IGEM Grant Report

☐ Progress (due January 1) X Annual (due July 31) ☐ Final (due August 31)

IGEM Grant # IGEM25-005 Principal Investigator: Krishnan S Raja

Submission Date: 07/28/2025 Primary Institution: University of Idaho

Section 1: Summary of Project Accomplishments:
Prepared different types of metal core-oxide shell nanocapsules that render self-healing of matrix. Figures 1 (a) - (c) illustrate the MCOS structures.

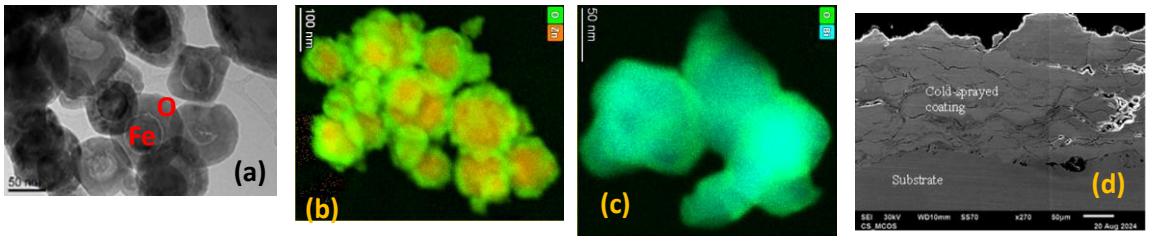

Fig. 1(a) – (c). Transmission electron microscopic (TEM) images of metal core oxide shell (MCOS) nanocapsules. (a) Iron core – iron oxide shell, (b) zinc core – zinc oxide shell, and (c) bismuth core and bismuth oxide shell structures. (d) Cold sprayed coating of nickel base alloy 625 + 10 wt% iron core-iron oxide shell nanocapsules on to 316 stainless steel substrate.

Self-healing composites were prepared by three different methods, such as (a) cold spray, (b) laser powder bed fusion (LPBF), and (c) compaction and sintering. Fig. 1 (d) illustrates the cross-section of a cold-sprayed coating comprising 10 wt% iron core-iron oxide shell nanoscapsules distributed in the Inconel 625 matrix. The cracks of the cold-sprayed coating were partially healed by filling the MCOS as illustrated in Fig. 2.

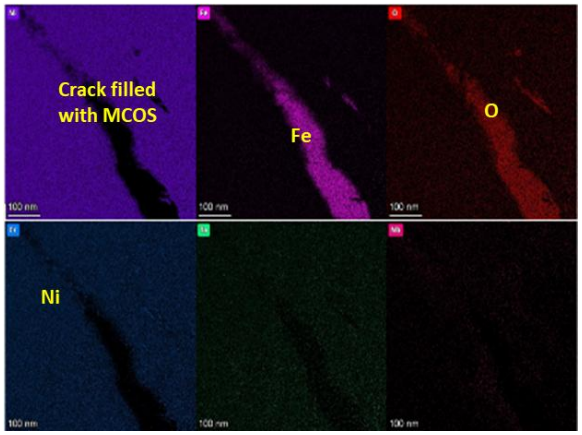

Fig. 2 Self-healing of the crack in the cold sprayed coating (10 wt% iron core-iron oxide shell nanocapsules distributed in the IN 625 matrix).

About twenty LPBF trials were performed to 3D print Alloy 625 + 10 wt% MCOS composit samples by varying laser power, and scanning speed. Microstructural characterization studies are being performed.

Different MCOS + ceramic matrix samples were prepared by the conventional compaction + sintering route. The process parameters were optimized and 3-point bend samples were prepared. Currently, the self-healing behaviors of ceramic-MCOS composite samples are being investigated through 3-point bend tests performed at elevated temperatures under various stress conditions.

Plan for the upcoming report period: LPBF process parameters will be optimized to achieve defect-free 3D prints and test samples will be prepared for further characterization. High-temperature 3-point bend tests will be performed on the ceramic-MCOS composite samples and self-healing behavior will be demonstrated. Microstructural characterization will be performed on all the pertinent samples using SEM, TEM, and XRD techniques.

Section 2: High-level summary of budget expenditures
We have spent 66.23% of the total budget, and the remaining 33.77% of the funds will be spent by December 31, 2025. The budget is being spent on time as planned, with 66.6% of the proposed work completed. Two graduate students were financially supported, and two faculty members received support for one month during the summer. Two graduate students will be supported in the fall of 2025. Several mechanical tests and microstructural characterization studies will be completed using the remaining funds.

Section 3: Demonstration of economic development/impact:
The investigators collaborated with GenNext Materials & Technologies LLC, a private industry partner in Reno, and won an STTR proposal. A patent will be applied for at the end of this year if more encouraging results are obtained. The investigators will submit a research grant proposal seeking significant funding from federal agencies.

Section 4: Number of faculty and student participants as a result of funding, and brief description of student efforts.

Two faculty members, two graduate students, and one undergraduate student participated in this project. The faculty members attended the regional NSF-iCorps program and learnt customer discovery and the commercialization process. The students' efforts include the large-scale synthesis of MCOS nanomaterials, the preparation of composite materials through compaction and sintering, and hands-on operation of sophisticated instruments such as Raman confocal microscopy, SEM, TEM, and XRD. The students made two presentations at the American Nuclear Society conference. Two manuscripts are being prepared for submission to peer-reviewed journals.

Section 5 : Updated details and/or progress on the long-term sustainability plan for the project and description of future plans for project continuation or expansion.

The investigators attended the regional NSF-iCorps program on customer discovery and commercialization. This program helped connect with several industrial personnel working in nuclear, aerospace, additive manufacturing, and coating industries. Several companies showed interest in collaborating. More positive results are expected at the end of the project, which will help carve out a concrete plan for project expansion. A patent application will be filed, which will allow the investigators to apply for the national-level NSF-iCorps program. The investigators will develop a 15-page proposal that expands on the current work and seek funding from the NSF and DOE.

Section 6: Expenditure Report – Attach an expenditure report as a separate document showing expenses toward the original budget submitted for this project. The expenditure report does not count toward the page limit. A written summary of budget expenditures should be provided in section 2 of this report.

	Budgeted, $	Spent, $	Balance, $	% Remaining
Salary	115410.40	73021.31	42389.09	36.7
Fringe	8,875.00	8,379.08	495.92	5.59
Materials & Supplies	35,190.60	24,704.77	10,485.83	29.80
Tuition	38,124.00	24,761.00	13,363.00	35.05
Total	197,600.00	130,866.16	66,733.84	33.77