LUNAR ALLOY METAL PRODUCTION PLANT
NASA 2023 BIG IDEA CHALLENGE

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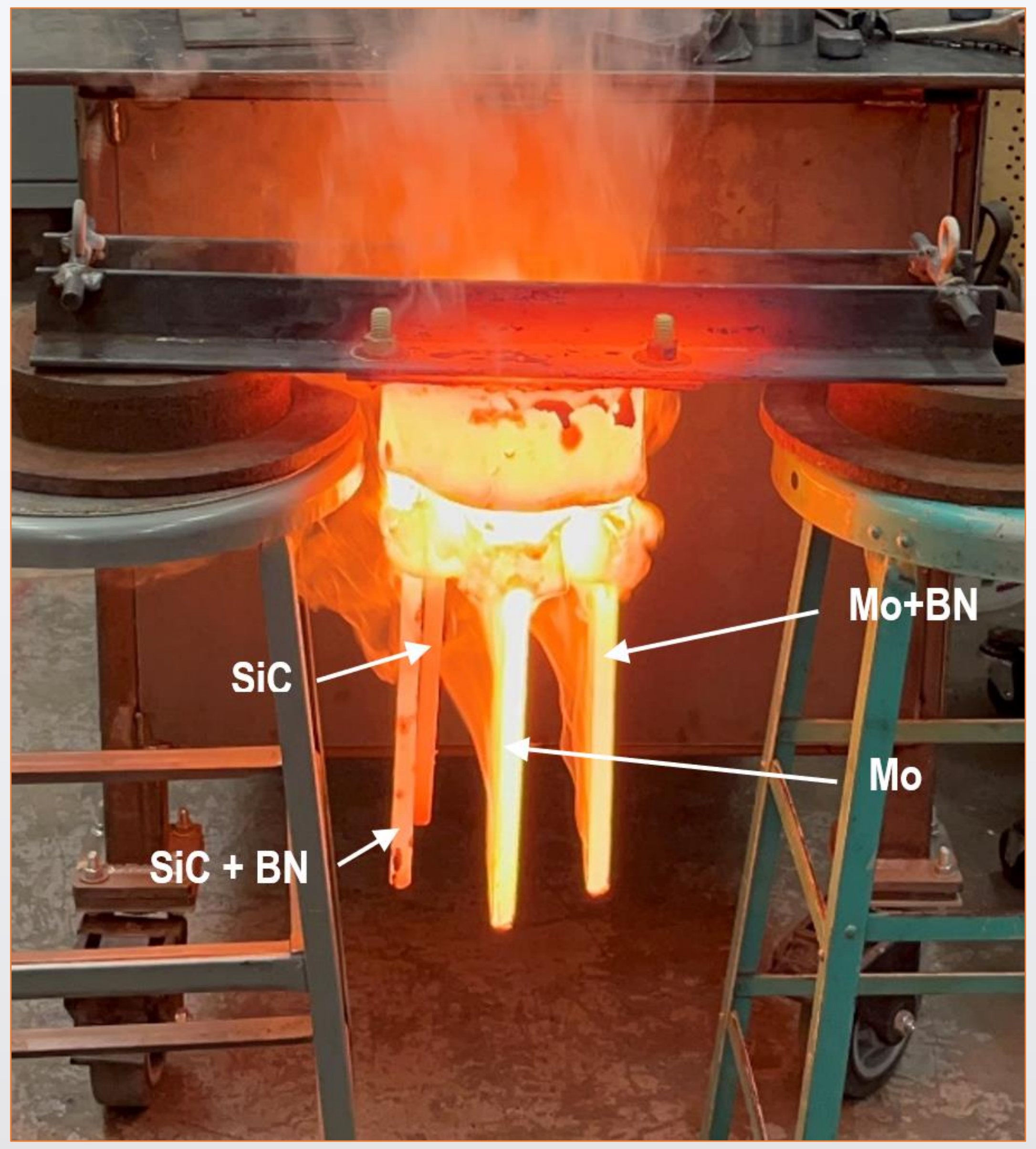
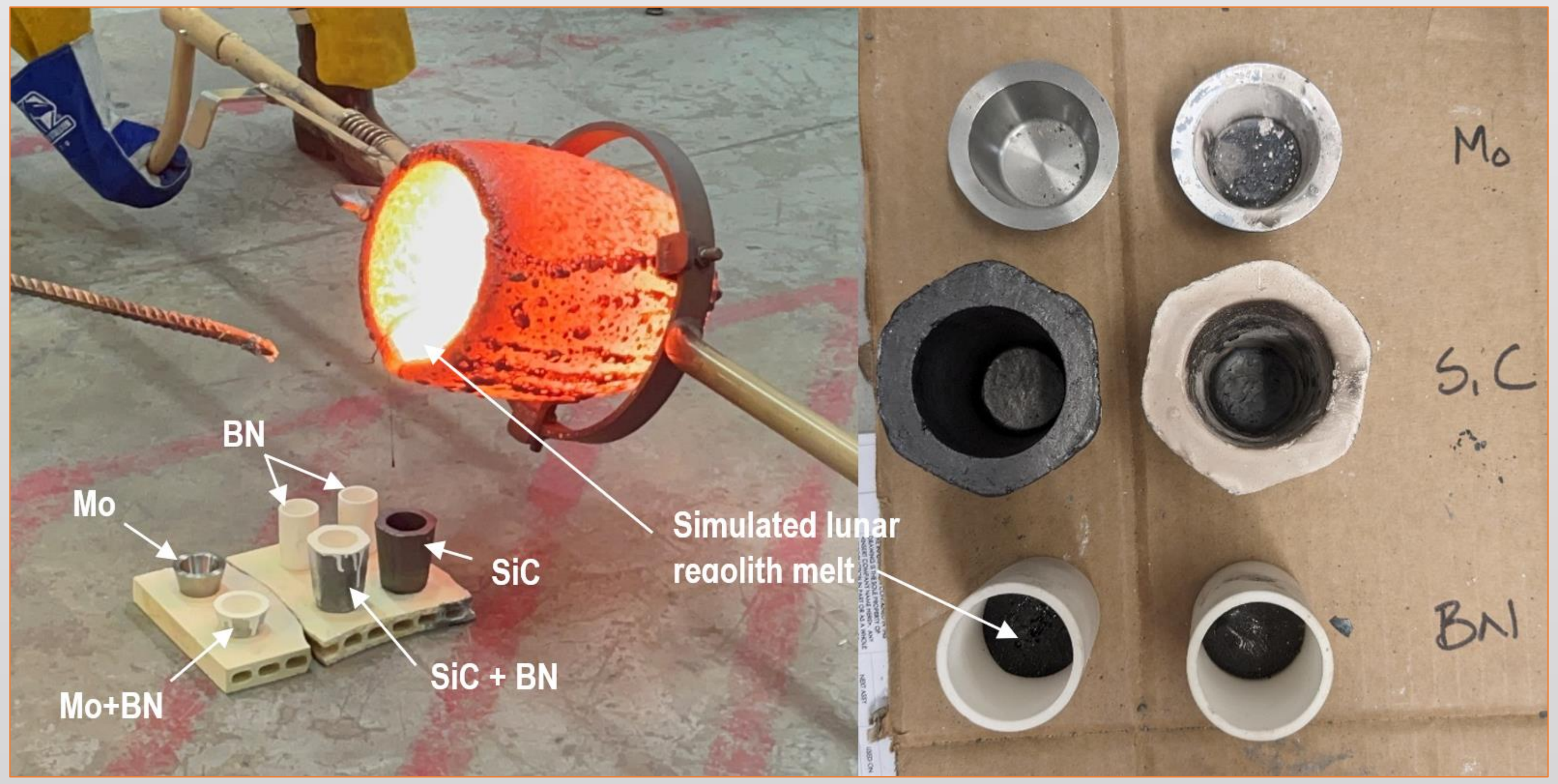
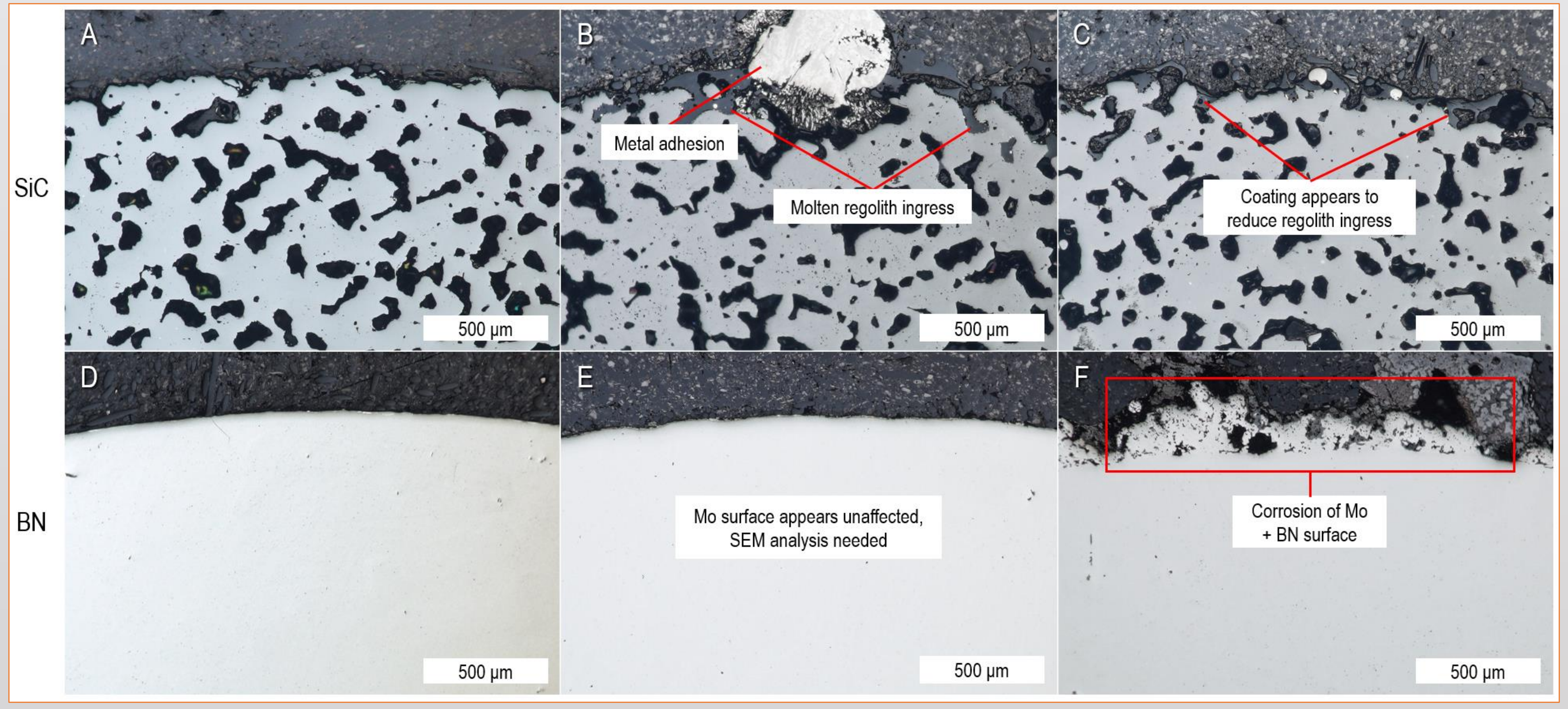
DESIGN & TESTING CONCEPT

The Lunar Alloy Metal Production Plant (LAMPP) is a self-contained, scalable, deployable metal production system designed for use in the lunar environment. LAMPP is based off the nascent technology of Molten Regolith Electrolysis (MRE) which has been proposed as a possible way to extract metals on the lunar surface.

Our teams' experimental objectives and experiment design aimed to test and validate refractory materials that can withstand the required temperature and radiation levels on the lunar surface for metal production through MRE. These efforts are meant to inform the system design with critical data to improve efficiency and increase the TRL of the LAMPP and MRE systems.







VERIFICATION TEST

Candidate refractory materials were selected for exposure testing to verify if they can effectively resist and contain simulated molten regolith. Sought-after qualities of the refractory material used in an MRE system include longevity, robustness, structural stability at high temperatures, and corrosion resistance in the presence of molten oxides and metals. Surface corrosion, density or section loss, and fatigue on a microstructural scale were assessed.

Test	Details	Properties Measured
Static dwell of refractory rods	1 hour, ≈ 1,400 °C	Surface deterioration and section loss
Static hold/cooling of refractory crucibles	Full cool, ≈ 1,400 °C start	Surface deterioration and section loss
Dynamic dwell of refractory rods	5 minutes, ≈ 1,400 °C	Surface deterioration and mass loss on spinning rods to simulate flow
Dynamic flow over refractory plates (ASTM C768)	Full cool, ≈ 1,400 °C start	Surface deterioration and mass loss and flow behavior

MRE REFRACTORY SUGGESTION

Based on the verification testing of aluminum oxide (Al_2O_3), Boron Nitride (BN), Graphite (C), Molybdenum (Mo), Silicon Carbide (SiC), and Zirconia (ZrO_2), the CSM team suggests that an MRE reactor, like the one provided in the LAMPP system, should utilize a composite refractory of a SiC structural base with a BN contact surface to enable efficient containment and transport of molten regolith. SiC showed the best overall performance, and a BN coating showed a reduction in mass loss and an increase in the flow rate of molten regolith. A composite system should consist of a SiC crucible lined with a thick BN refractory-wearing surface. This suggestion also extends to any subsequent subsystem that contacts molten regolith.