Study on the Properties of $Gd_xTi_yO_z$ Pellets.

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1. Introduction

In nuclear power generation, the excess reactivity is needed to compensate for fuel burn-up, fission product poisoning and loss of reactivity due to changes in temperature of fuel, moderator and other core constituents. However, the energy production cost can be reduced by increasing the fuel burn-up with extended cycle. In order to extend the fuel cycle, the fuel assemblies loaded at the beginning of a reactor cycle should have some more amount of excess reactivity. This means in turn the excess reactivity to be controlled.

Gadolinia, which is nuclear burnable poison because of the presence of ^{155}Gd and ^{157}Gd, is blended with TiO_2 into so called gadolinium titanite pellets in which a Gd density range of 2.00-4.70g/cm^3 is uniformly contained in the $Gd_xTi_yO_z$ pellets. [1][2]

The sinterability of Gd_2O_3+TiO_2 mixed oxides was tested for various mixing ratios and sintering parameters, and Gd density, sintered density and XRD phases of $Gd_xTi_yO_z$ pellets were evaluated in this study.

2. Experimental

The mixing ratio of Gd_2O_3/TiO_2 was calculated according to the Gd density and sintered density of $Gd_xTi_yO_z$ pellet. The weighed amount of both Gd_2O_3 and TiO_2 was blended in a Turbula mixer for 1h, then milled by using Planetary mill with a zirconia jar containing 10mm zirconia balls at a rotation speed of 300rpm for 1h. The milled powder was pressed into cylindrical compacts using a double-acting hydraulic press under 300MPa. The 2.00 Gd g/cm^3 pellets of different Gd density were sintered at 1400℃ and 1450℃, and the 4.20, 4.64 and 4.70 Gd g/cm^3 pellets were sintered at 1600℃ and 1650℃ in air atmosphere for 4hr. Density of sintered pellet was measured by water immersion method. Ceramography of the pellets was done and pore structure was analyzed by using image analysis system on the polished sections. XRD on the pellet was analyzed by using Cu target(Kα 1.54056Å) with sampling width of 0.02degree and scanning speed of 4.00 deg/min.

3. Results

3.1 X-ray diffraction studies

The XRD patterns of $Gd_xTi_yO_z$ sintered at 1650℃ with different Gd contents are shown in Fig. 1. It was observed that Gd_2TiO_5 and $Gd_2Ti_2O_7$ phases in the 4.2g Gd g/cm^3 of $Gd_xTi_yO_z$ sintered pellets from the XRD patterns. The 4.637g Gd g/cm^3 was Gd_2TiO_5 and the 4.7g Gd g/cm^3 was Gd_2TiO_5. Fig. 2 shows 2.0 Gd g/cm^3 XRD patterns. It was observed that TiO_2 and $Gd_2Ti_2O_7$ phases in the 2.00g Gd g/cm^3 of $Gd_xTi_yO_z$ sintered pellets.

3.2 Sinterability

Fig. 3 shows the changes of the sintered density with the Gd contents of $Gd_xTi_yO_z$ at different sintering processes. The changes of sintered density were rather affected by the different Gd contents than by the temperature changes. The 4.70g Gd g/cm^3 density was higher than the others. 4.20 Gd and 4.64 Gd densities were nearly not different. Density of 2.00g Gd g/cm^3 of $Gd_xTi_yO_z$ sintered pellets was 5.26 g/cm^3 at 1400°C and 5.29 g/cm^3 at 1450°C. Fig. 4 shows the micrographs of $Gd_xTi_yO_z$ with Gd contents. It was observed that a lot of white spots in the 4.20 Gd g/cm^3 micrograph. This was reduced as the increasing Gd contents. It was comfirmed that the spots were $Gd_2Ti_2O_7$ phase considering the XRD patterns.

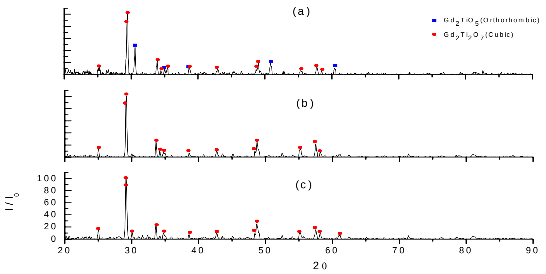

Fig. 1. XRD patterns of $Gd_xTi_yO_z$ pellets sintered at 1650°C with different Gd contents ; (a) 4.20 Gd g/cm^3, (b)4.64 Gd g/cm^3 , (c)4.70 Gd g/cm^3

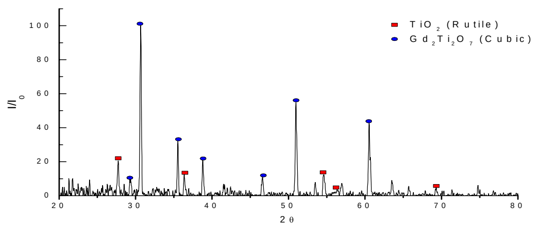

Fig. 2. XRD patterns of $Gd_xTi_yO_z$ pellet sintered at 1450°C with Gd density of 2.00 Gd g/cm^3.

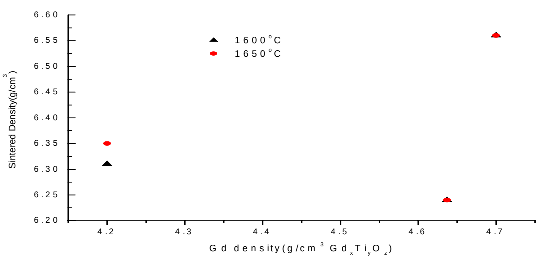

Fig. 3. Densities of $Gd_xTi_yO_z$ pellets sintered at 1600°C and 1650°C as function of Gd content.

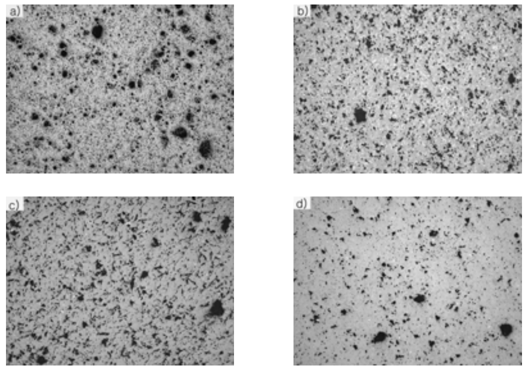

Fig. 4. Photos of microstructure of $Gd_xTi_yO_z$ pellets.; (a) 2.00 Gd g/cm^3, (b) 4.20 Gd g/cm^3, (c) 4.64 Gd g/cm^3, (d) 4.70 Gd g/cm^3

4. Conclusionc

1. The XRD patterns of the $Gd_xTi_yO_z$ pellets with the Gd density ranges of 4.64-4.70g/cm^3 only show Gd_2TiO_5 peaks as increasing Gd contents.
2. $Gd_2Ti_2O_7$ phase was observed on the microstructure as the white spots.
3. The density of $Gd_xTi_yO_z$ pellets was rather affected by the changes of Gd contents than by the temperat-ures.

Acknowledgment

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Reference

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