7-3 Demonstration of Excellent Thermal Properties of Minor Actinide Nitride Fuel

–High-Quality Thermal Conductivity Data of MA Nitride Obtained from Small Samples–

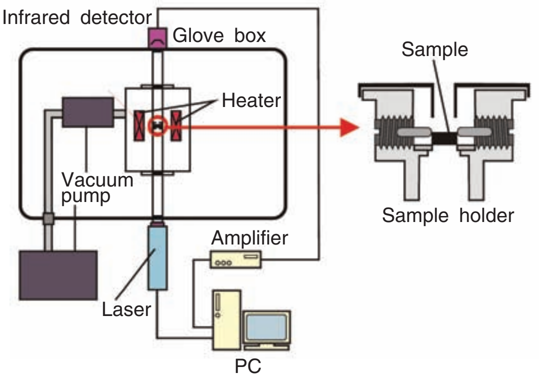

Fig.7-6 Schematic diagram of the thermal diffusivity measurement apparatus
In the glove box, the oxygen and moisture contents were controlled to less than two and three ppm, respectively.

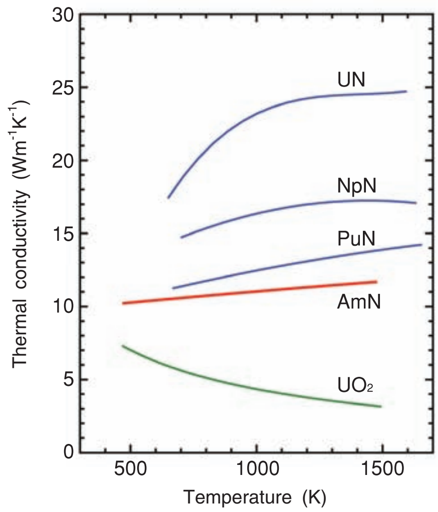

Fig.7-8 Thermal conductivity of AmN corrected to theoretical density, together with those for UN, NpN, PuN and UO_2
Thermal conductivity of AmN was smaller than UN, NpN and PuN, but larger than UO_2.

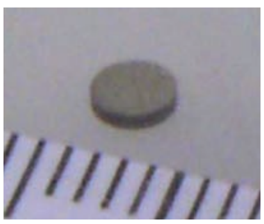

Fig.7-7 Sintered AmN disk sample
The sample color was black. The diameter and thickness were about 3 mm and 0.6 mm, respectively.

The spent fuels arising from nuclear power plant contain minor actinides (MAs:Np,Am,Cm) which are long-lived radioactive nuclides, and thus, the management of MA is a key issue for sustainable nuclear energy use. To solve this problem, the technology of partitioning and transmutation of MA, which can significantly reduce the heat generation and radiotoxicity of high level radioactive waste, has been examined. Among various fuel types, nitride fuel is one of the candidates for MA-bearing fuels for transmutation because of its high melting point, good thermal conductivity and mutual solubility.

Facing this task, it is important to obtain thermal property data such as heat capacity and thermal conductivity to design the MA-bearing fuels. However, the thermal properties of MA nitrides are little known due to their high specific radioactivity and the high reactivity with water and oxygen. Thus, we installed a laser flash apparatus in a glove box with a highly-purified argon gas atmosphere (Fig.7-6) for thermal diffusivity measurement and a drop calorimeter for heat capacity measurement. These apparatuses enabled us to obtain high-quality thermal property data of MA nitrides.

The diameter of the MA nitride disk sample prepared by the carbothermic reduction of MA oxide was about 3 mm (Fig.7-7). With this small disk and its fragments, we measured the thermal diffusivity and heat capacity, respectively.

We have measured the thermal properties of various MA nitrides. As an example, the results of thermal conductivity measurement of AmN is here described. It was found that the thermal diffusivity of AmN tended to slightly decrease with increasing temperature and the heat capacity of AmN was nearly the same as other actinide nitrides. The thermal conductivity of AmN, which was determined from the thermal diffusivity, heat capacity and bulk density, tended to slightly increase with temperature in the temperature range from 473 to 1473 K (Fig.7-8). It was also found that the thermal conductivity of AmN was smaller than UN, NpN and PuN, but larger than UO_2. Thus, in this study, the advantage of MA nitride fuel was confirmed in view of its thermal properties. In addition, we have been measuring the thermal expansion of MA nitrides by high temperature X-ray diffraction analysis.

The present study was carried out within the task “Technological development of a nuclear fuel cycle based on nitride fuel and pyrochemical reprocessing” entrusted from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

Reference

Nishi, T. et al., Thermal Diffusivity of Americium Mononitride from 373 to 1473 K, Journal of Nuclear Materials, vol.355, issues 1-3, 2006, p.114-118.