Thermal and Mechanical Properties of U_3Si_2

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Abstract

U_3Si_2 is one of the candidate material for accident tolerant fuel (ATF). To develop U_3Si_2 based ATF, it is necessary to accurately understand the basic properties of U_3Si_2 such as thermal and mechanical properties. In this study, we fabricated dense U_3Si_2 polycrystalline sample and measured thermal and mechanical properties.

Keywords: Accident tolerant fuel, U_3Si_2, Thermal conductivity, Debye temperature, Hardness

1. Introduction

Recently, accident tolerant fuel (ATF) has become one of the primary focus after the Fukushima Daiichi accident. The fuel for enhanced ATF should have higher uranium density and higher thermal conductivity (λ) than those of the current nuclear fuel of UO_2. Several candidates have been explored as alternative nuclear fuel materials for ATF, and U_3Si_2 attracts attention recently[1].

The density of U_3Si_2 is 11.3 g-U/cm^3, which is larger than that of UO_2, 9.7 g-U/cm^3. The λ of U_3Si_2 and UO_2 at 1000 K are 12.4~17.6 W/mK and 3.6 W/mK, respectively[2]. Moreover, U_3Si_2 is thermally stable up to melting temperature and has good corrosion resistance[2]. For designing U_3Si_2 based ATF, the basic properties of U_3Si_2 must be understood. There are however uncertainties in the reported thermal conductivities for U_3Si_2[2]. In addition, there are no experimental data regarding the mechanical properties and elastic constant yet. Therefore, in the present study we intended to report thermal and mechanical properties of U_3Si_2 through synthesis of single phase U_3Si_2 and measurement of these properties.

2. Experimental

The nominal composition of U_3Si_2 was prepared from natural uranium and Si with 2 wt% of excess Si by arc melting in Ar atmosphere. The U_3Si_2 bulk sample was then synthesized by spark plasma sintering (SPS) at a pressure of 75 MPa and a temperature of 1123 K followed by annealing at 1000 K for 72h. The Vickers indentation test was performed using a Vickers hardness tester (Akashi, hardness tester). The applied load was 9.8 N with a loading time of 10 s and a series of 11 indentations were placed on the surface.

3. Results and discussion

The X-ray diffraction measurement showed that almost single phase of tetragonal U_3Si_2 was obtained. The density of the pellet prepared by SPS was 97% of the theoretical density. Figure 1 show the Vickers hardness as a funvtion of the load. The average Vickers hardness of 7.51±0.41 GPa are plotted together with the reported UN and UO_2. The Vickers hardness of U_3Si_2 obtained from the present study is higher than those reported for UN and UO_2.

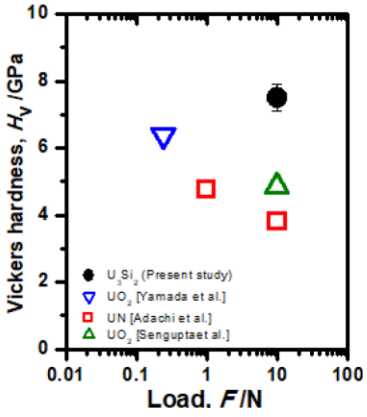

Figure 1 Vickers hardness as a function of the load.

4. Conclusion

A dense U_3Si_2 sample was fabricated and a single phase was obtained from the sample. The thermal and mechanical properties were evaluated. The Vickers hardness obtained from the present study was 7.51±0.41 GPa.
The mechanical properties and elastic constant of U_3Si_2 will be discussed in the presentation.

References

[1] Bragg et al., *Nuclear News*, 57, 2014, p83.

[2] White et al., *Journal of Nuclear Materials*, 464, 2015, p275-280.

[3] Adachi et al., *Journal of Nuclear Materials*, 384, 2009, p6-11.

[4] Sengupta et al., *Journal of Nuclear Materials*, 325, 2004, p141-147.