INCREASING THE PERFORMANCE OF U-Mo FUELS

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ABSTARCT

Recent developments showed that uranium-molybdenum nuclear fuel particles dispersed in an aluminum matrix had misbehavior when irradiated at high neutron fluxes. The appearance of a third phase, with the presence of great porosity in the interaction zone of the Al/U-Mo interface, conditions severely the performance of this fuel. At the light of the resolution of this limitation, UMo monolithic fuel achieves a greater importance, since there is some expectation that in this bulk geometry the problem will not be present.

From the simplest point of view, the addition of extra alloys to the aluminum matrix or to the nuclear fuel can be an alternative to reduce the interface growing kinetics and thereafter the porosity. The kinetics reduction would be a quantitative effect controlling chemical potentials (diffusion driving force) and barely will avoid the problem. Similar considerations can be attributed to the monolithic fuel if only quantitative solutions are proposed.

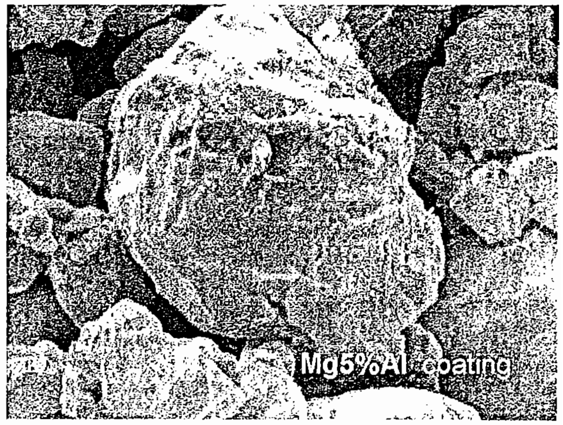
In this paper are presented two drastic alternatives, from the point of view of qualitative metallurgy, for increasing the performance of U-Mo fuels. The first one is related with the coverage of the fuel particles with compound diffusion barriers to avoid the transportation of uranium and aluminum threw them. The second alternative is a monolithic fuel with zircaloy cladding where the interaction is much smaller than with aluminum.

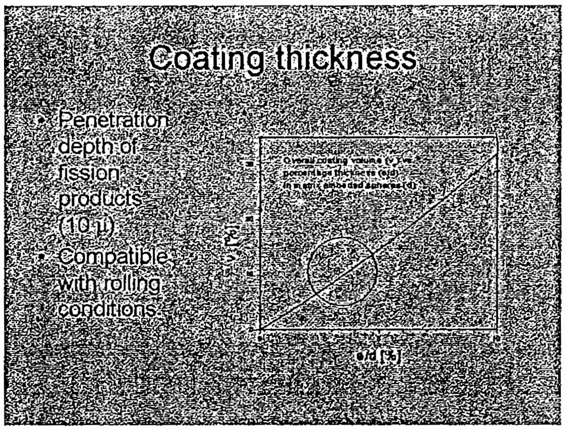
The basic assumptions in the particle coverage with diffusion barriers are that magnesium and uranium are immiscible and the high temperature coherent intermetalic Mg_2Si is insoluble in a Mg and Si saturated (ppm´s) aluminum matrix. Magnesium, in contact with the nuclear material, will avoid uranium diffusion and Mg_2Si, in between the previous barrier and the matrix, will avoid aluminum diffusion. Testing is being performed so as to develop coverage techniques by dip coating and chemical vapor deposition (CVD) that allow depositions of few microns thickness. Coverage results will be shown that involve magnesium and aluminum. Germanium results are being evaluated and Si CVD is in preparation.

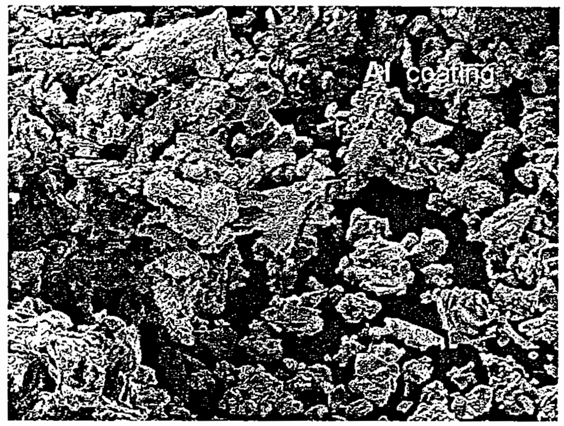
Feasibility of a U-Mo monolithic fuel with zircaloy cladding is being analized. Zircaloy has mechanical properties much similar to U-Mo alloy than aluminum and colamination tests are being set up. Other properties of both materials are considered such as thermal expansion, diffusion pairs, hot and cold rolling, corrosion resistance, hydriding techniques for recondition burned fuels, etc.

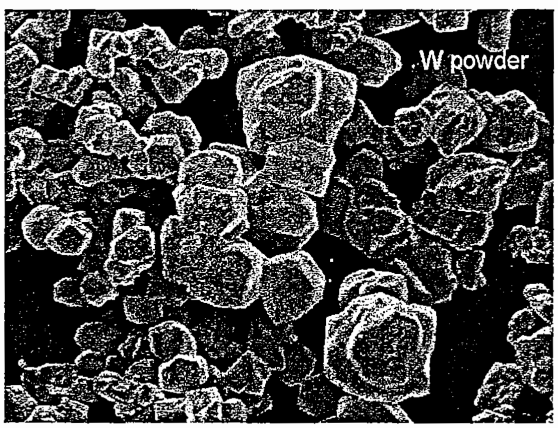
Coating strategy

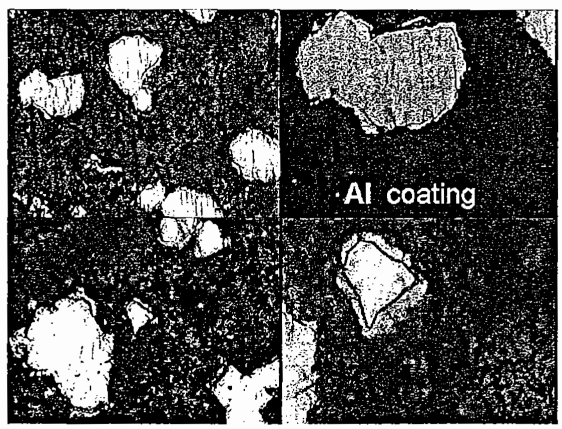
- Reduction of the U-Mo / Al interface kinetics incorporating diffusion barriers.

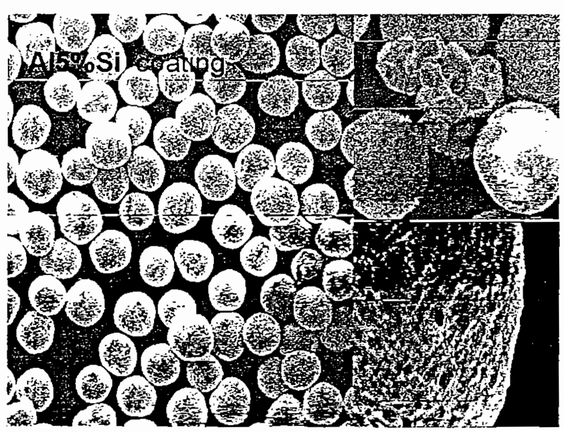


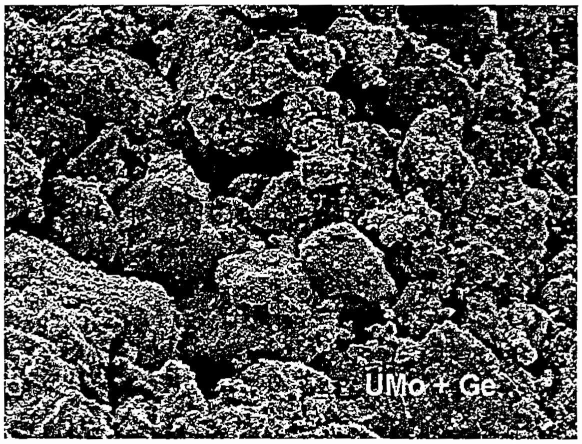












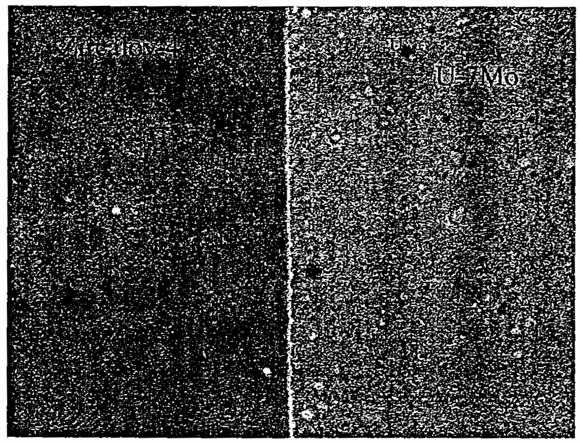
Monolithic UMo

+

Zircaloy cladding

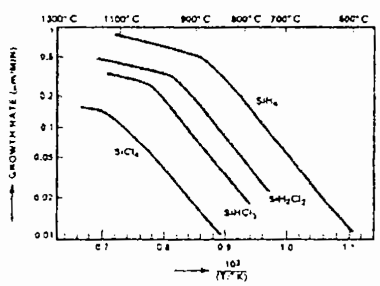
Silane production

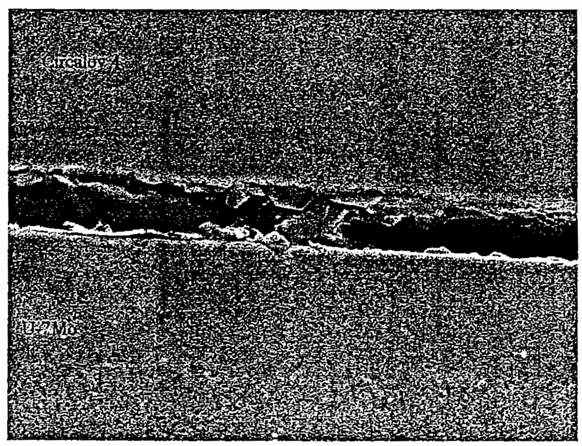
- $Mg_2Si + HCl \rightarrow SiH_4$
- $SiH_4 + H_2 + 500\ ^oC \rightarrow Si$
- Excess gases are burned



CVD coating

Temperature dependence of silicon growth rate





Capabilities/proposals

- Al-5%Si
- Ge

in preparation

- Si
- $Mg + Si \rightarrow Mg + Mg_2Si$

Conclusions

- Incorporation of coverage processes in the end steps of powder production
- Dip coating is applicable for Mg, Al, Ge.
- Si coating using CVD
- Colamination of UMo/Zircaloy 4 is being tested
- Miniplates fabrication