sup>[12]</sup> further found that the chromizing coating using part of  $CeO_2$  as filler exhibits better oxidation resistance than the chromizing coatings using pure  $Al_2O_3/CeO_2$  as filler. The authors work<sup>[13]</sup> also indicated that  $Y_2O_3/CeO_2$  can be added into aluminide coating using part of  $Y_2O_3/CeO_2$  as filler at 600 °C. Oxidation results showed that  $Y_2O_3/CeO_2$  significantly enhanced the isothermal oxidation resistance of aluminide coatings. Based on these studies, the objective of the present work was to analyze the effect of  $Y_2O_3/CeO_2$  on alumina phase transformation and cyclic oxidation resistance of aluminide coatings.

## 1 Experiment

Received date: February 14, 2016

Foundation item: Scientific Research Fund of Heilongjiang Provincial Education Department (11531319)

Corresponding author: Zhang Haijun, Ph. D., Associate Professor, College of Materials Science and Engineering, Heilongjiang University of Science and Technology, Harbin 150022, P. R. China, Tel: 0086-451-88036740, E-mail: kjdx1@163.com

Copyright © 2017, Northwest Institute for Nonferrous Metal Research. Published by Elsevier BV. All rights reserved.

Samples with dimensions of 15 mm×10 mm×2 mm were cut from an electrolytic nickel plate. They were ground to a final 800# SiC paper. After ultrasonically cleaning in acetone, they were aluminized using conventional pack cementation in a homogeneous mixture of 75 wt%Al powder as master alloy source, 20 wt% inert filler (namely 100 wt% Al<sub>2</sub>O<sub>3</sub>, 50 wt% Y<sub>2</sub>O<sub>3</sub> (40~50 nm) + 50 wt% Al<sub>2</sub>O<sub>3</sub> and 50 wt% CeO<sub>2</sub> (40~50 nm) + 50 wt% Al<sub>2</sub>O<sub>3</sub>, respectively) and 5 wt% NH<sub>4</sub>Cl as activator in a pure Ar atmosphere at 800 °C for 7 h. Afterwards, the samples were brushed, cleaned in bubbling distilled water for 30 min and then ultrasonically cleaned in acetone to remove any loosely embedded pack particles. The details and processing parameters were reported in Ref.[13].

The cyclic oxidation at 1000 °C up to 40 h in air was performed by automatically lifting samples from the hot zone of a vertical furnace after an 1 h exposure period followed with 10 min cooling to room temperature. Mass changes of the oxidized specimens were measured after fixed time intervals using a balance with 0.01 mg sensitivity. The composition and phases of the various aluminide coatings before and after oxidation was investigated using Camscan MX2600FE type scanning electron microscopy (SEM) with energy dispersive X-ray analysis (EDAX), transmission electron microscopy (TEM) and D/Max-2500pc type X-ray diffraction (XRD). Electroless Ni-plating was plated on the surface of the oxidized specimens to prevent the spallation of the scales for observing cross-sections.

## 2 Results

### 2.1 Microstructure

After pack cementation at 600 °C for 10 h, the aluminide coatings were prepared. Previous results indicated that the addition of Y<sub>2</sub>O<sub>3</sub> or CeO<sub>2</sub> in the pack significantly retarded the grain growth of the aluminide coating<sup>[13]</sup>. The average Al concentration in the surface zone (<4 μm: the profile depth of electron beam) is close to 41 wt% for the three aluminide coatings on a basis of EDAX area analysis. XRD results also reveal that all aluminide coatings contain only δ-Ni<sub>2</sub>Al<sub>3</sub> phase, as seen in Fig. 1.

Fig.2 shows the corresponding cross-sectional morphologies of δ-Ni<sub>2</sub>Al<sub>3</sub> coatings developed on Ni using different filler. Clearly, the aluminide coatings using part of Y<sub>2</sub>O<sub>3</sub> or CeO<sub>2</sub> as filler is more compact than the aluminide coating using pure Al<sub>2</sub>O<sub>3</sub> as filler even all have the same thickness about 50 μm. From Fig.2a, it can be found that there is a 2~3 μm interdiffusion zone (as arrowed). However, for aluminide coatings using Y<sub>2</sub>O<sub>3</sub>/CeO<sub>2</sub> as filler, the thickness of interdiffusion zone is significantly decreased, especially the later. No bright Y<sub>2</sub>O<sub>3</sub>/CeO<sub>2</sub>-oxides particles can be found from Fig.2b and Fig.2c. The result is contrary to Zhou<sup>[9]</sup> but the same as other works<sup>[10-12]</sup> using finer Y<sub>2</sub>O<sub>3</sub>/CeO<sub>2</sub> particles as filler.

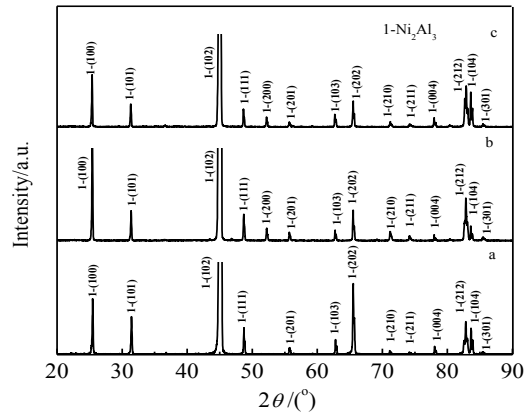


Fig.1 XRD patterns of aluminide coatings using different filler (a-Al<sub>2</sub>O<sub>3</sub>, b-Al<sub>2</sub>O<sub>3</sub>+Y<sub>2</sub>O<sub>3</sub>, c-Al<sub>2</sub>O<sub>3</sub>+CeO<sub>2</sub>)

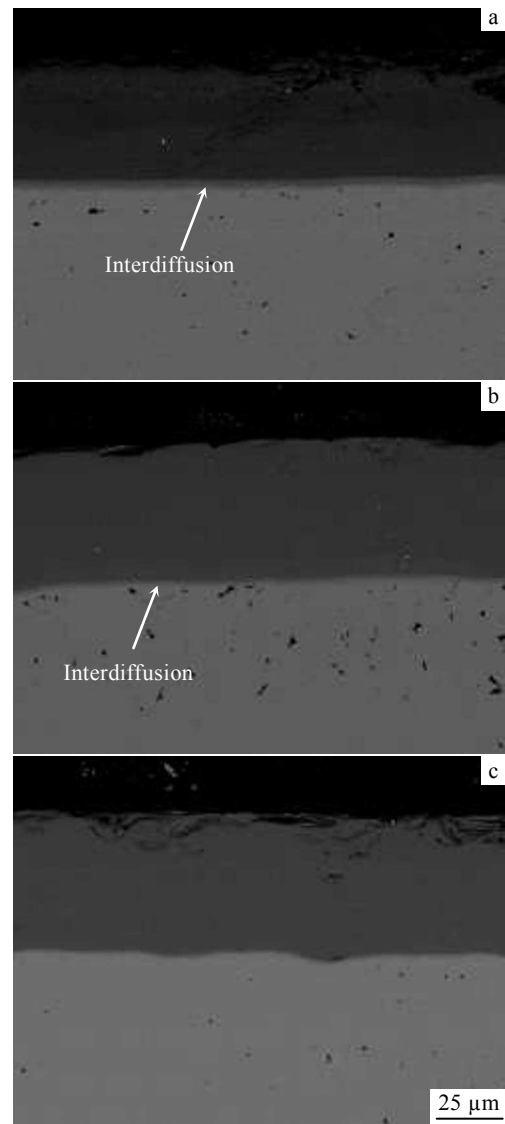


Fig.2 Cross sectional morphologies of aluminide coatings using different filler: (a) Al<sub>2</sub>O<sub>3</sub>, (b) Al<sub>2</sub>O<sub>3</sub>+Y<sub>2</sub>O<sub>3</sub>, and (c) Al<sub>2</sub>O<sub>3</sub>+CeO<sub>2</sub>

Download English Version:

<https://daneshyari.com/en/article/7210466>

Download Persian Version:

<https://daneshyari.com/article/7210466>

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