# Properties of Dysprosium Titanate as a Control Rod Material

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## 1. Introduction

The major advantages of dysprosium titanate as a neutron absorber are a relatively low swelling, no gas release under an irradiation and a compatibility with the cladding [1, 2]. The material properties and fabrication processes of dysprosium titanate($Dy_xTi_yO_z$) are not well known. This study has developed the fabrication processes of dysprosium titanate pellets by a powder process [3] and analyzed the thermal-material properties of the pellets. The pellets were loaded into a capsule and irradiated in the Hanaro research reactor. Dysprosium distribution and the microstructure of the irradiated pellets were analyzed by using EPMA and SEM.

## 2. Experimental

$Dy_xTi_yO_z$ pellets were fabricated by a powder process based on the sinterability tests of $Dy_2O_3$+x mol%$TiO_2$ (x=45~67) compacts. Sintered density and phase structures were estimated by an immersion method and an x-ray diffraction, respectively. Thermal diffusivity and heat capacity of the pellet were measured by using laser flash method and DSC, respectively. $Dy_xTi_yO_z$ pellets were irradiated to test their applicability for neutron absorbing materials. The irradiation tests were performed for 254 EFPD in the HANARO at the position of OR6 throughout the test. After an irradiation, visuals, dimensions and elemental distributions of the irradiated pellets were evaluated in a hot cell.

## 3. Results and discussion

The pellet density depends on the sintering temperature, mixing ratio of $Dy_2O_3/TiO_2$ and the power treatment. Fig. 1 shows that the sintered density increased with the temperature and the mixing ratio.

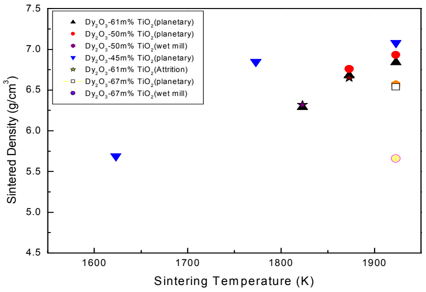

Fig. 1 Sintered densities of $Dy_xTi_yO_z$ pellets with different fabrication parameters.

There are two binary compounds in the $Dy_2O_3$-$TiO_2$ system with the mixing ratio of $Dy_2O_3$:$TiO_2$ equal to 1:1 and 1:2 respectively, in accordance with the equilibrium phase diagram. The peaks show a two phase mixture of the $Dy_2TiO_5$ and $Dy_2Ti_2O_7$ for the ratio of 0.6:1 and a single phase of $Dy_2TiO_5$ for the ratio of 1:1. Fig. 2 shows the XRD results of the three $Dy_xTi_yO_z$ pellets with the mixing ratio of $Dy_2O_3$:$TiO_2$ equal to 1.2:1. The pellet sintered at 1623K has α-orthorhombic phase, but the other pellets have a mixture of cubic and β-hexagonal phases which exist at a high temperature. Phase transformation of the $Dy_xTi_yO_z$ solid solution was irreversible at a sintering condition.

Fig. 3 shows the thermal conductivity of $Dy_xTi_yO_z$. The conductivity ranges from 1.5 W/m-K to 2.0 W/m-K and remains almost constant with the temperature up to 1000K.

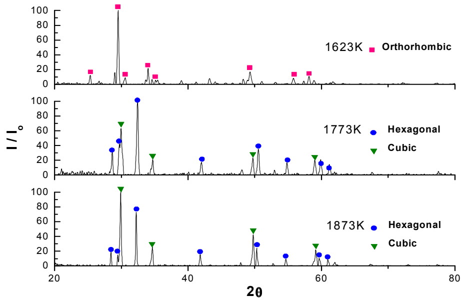

Fig. 2 Phase structures of the $Dy_xTi_yO_z$ pellets.

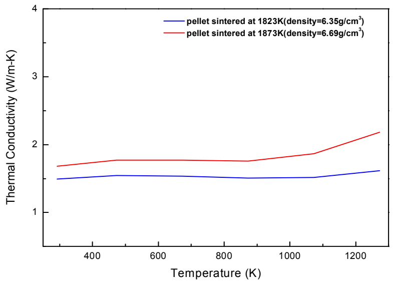

Fig. 3 Thermal conductivity of $Dy_xTi_yO_z$ ($Dy_2O_3$:$TiO_2$ =0.6:1).

After irradiation test of the $Dy_xTi_yO_z$ pellets ($Dy_2O_3$:$TiO_2$ =0.6:1), PIE was performed in a hot cell. Fig. 4 shows that the pellets have maintained their geometrical integrity during the irradiation.

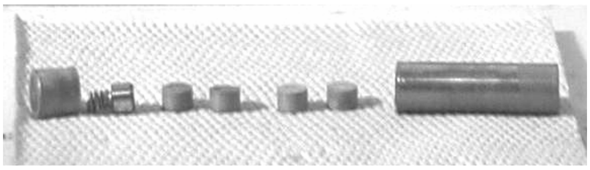

Fig. 4 Visual inspection of the irradiated $Dy_xTi_yO_z$ pellets.

All the pellets swelled a little after an irradiation when compared with the dimensions of the un-irradiated pellets. The centerline temperature of $Dy_xTi_yO_z$ calculated using reference models [4, 5] were 970K~ 982K.

The radial profiles of the Dy, Ti, and O are presented for $Dy_xTi_yO_z$ in Fig. 5. The Dy concentration varies due to a depletion of the neutron absorbing isotopes.

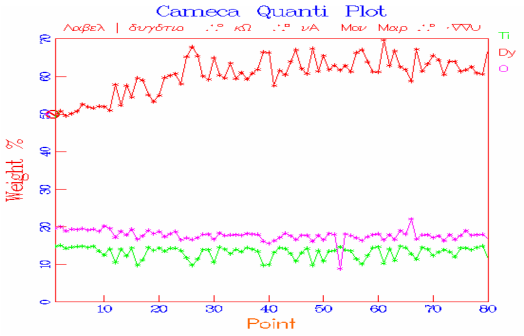

Fig. 5 Radial profile of the Dy, Ti, and O concentrations in $Dy_xTi_yO_z$

## 4. Conclusion

The phase transformation of $Dy_xTi_yO_z$ was irreversible during the sintering process. Thermal conductivity of $Dy_xTi_yO_z$ ranges from 1.5~2.0 W/m-K depending on the density, and remains almost constant with the temperature up to 1000K. The irradiation test was successful and some preliminary PIE results showed in-pile performances with a stable geometry.

## REFERENCES

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