COVER PAGE

Project Title: Development of Cold Spray Additive Manufacturing for Tungsten-Based Plasma-Facing Components	
Federal Award Identification Number: DE-SC0025731	
Agency Code: 8900	**Organization:** Office of Fusion Energy Sciences
Recipient Award Identification Number: Not Provided	**Project Period:** 01/01/2025 - 12/31/2027
Reporting Period: 01/01/2025 - 12/31/2025	**Budget Period:** 01/01/2025 - 12/31/2025
Report Term: Once per Budget Period	**Submission Date and Time:** 10/02/2025 08:52 PM ET
Principal Investigator Information: Grant Crawford	**Recipient Organization:** South Dakota School of Mines & Technology 501 E Saint Joseph St Rapid City, SD 57701-3901 Country: USA **UEI:** CJAJYT2KW771

ACCOMPLISHMENTS

- What are the major goals and objectives of this project?

The overall goal of the proposed project is to explore and develop cold spray additive manufacturing for W-based materials used in plasma-facing components. The project aims to establish the relationship between cold spray process conditions, microstructural features, and irradiation-induced degradation of W-based materials made with cold spray technology. Ultimately, this project will demonstrate the effectiveness of cold spray-produced W-based composites as plasma-facing materials.

- What was accomplished towards these goals?

The technical approach for this project comprises four primary research tasks:
Task 1: Discovery of processing-microstructure relationships in W-based cold spray
Task 2: Measurement of mechanical properties of cold spray coatings
Task 3: Perform ion irradiation experiments and characterize the resulting microstructure and mechanical properties
Task 4: Development of cold spray process for the repair of W-based plasma-facing materials.
The relationship between processing and microstructure in W-based cold spray will be studied using four model plasma-facing material (PFM) systems commonly reported in the literature. The initial focus during this period was on pure tungsten (PFM 1) to understand its deformation behavior, which will help establish a foundation for developing the other three PFMs. The other PFMs are PFM 2: Doped Tungsten (W-ZrC), PFM 3: Binary Solid Solution (W-Ta), and PFM 4: Doped Tungsten + Binary Solid Solution (W-ZrC + W-Ta). Additionally, the work on PFM 1 will serve as a basis for eventually comparing and selecting among the different model PFM systems.
The main Task 1 activities included: (i) sourcing tungsten, tantalum, and zirconium carbide powders, (ii) setting up a higher temperature cold spray system, and (iii) characterizing these powders. Regarding powder sourcing: The quality of powders is vital in cold spray, as the initial microstructure and phase are preserved during deposition. Two different qualities of tungsten powder were obtained, varying in particle shape, internal microstructure, purity, and cost, allowing a comparative study of how powder characteristics affect tungsten cold sprayability. The cold spray system at Arbegast Materials Processing and Joining (AMP) Laboratory was upgraded to reach 900 °C, aligning better with literature conditions for tungsten cold spray deposition. This upgrade enables AMP to produce more tungsten coatings for the DOE FAIR project. The powders' microstructures, residual stress, and particle size and shape were analyzed using X-ray diffraction (XRD), scanning electron microscopy, and electron backscatter diffraction. During this period, Task 2 concentrated on acquiring and preparing substrates for cold spray, with no updates provided for Tasks 3 and 4.

- What do you plan to do during the next reporting period to accomplish the goal and objectives?

In the upcoming reporting period, the main focus will be on completing Tasks 1 and 2. To accomplish Task 1, a series of experiments centered on PFM 1 (pure tungsten) will be prioritized. The initial phase will involve single splat experiments to examine deformation behavior and compare preprocessed and as-received powders, as well as two different tungsten powder qualities. The deformation characteristics of tungsten will be analyzed through focused ion beam (FIB) cross-sections of single splat particles. This analysis will aid in determining the optimal cold spray parameters, the necessary preprocessing for tungsten powder, and the best powder sources for subsequent activities. The following experiments will utilize the top-performing tungsten powders to deposit multiple layers, building up a cold spray deposition of PFM 1. Task 2 will assess the quality of the cold spray deposition. The next experimental phase will concentrate on PFMs 2 (W and Ta coatings) and 3 (W and ZrC coatings), building on the initial PFM 1 experiments. A down-selection process will evaluate the coatings in Task 2 to identify the top two PFM formulations. By the end of the next reporting period, the selected samples will undergo evaluation under various ion irradiation conditions.

- What opportunities for training and professional development were provided for participants?

This reporting period focused on selecting tungsten, tantalum, and zirconium carbide powders and characterizing their properties for cold spray applications, such as particle size, shape, microstructure, and phase. Due to the high-temperature nature of many of these materials, a high-temperature cold spray system was installed at South Dakota Mines, enabling training on the VRC Raptor with an applicator heating system.

- How have the results been disseminated to communities of interest? In particular, provide details for any dissemination not reported in the research product section of this report.

Nothing to report.

PRODUCTS

PUBLICATIONS

There are no publications to report.

INTELLECTUAL PROPERTIES

There are no intellectual properties to report.

PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS

The table below only contains participants who have identified an affiliation with the Awardee Institution. Participants from any associated subawards may not be included in this count.

PARTICIPANTS DETAIL

Project Role	Number of People	Total Person Months Worked
Co-Investigator	2	2
Co-Project Director	1	3
Principal Investigator/Project Director	1	1
Staff Scientist (doctoral level)	1	1
Total Responses	**5**	**7**

PARTNERS DETAIL

There are no partners to report.

IMPACT

What was the impact on the development of the principal discipline(s) of the project?
The overall goal of the proposed project is to research and develop cold spray additive manufacturing of W-based materials for plasma-facing components. The project will examine the relationship between cold spray processing conditions, microstructural features, and irradiation-induced degradation of W-based materials produced by cold spray technology. Ultimately, this project aims to demonstrate the effectiveness of cold spray-produced W-based composites as plasma-facing materials. At this phase of the FAIR project, the overall impact was relatively modest. The current reporting period has been dedicated to assessing various tungsten powder sources and implementing a high temperature cold spray system.

What was the impact on other disciplines?
At this stage of the project the research activities have not contributed substantially to other disciplines. Ultimately, the research will provide critical knowledge relating process-structure-property relationships for producing quality cold spray depositions using high strength refractory metals, which could be used in a variety of critical applications including military weapon systems, hypersonics, and aerospace applications.

What was the impact on physical, institutional, and information resources that form infrastructure?
At this stage of the FAIR project, the influence on the physical and institutional resources that have formed the South Dakota Mines infrastructure has been minimal. However, the addition of this project to the Arbegast Materials Processing and Joining Laboratory has highlighted the necessity to develop the high-temperature cold spray materials and equipment at South Dakota Mines.

What was the impact on technology transfer?
Nothing to report

What was the impact on society beyond science and technology?
Nothing to report

What was the impact on the development of human resources?
Nothing to report

What percentage of the award's budget was spent in foreign country(ies)?
None (0%)