

Optimization of a WCl_6 CVD System to Coat UO_2 Powder with Tungsten

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In order to achieve deep space exploration via Nuclear Thermal Propulsion (NTP), Marshall Space Flight Center (MSFC) is developing W- UO_2 CERMET fuel elements, with focus on fabrication, testing, and process optimization. A risk of fuel loss is present due to the CTE mismatch between tungsten and UO_2 in the W-60vol% UO_2 fuel element, leading to high thermal stresses. This fuel loss can be reduced by coating the spherical UO_2 particles with tungsten via H_2/WCl_6 reduction in a fluidized bed CVD system. Since the latest incarnation of the inverted reactor was completed, various minor modifications to the system design were completed, including an inverted frit sublimator. In order to optimize the parameters to achieve the desired tungsten coating thickness, a number of trials using surrogate HfO_2 powder were performed. The furnace temperature was varied between 930°C and 1000°C, and the sublimator temperature was varied between 140°C and 200°C. Each trial lasted 73-82 minutes, with one lasting 205 minutes. A total of 13 trials were performed over the course of three months, two of which were re-coatings of previous trials. The powder samples were weighed before and after coating to roughly determine mass gain, and Scanning Electron Microscope (SEM) data was also obtained. Initial mass results indicated that the rate of layer deposition was lower than desired in all of the trials. SEM confirmed that while a uniform coating was obtained, the average coating thickness was 9.1% of the goal. The two re-coating trials did increase the thickness of the tungsten layer, but only to an average 14.3% of the goal. Therefore, the number of CVD runs required to fully coat one batch of material with the current configuration is not feasible for high production rates. Therefore, the system will be modified to operate with a negative pressure environment. This will allow for better gas mixing and more efficient heating of the substrate material, yielding greater tungsten coating per trial.