Conformal Pinhole-free Metallic Nanofilms for Advanced Particle Fuel Coating by Atomic Layer Deposition (ALD)

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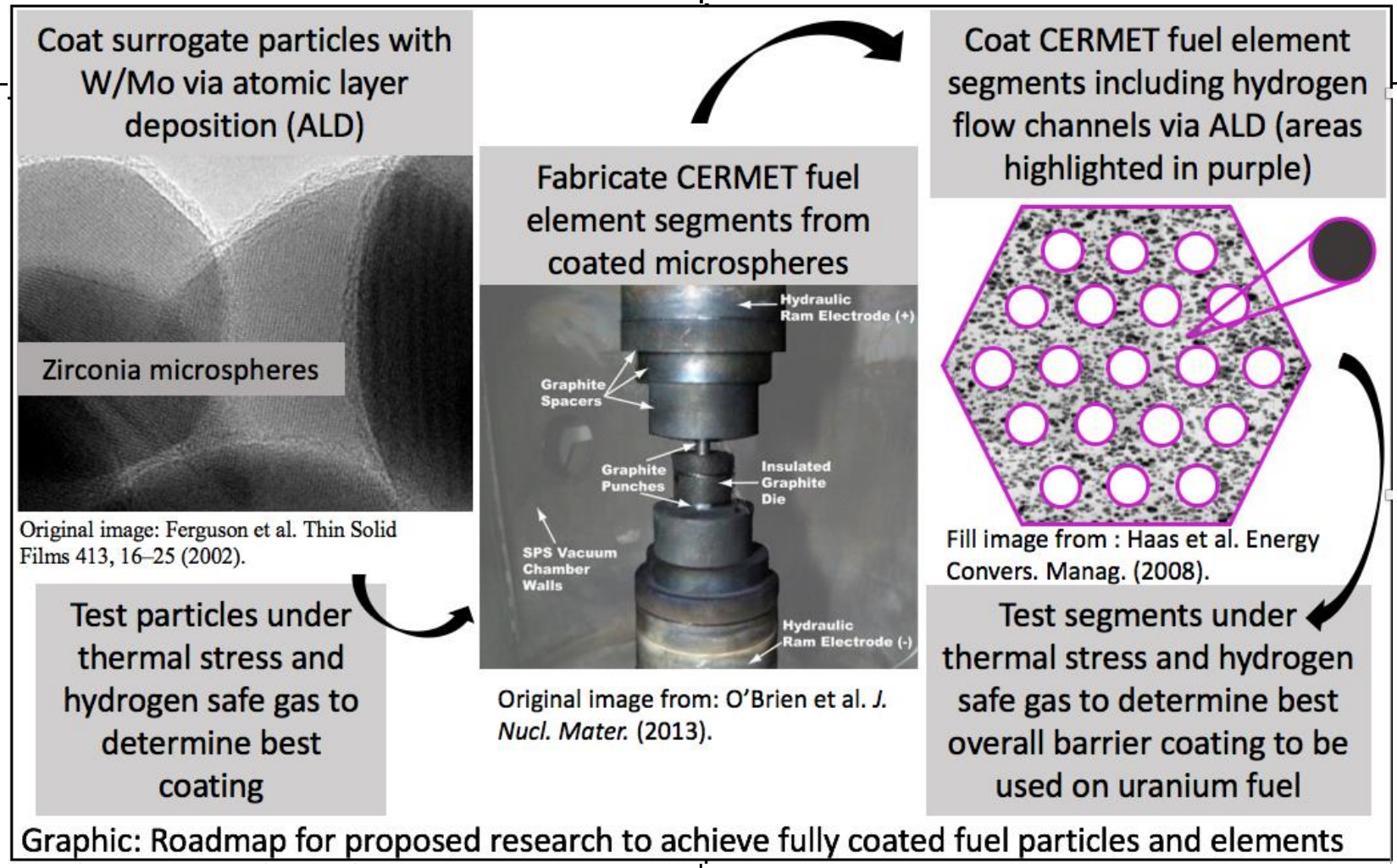
Research Objectives

- Increase lifetime of nuclear thermal propulsion fuel by decreasing hydrogen embrittlement
- Apply nanometer scale, conformal barrier coatings via Atomic Layer Deposition
- Optimize tungsten and molybdenum ALD for particle coating and for fuel element coating
- Increase TRL of advanced nuclear fuel coating from 2 to 3
- Current state of the art fuel coatings are deposited via chemical vapor deposition which forms porous films with cracks, ALD will achieve thinner, conformal films to reduce precursor waste and fuel displacement and increase film efficacy

Research Approach:

- Task 1: Optimize atomic layer deposition (ALD) of W and Mo on surrogate fuel particles
- Task 2: Test coated surrogate particles for resistance to thermal stress and hydrogen diffusion and fabricate surrogate loaded fuel element segments with best performing coated particles
- Task 3: Perform ALD of best coating on surrogate-loaded fuel element segments and test them for overall resistance to thermal stress and hydrogen diffusion
- Task 4: Use density functional theory and molecular dynamics to screen W, Mo, and their alloys by calculating hydrogen diffusion energy barriers



Graphic: Roadmap for proposed research to achieve fully coated fuel particles and elements

Potential Impact

- Development of nuclear thermal propulsion fuel with a longer lifetime, streamlined fabrication of fuel elements, and 100 % coating surface coverage to pacify fissionable fuel material towards hydrogen
- ALD application of the thinnest necessary barrier coating
- Process concepts can be transferred to more complex fuel types such as uranium, zirconium, and carbon-graphite composite fuels
- Fuels in other environments such as water or helium can also be coated via ALD to provide protection from diffusion of the respective corrosive elements in those environments