# *NUCLEAR ENERGY UNVERSITY PROGRAMS*

## ALD Produced $B_2O_3$, $Al_2O_3$ and $TiO_2$ Coatings on $Gd_2O_3$ Burnable Poison Nanoparticles

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**Abstract**

This project will demonstrate the feasibility of using atomic layer deposition (ALD) to apply ultrathin neutron-absorbing, corrosion-resistant layers consisting of ceramics, metals, or combinations thereof, on particles for enhanced nuclear fuel pellets. Current pellet coating technology utilizes chemical vapor deposition (CVD) in a fluidized bed reactor to deposit thick, porous layers of C (or PyC) and SiC. These graphitic/carbide materials degrade over time owing to fission product bombardment, active oxidation, thermal management issues, and long-term irradiation effects. ALD can be used to deposit potential ceramic barrier materials of interest, including $ZrO_2$, $Y_2O_3$:$ZrO_2$ (YSZ), $Al_2O_3$, and $TiO_2$, or neutron-absorbing materials, namely B (in BN or $B_2O_3$) and Gd (in $Gd_2O_3$). This project consists of a two-pronged approach to integrate ALD into the next-generation nuclear plant (NGNP) fuel pellet manufacturing process:

- Researchers will apply $Al_2O_3$ and $TiO_2$ coating on $Gd_2O_3$ particles to fabricate homogeneous gadolinium aluminate and titanate ceramic powders and study their thermo-mechanical properties. Of significant interest are the thermo-physical properties of $Gd_2O_3$-containing composite materials, such as aluminates ($GdAlO_3$) and titanates ($Gd_2TiO_3$), so that the thermal conductivity, coefficient of thermal expansion, specific heat, etc., are known for NGNP modeling and simulations. $GdAl_2O_5$ and $Gd_2TiO_3$ can either be integrated into the fuel pellet core using traditional solid-state techniques, or can be applied to the surfaces of $UO_2$ particles using standard ALD techniques.
- The second aim is to coat nanometer-scale $ZrO_2$, YSZ, and BN/$B_2O_3$ films on carbonaceous powders to test the high-temperature corrosion resistance and thermo-mechanical properties of these chemically inert ceramic materials. The CVD-derived, porous carbonaceous layers—namely C, PyC, and SiC—are extremely sensitive to oxidation at high temperatures, especially in low-oxygen partial-pressure environments found in nuclear reactors. Researchers will test coated powders in this environment using a high-temperature thermogravimetric analyzer, and will measure corrosion resistance and thermal shock properties of C and SiC particles for varying ALD film thicknesses.