Neutron Shielding Effect of Gadolinium Oxide Layers Prepared by Plasma Thermal Spray

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1. Introduction

The nuclear spent fuel and transportation and storage containers require a high performance neutron and gamma ray shielding besides excellent corrosion resistance and mechanical properties [1]. At materials point of view, gadolinium is better neutron absorber than boron, because of no-He formation and good metallurgical effect [2,3].

In this study, gadolinium was plasma thermal spray coated on a 304 stainless steel plate with bonder nickel powders to develop the high performance neutron shielding layers for a domestic nuclear spent fuel transportation and storage.

2. Methods and Results

2.1 Sample Preparation

The thermal spray coating was carried out on the surface of 304 stainless steel plate. The raw materials were gadolinium and nickel powders, which were mixed with various ratios such as 1:1, 1:3, and 1:9. The thermal spray coating conditions were DC 500 A in argon and hydrogen environment with a gun speed of 600 mm/sec.

2.2 Microstructure Observation and Chemical Analysis

Scanning electron microscope was used to observe the microstructure of the coated layers. X-ray diffractometer was used for the chemical analysis. As shown in Fig 1, the coating layer was dense and consisted of very fine particles.

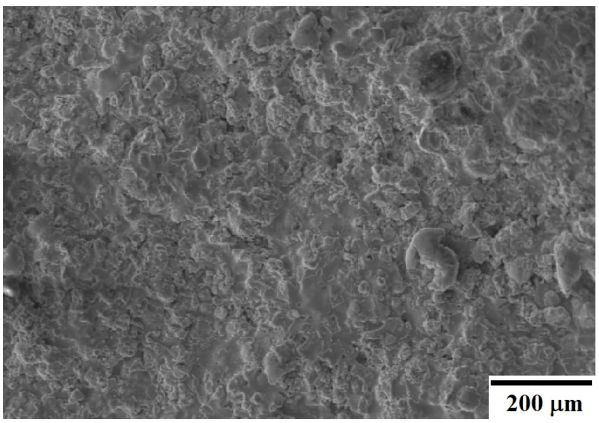

Fig. 1. Typical microstructure of the coating layer observed by scanning electron microscopy.

Fig, 2 is the typical X-ray spectra of the coating layers, which was very fine crystalline of gadolinium oxide and nickel peaks.

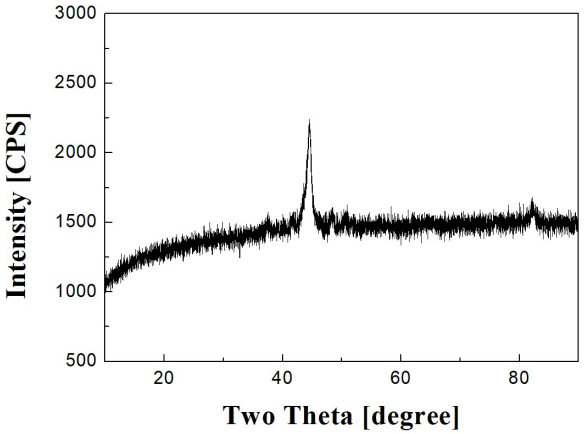

Fig. 2. Typical X-ray spectra of the coating layer.

2.3 Neutron Shielding Test

A research reactor, HANARO, in KAERI was used to test the neutron shielding effect of the coating layers. The test and analysis method were ASTM E261-16.

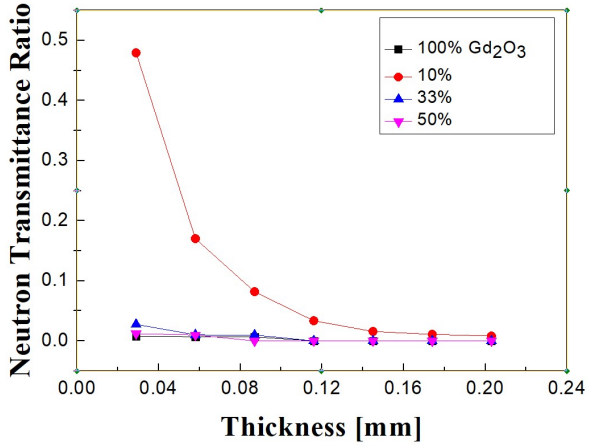

Fig. 3. Typical neutron shielding efficient with various gadolinium and nickel composition.

3. Conclusions

The thermal spray coating layers were more than 0.2 mm thick, which consisted of very fine gadolinium oxide particles around binder nickel. 0.2 mm thick

coated layer with about 50% gadolinium oxide showed a perfect neutron shield against the neutron beam with 0.13 nm wave length and 48.4 meV energy.

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