

SiO₂ 2 가 UO₂

Effect of SiO₂-based Additive on Creep of UO₂ Pellet

150

UO₂ SiO₂ 2 가
 . , 50SiO₂-47CaO-3Cr₂O₃ (wt%)
 SiO₂ 2 가 . 0.1 wt% 가
 UO₂ 가 0.3 wt% 가 UO₂
 UO₂ 12 . 0.5 wt% 가 0.3 wt% 가
 SiO₂ 2
 가 UO₂ .

Abstract

In order to improve the creep property of UO₂ pellet, the effect of SiO₂-based additives has been investigated. The additive composition, 50SiO₂-47CaO-3Cr₂O₃ (wt%), was selected according to the amount of liquid phase and the dihedral angle. The creep rate of 0.1 wt%-added UO₂ was slower than that of pure UO₂. However, the creep rate of 0.3 wt%-added UO₂ was about 12 times faster than that of pure UO₂ depending on the applied stress. In the case of 0.5 wt%-added UO₂, the creep rate decreased in comparison with that of 0.3 wt%-added UO₂. The changes in the creep rate can be attributed to the competition between the effect of the viscous grain-boundary phase and that of the grain growth due to the additives.

1.

swelling . 가 가
 가 가 가 . 가

가
(PCI, Pellet- Cladding Interaction)

PCI

가 가
aluminosilicate
가 2 ,
SiO₂ UO₂
가 가 SiO₂-ZnO, SiO₂-CaO-Cr₂O₃, SiO₂-MnO,
SiO₂-Y₂O₃-Cr₂O₃ 가 1 wt% , 2
SiO₂-CaO-Cr₂O₃ 가 SiO₂-CaO-Cr₂O₃
가 UO₂ UO₂

2.

(1) 가

SiO₂-ZnO, SiO₂-CaO-Cr₂O₃, SiO₂-MnO, SiO₂-Y₂O₃-Cr₂O₃, 4

가 51SiO₂-49ZnO, 50SiO₂-47CaO-3Cr₂O₃, 51SiO₂-49MnO, 42SiO₂-53Y₂O₃-5Cr₂O₃
(wt%) 가 가 UO₂
ADU-UO₂ 1 wt% 가 3 sieve UO₂

(2)

가 SiO₂-CaO-Cr₂O₃ 50SiO₂-47CaO-3Cr₂O₃ (wt%) ,
가 0.1, 0.3, 0.5 wt% CaO CaCO₃ 가 CaCO₃ CaO
2 가 73% SiO₂-CaO-Cr₂O₃
가 0.07, 0.22, 0.37 wt%

95.5±1 %TD UO₂ 가 가 turbula 1
100mesh sieve mixing 3 AZB 0.1-0.3wt% 가 turbula
1 zinc stearate 0.2wt% 가 turbula 20
3ton/cm² , 1700 , H₂-
5%CO₂ 4 , ,
1300 ,

CO₂ 1 , .
 UO₂ 가 가 turbula 1 100mesh sieve mixing 3
 . AZB 0.1-0.3wt% 가 turbula 1
 zinc stearate 0.2wt% 가 turbula 20 . 3ton/
 cm² , 1700 , H₂-5%CO₂ 4
 . ,
 1300 , CO₂ 1 ,

(3)

H₂ Ar 가
 (1500) , 20, 35, 50, 65MPa , 1%
 . 1% PCI 1%
 가
 &

$$\epsilon = \frac{\Delta L/t}{L}$$

L: , DL: , t:

3.

Fig. 1 51SiO₂-49ZnO, 50SiO₂-47CaO-3Cr₂O₃, 51SiO₂-49MnO, 42SiO₂-53Y₂O₃-5Cr₂O₃ (wt%) 4
 가 가 UO₂ SiO₂-CaO-Cr₂O₃ 가 가

. SiO₂-ZnO 2
 , ZnO가
 SiO₂-Y₂O₃-Cr₂O₃ SiO₂-CaO-Cr₂O₃

. SiO₂-MnO SiO₂-CaO-Cr₂O₃
 3 가 가
 가 SiO₂-CaO-Cr₂O₃

SiO₂-CaO-Cr₂O₃ 가 , 50SiO₂-47CaO-
 3Cr₂O₃ Fig. 2 .
 SiO₂-CaO-Cr₂O₃ CaO가 CaCO₃ 가 CaCO₃

CaCO₃가 CO₂가 ,
 . 700 1 5 K/min 1700
 4 , 가 90%
 . CaCO₃ CO₂

900 , H₂ 2 1700 , H₂-5%CO₂
 4 가 95.5% (0.1 wt%), 95.4% (0.3 wt%), 94.6% (0.5 wt%) 95.5 ± 1%

Fig. 3(a)-3(c) SiO₂-CaO-Cr₂O₃ 가 8.08 μm (0.1 wt%), 8.64 μm (0.3 wt%), 24.04 μm (0.5 wt%) 가 가 가 Fig. 3(d)
 0.5 wt% 가 3
 가 0.5 wt% 3

가 1500 20MPa, 35MPa, 50MPa, 65MPa 가 7.5 μm
 UO₂

transient 가
 1 %
 1 %

가 Fig. 4 UO₂ 35 MPa
 가 power-law (dislocation) UO₂ 가
 가 0.1 wt% UO₂ 가 ,
 가 65 MPa 1% 가 가 가
 . 0.1 wt% 가 가 7% 가 가
 2

UO₂ 가
 UO₂ 가
 UO₂ 가
 2 가
 50SiO₂-47CaO-3Cr₂O₃ (wt%) 1540

가 1500 2
 soft 2
 , 가 가 가 가
 UO₂ UO₂
 가 (viscous creep) .[4] 0.5 wt% 가 UO₂
 가 0.3 wt% 가 0.3 wt% 가
 2.8 . 0.5 wt% 가 ,
 50 MPa

Fig. 5 . 가
 0.1 wt% 가 UO₂ 가
 , 50 MPa power-law 가
 0.3 wt%, 0.5 wt% 가 UO₂ 가
 . 0.3 wt% 가 50 MPa 가
 2 grain boundary sliding UO₂
 가 .

4.

UO₂ SiO₂ 2
 가 UO₂ .
 , SiO₂-ZnO, SiO₂-CaO-Cr₂O₃, SiO₂-MnO, SiO₂-Y₂O₃-Cr₂O₃, 4
 50SiO₂-47CaO-3Cr₂O₃ (wt%) SiO₂ 2 가
 . 0.3 wt% 가 UO₂ UO₂ 12
 . , 0.5 wt% 가 0.3 wt% 가
 , 0.1 wt% 가 UO₂ 가 .
 SiO₂ 2 , 가 UO₂ .

1. K. W. Lay, H. S. Rosebaum, J. H. Davis and M. O. Marlowe, "Nuclear Fuel," US Pat. 4869866 (1989).
2. K. W. Lay, H. S. Rosebaum and J. H. Davis, "Nuclear Fuel," US Pat. 4869867 (1989).
3. K. W. Kang, J. H. Yang, K. S. Kim, J. H. Kim and K. W. Song, "Effect of Additives on Creep Property of UO₂ Pellet," (2001).
4. D. S. Wilkinson, "Creep Mechanisms in Multiphase Ceramic Materials," *J. Am. Ceram. Soc.*, **81**[2] 275-99 (1998).

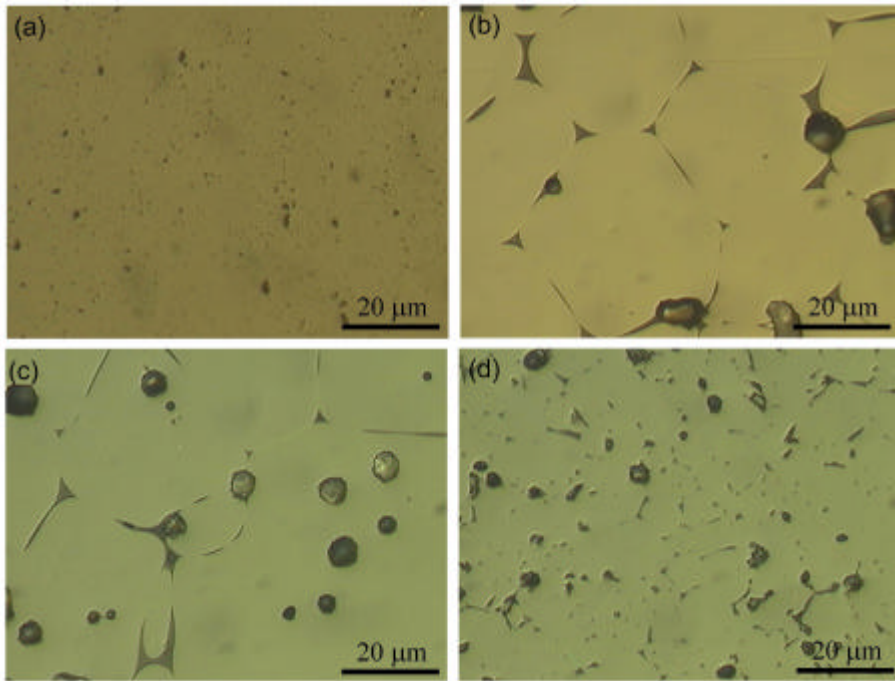


Fig. 1. 가 1 wt% 가 . (a) 51SiO₂-49ZnO, (b) 50SiO₂-47CaO-3Cr₂O₃, (c) 51SiO₂-49MnO, (d) 42SiO₂-53Y₂O₃-5Cr₂O₃, wt%.

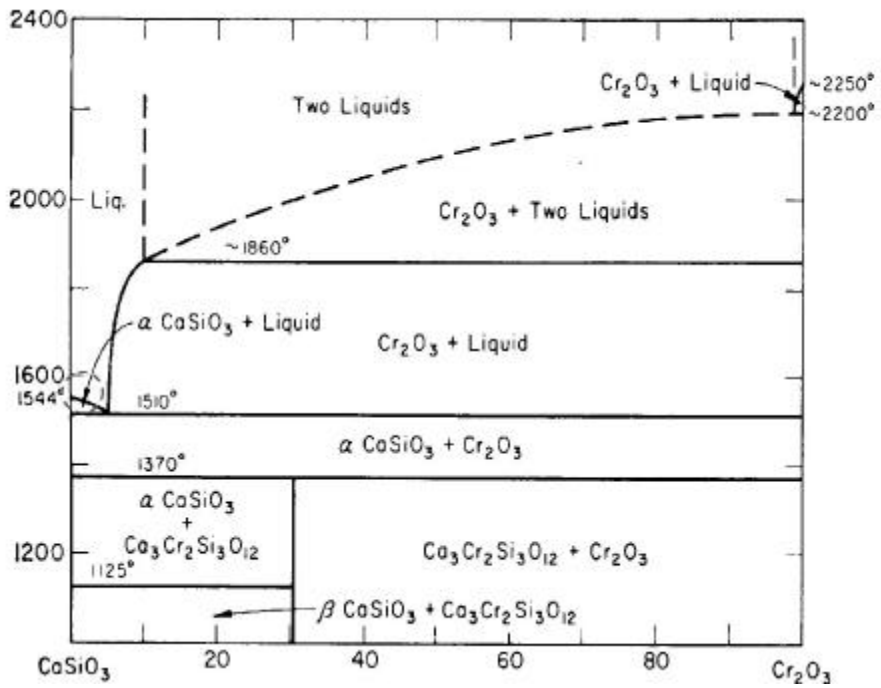


Fig. 2. SiO₂-CaO-Cr₂O₃ 가

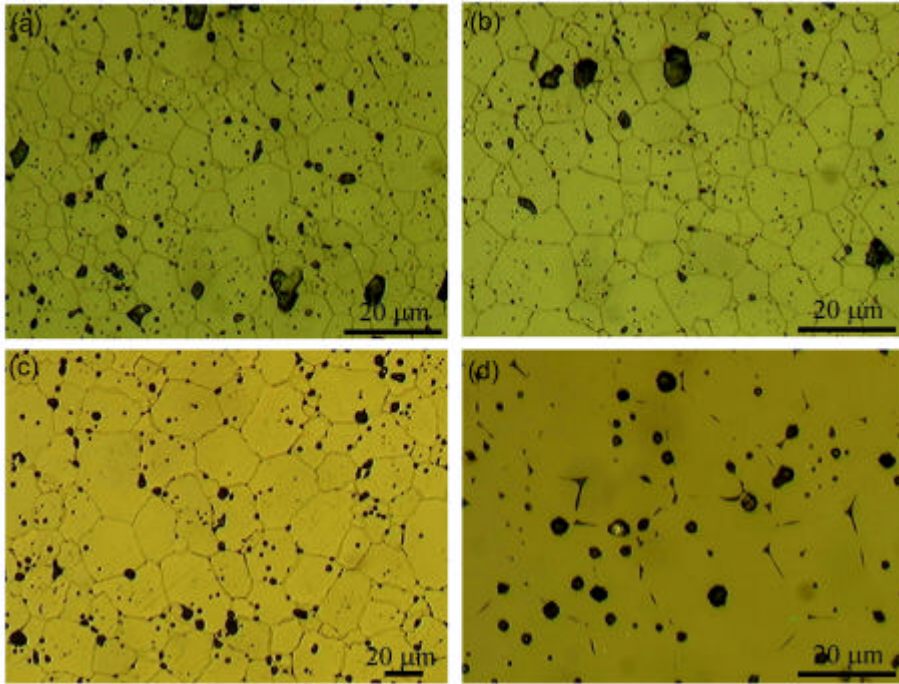
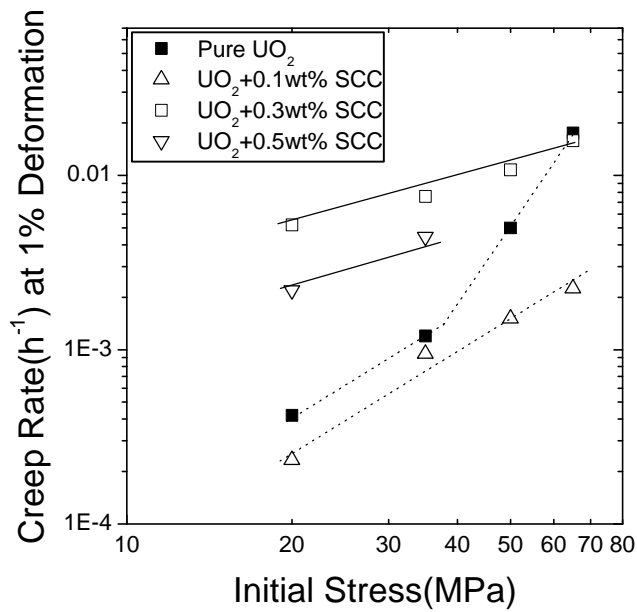


Fig. 3. $\text{SiO}_2\text{-CaO-Cr}_2\text{O}_3$ 가 가 . (a) 0.1 wt%, (b) 0.3 wt%, (c) 0.5 wt%, (d)



0.5 wt%

Fig. 4. 가 1 %

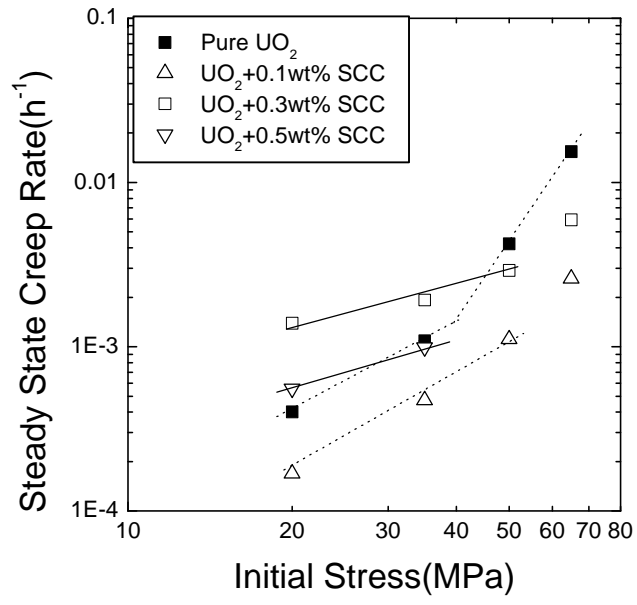


Fig. 5. 가