Chemical Vapor Deposition of Niobium Coating on Zirconia Microspheres

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Introduction

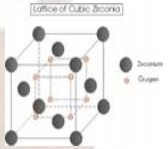
- As part of the Department of Energy's Advanced Fuel Cycle Initiative, a coating method for eventual use in fabricating actinide-burning transmuter fuel was developed.
- Chemical vapor deposition (CVD) was the method chosen to coat zirconium oxide non-radioactive microspheres in method development experiments. CVD uses a vaporized chemical compound, or precursor, to coat a substrate.

Precursor

Niobium pentachloride

Solid at room temperature

Melting point is 205˚C



Substrate

Zirconium oxide

100-µm spheres

Chemistry

$$NbCl_5 + 2.5\ H_2\ (g) = Nb + 5\ HCl\ (g)$$

$\Delta G_{750°C}$ = -6.2 kcal

The CVD System

Fluidizing the Microspheres

Conditions

Substrate – Zirconium oxide 100-µm spheres

Substrate Temperature - 750-800ºC

Fluidizing gas – Helium 4% hydrogen at flowrate of 100mL/min

Precursor – Niobium pentachloride

Precursor introduction gas – Helium

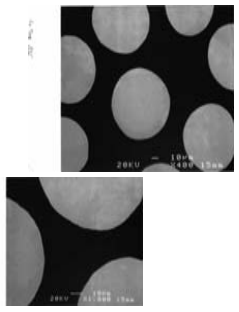
Chemical Reaction - $NbCl_5 + 2.5\ H_2 = Nb(s) + 5\ HCl$

Reactor Vessel Composition - Quartz

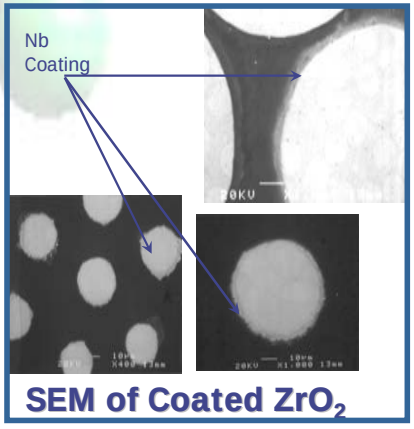
Temperature Limitation

- The coating process had a temperature constraint of ~ 1000°C because americium and americium oxide volatilize at temperatures commonly used for fabrication of nuclear fuel.
- Initial process development activities were carried out using zirconia microspheres as a surrogate for the actinide oxides.

SEM of Uncoated ZrO_2

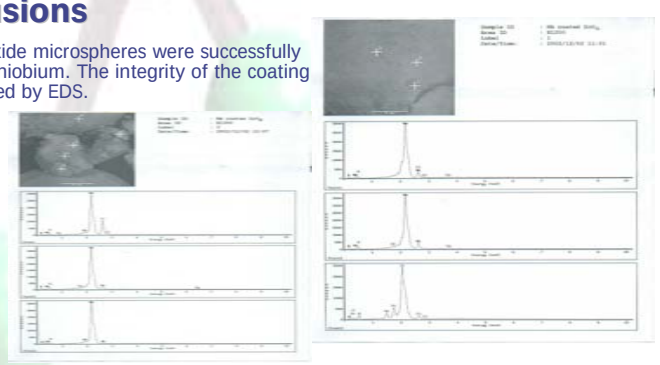


SEM of Coated ZrO_2



Conclusions

Zirconium oxide microspheres were successfully coated with niobium. The integrity of the coating was confirmed by EDS.



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