Additive Manufacturing Solutions for Energy Materials

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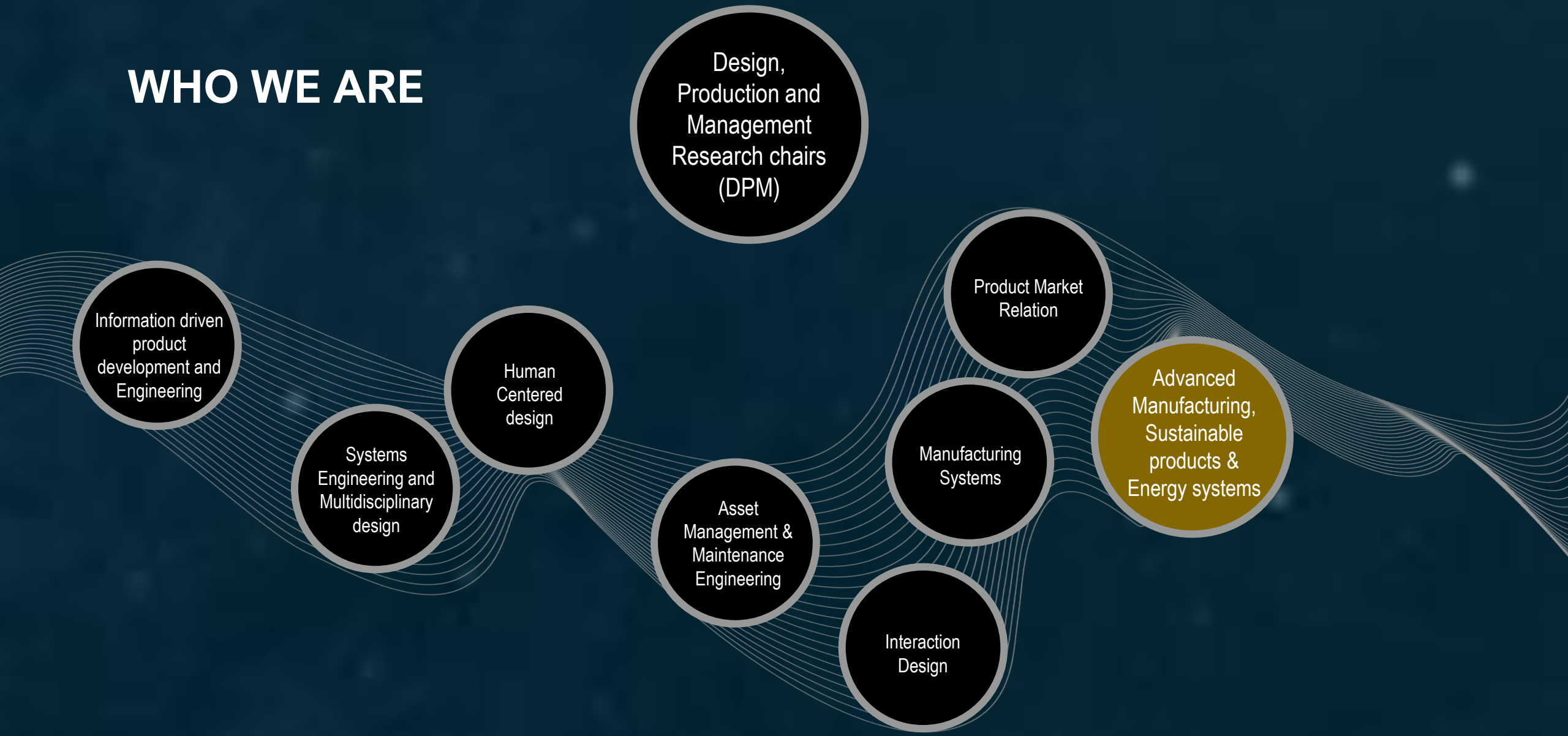
TU Delft Delft University of Technology
TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY
UNIVERSITY OF TWENTE.
WAGENINGEN UNIVERSITY & RESEARCH
4TU. Energy

WHO WE ARE



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WHAT WE DO

Tuning via Additive Manufacturing

Composite Materials

Multi-Materials

Graded Materials

Feature scaling

TOWARDS NOVEL ENERGY MATERIALS & ENERGY CONVERSION AND STORAGE SYSTEMS

COMET

ThermoDust

SPACEFUSE

Heat Transfer Materials

BEAM-TMD

PrintFuel

Electrochemical Materials

IPCEI-CIS-MISD

Thermochemical Materials

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WHO WE ARE

Advanced Manufacturing, Sustainable products & Energy systems (AMSPES)

CHAIR

prof.dr. I. Gibson (Ian)
Full Professor, head of the research chair

dr.ir. T.H.J. Vaneker (Tom)
Associate Professor, head of the Advanced Manufacturing

ACADEMIC STAFF

dr.ir. K. Goulas (Constantinos)
Assistant Professor

Dr. Davoud Jafari
Assistant Professor
Additive Manufacturing Solutions for Energy Materials

dr.ir. M. Mehrpouya (Mehrshad)
Assistant Professor

S. Sanchez PhD (Salomé)
Assistant Professor

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Toward Next Generation Metal-Supported Solid Oxide Fuel Cells

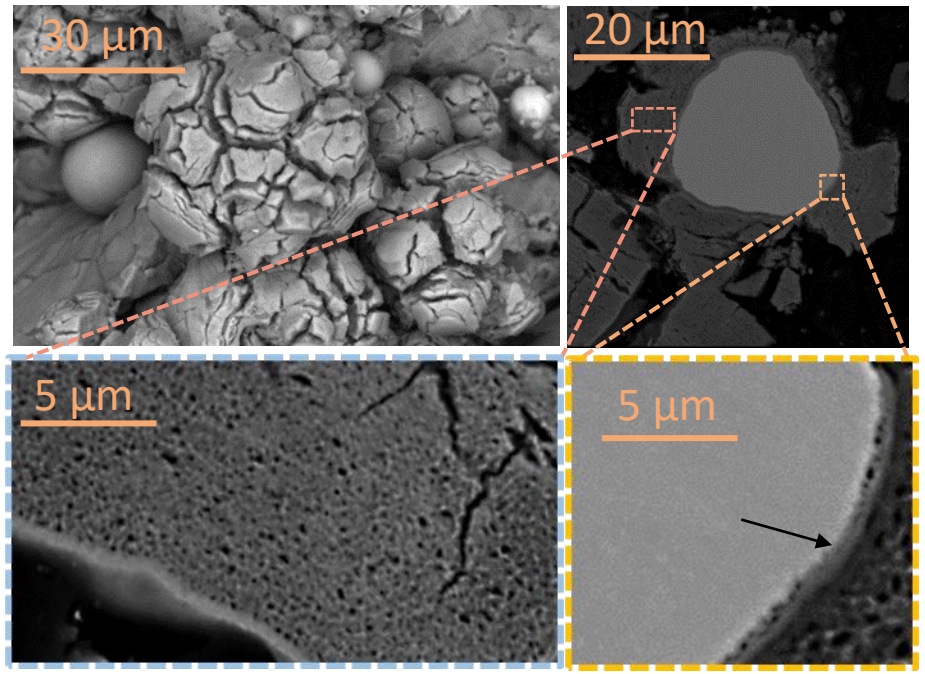
Dr. D. Giuntini (TU/e), Dr. D. Jafari (UTwente)

Challenge:

- Current metal-supported SOFCs face challenges for mobile applications and require multiscale structures and thinning.

Objectives:

- We will use advanced sintering to achieve control of porous morphologies, creating a graded-porosity anode for SOFCs (objective 1).
- We will apply a thin (< 1 µm) dense electrolyte layer and a functional porous cathode using Plasma Electrolyte Oxidation (PEO) coating (objective 2).



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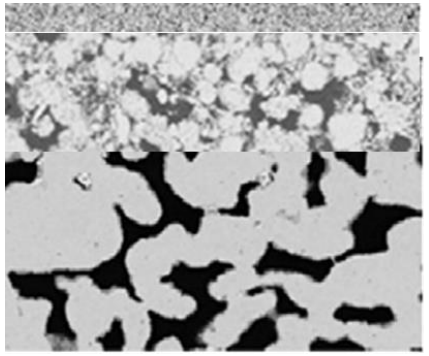
Engineered porous electrodes via 3D Printing and functional coating for metal-supported solid oxide fuel cells (PRINTFUEL)

Objective 1
Manufacturing – Microstructure – Performance

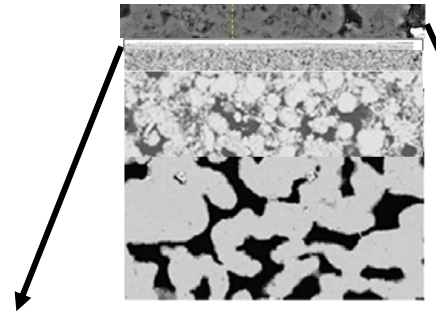
3D Printing + Advanced Imaging



3D printed graded porous materials

Objective 2
Coating – Composition – Performance

Plasma Electrolytic Oxidation + Advanced Imaging

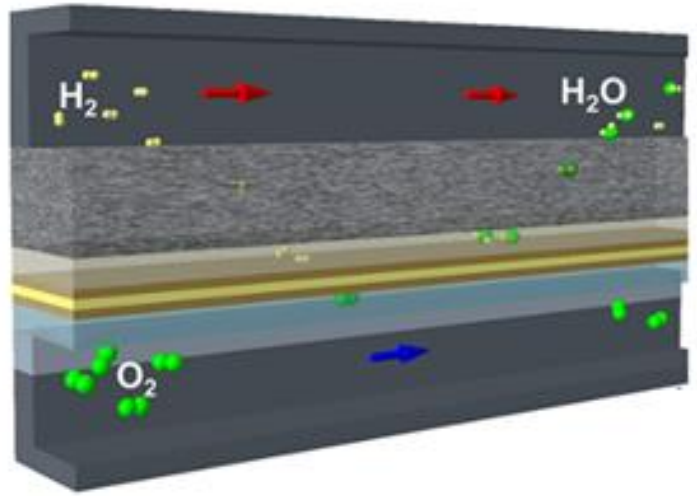


PEO coated electrolyte thickness < 1 µm

PEO coated 5 – 100 µm

Surface coating

Objective 3
Novel concept for solid oxide fuel cells



Electrochemical performance

Engineered porous electrodes to unlock next-generation solid-state proton-conducting electrochemical cells (PCEC) for hydrogen production

Dr. XiaoYu Wu (Waterloo), Dr. D. Jafari (UTwente)

Challenges:

- For the application of PCECs electrolytes, the sinterability of pure or doped $BaZr_{0.8}Y_{0.2}O_{3-\delta}$ (BZY) is poor and it is challenging to make a dense BZY electrolyte layer without sacrificing its high proton conductivity (Challenge 1).
- A smartly designed electrode structure with pores at different length scales is required for enhanced performance (Challenge 2).

Objective:

- Building upon the two previous developments in PrintFuel (AM and PEO coating), we will design and test a new cell concept for PCECs and will evaluate the electrochemical performance and stability of the so-developed PCECs.

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BEAM-TMD: Powder Bed Additive Manufacturing of Transition Metal Dichalcogenide-based Composites for Electrochemical Systems and Space Applicatins


Prof. I. Odnevall


Dr. N. Alinejadian


Dr. D. Jafari

BACKGROUND

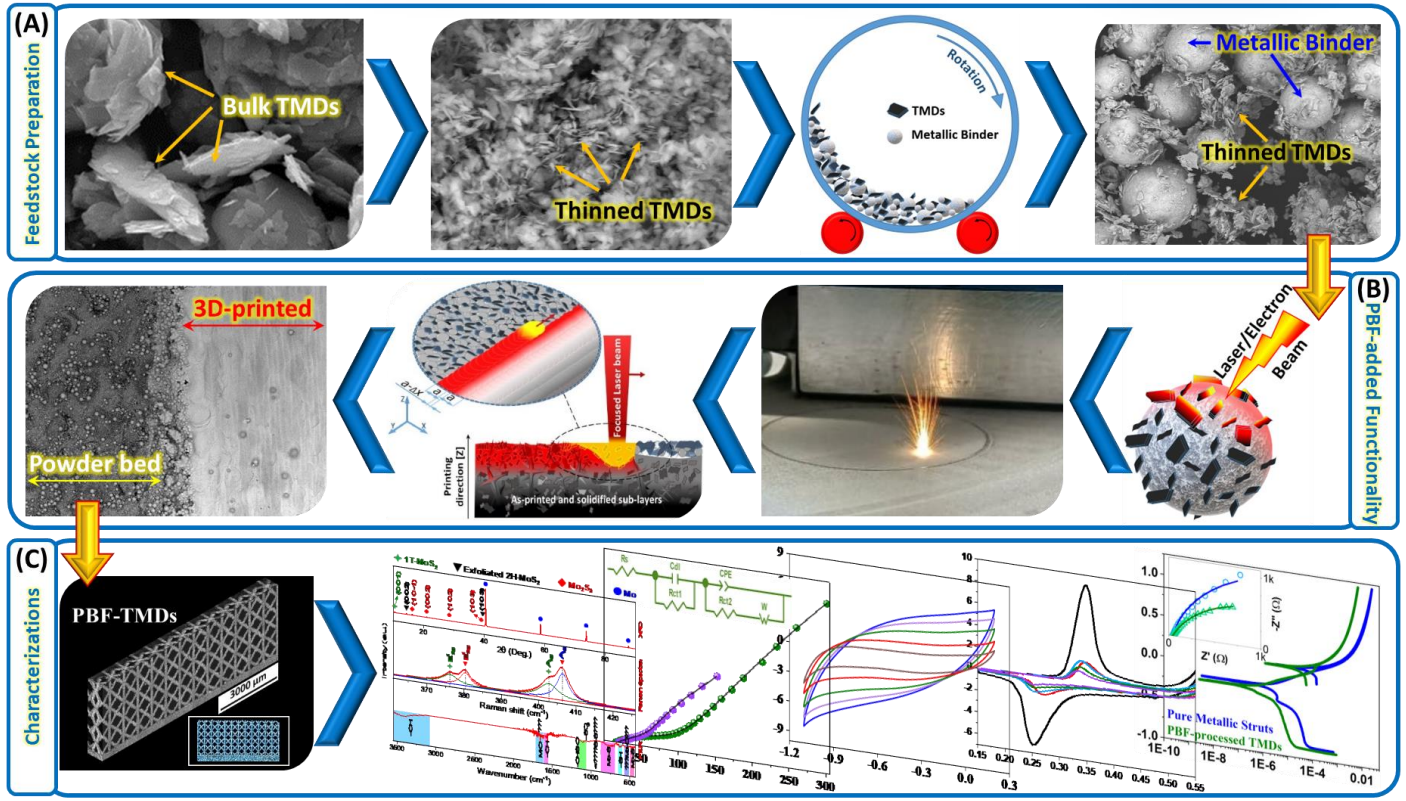
- Decarbonisation of energy economy
- Mitigation of the environmental pollution

PROBLEM

- Multi-step fabrication of electrochemical systems
- Complex pre-processing of precursors/feedstock
- Multi-factor susceptibility of process parameters
- Difficulty in control of the microstructure & morphoolgy
- High-energy post-processing stages
- Environmental and sustainability challenges

AIM

- Elimination of multi-step processing
- Direct processing porous electroactive 3D structures (mili to meso scale porosity)
- In-situ delivering the functionality to AM structure
- Tuned chemical-, physical-, crystallographic-, and electrochemical properties.



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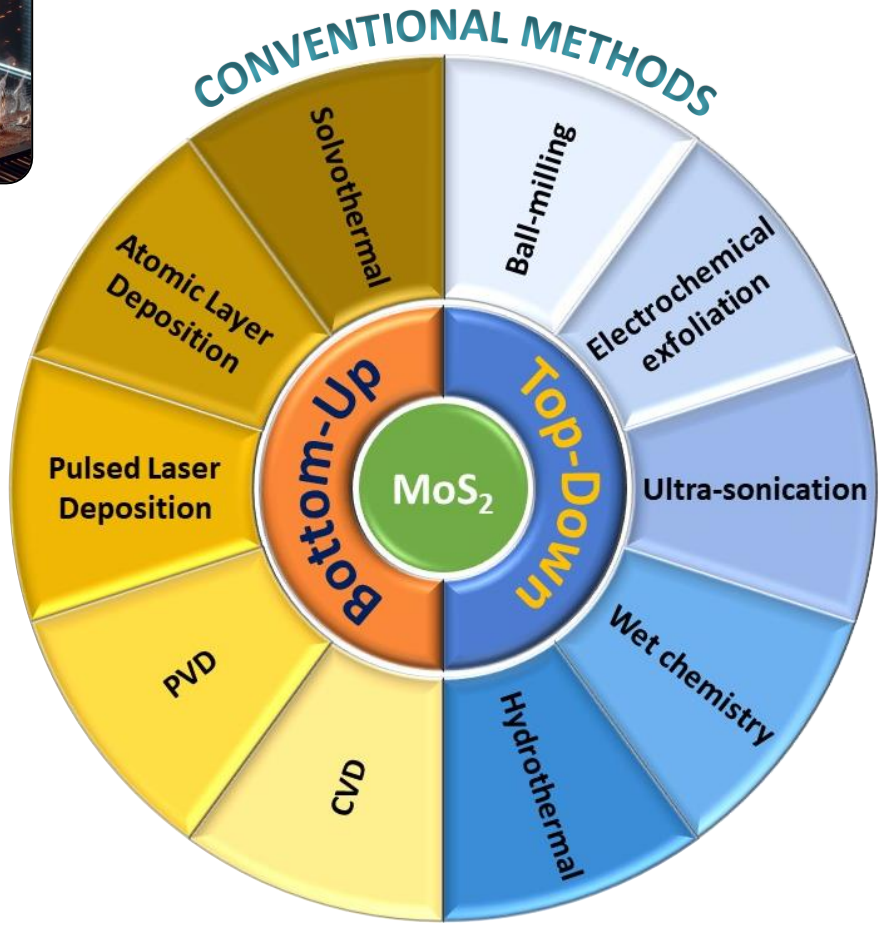

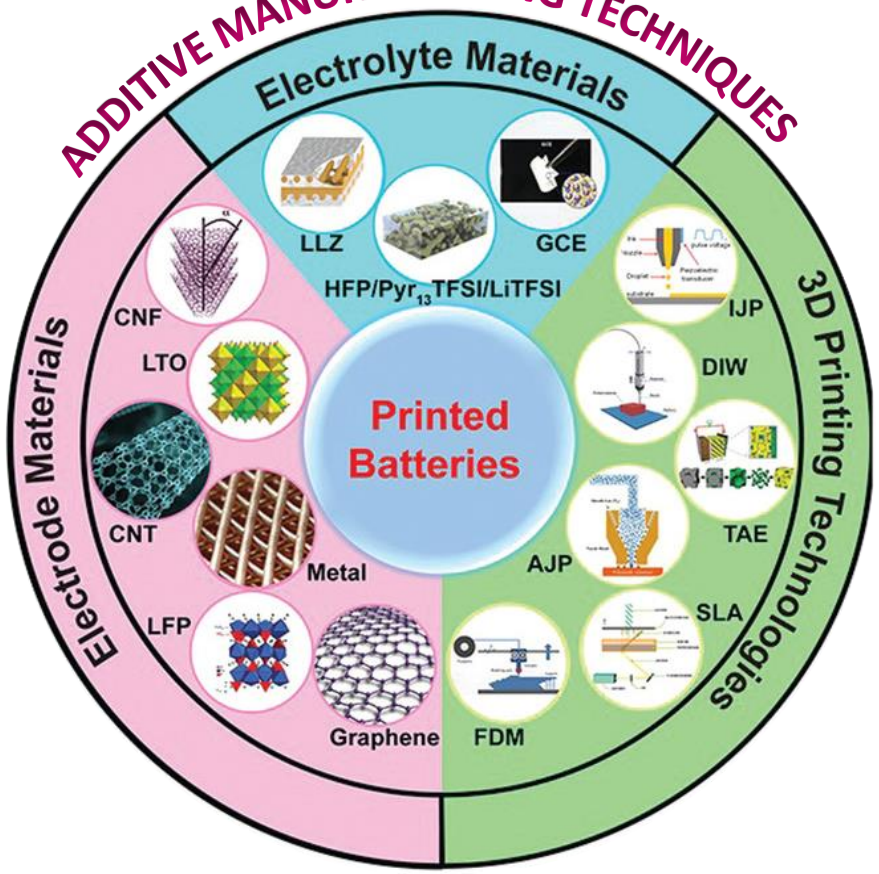

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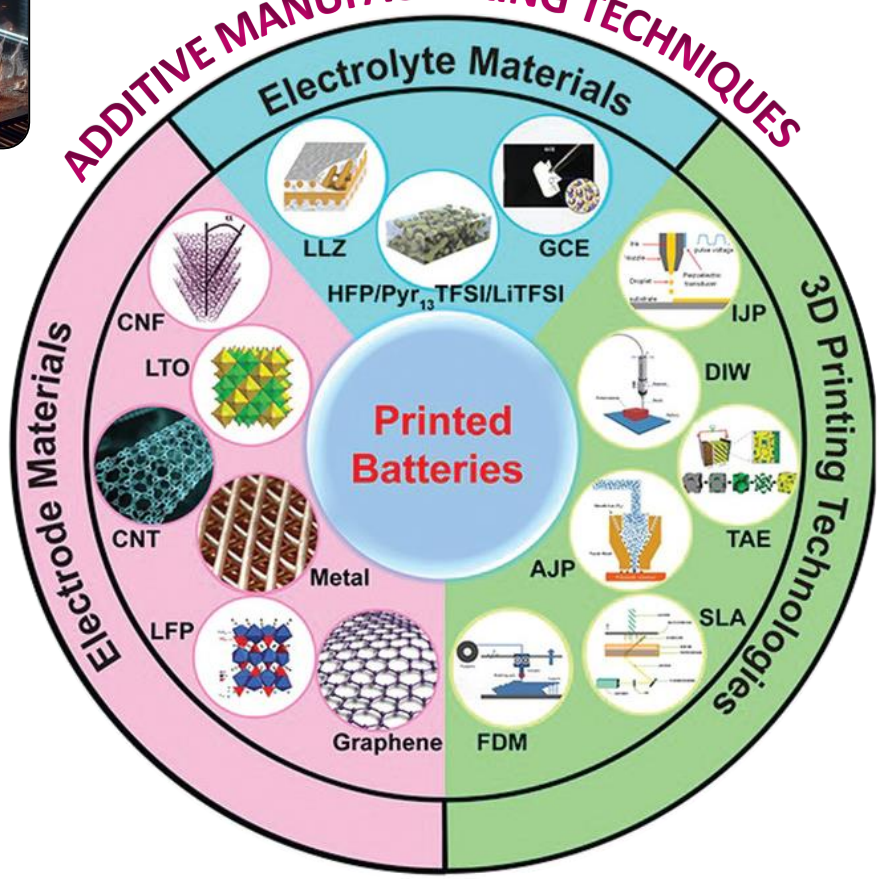

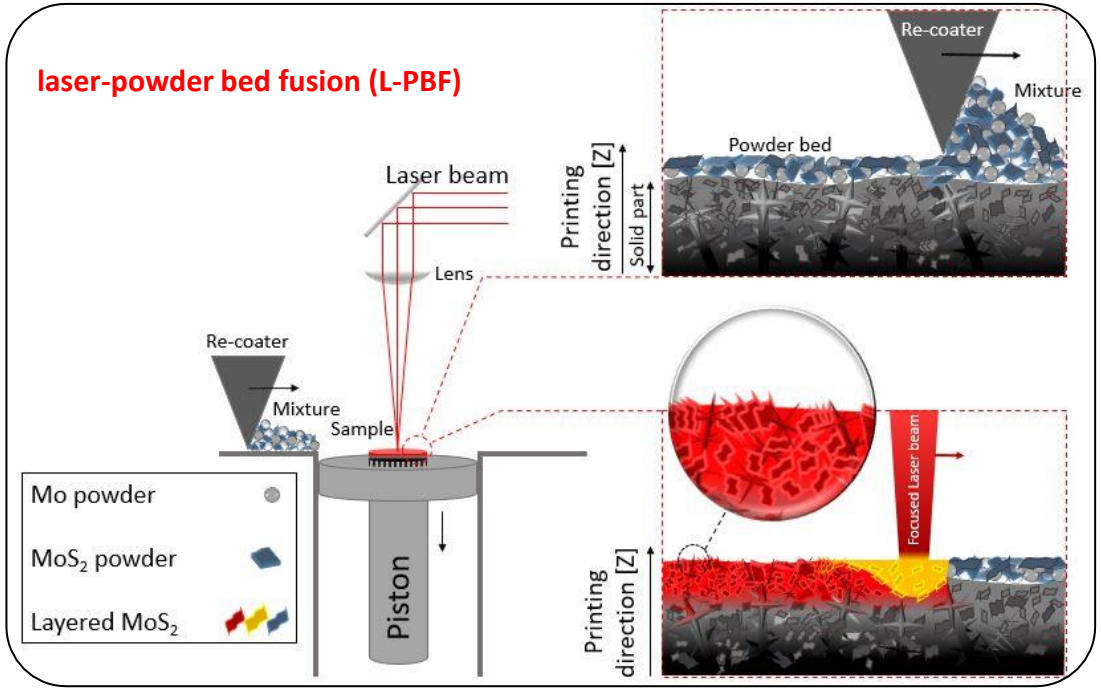

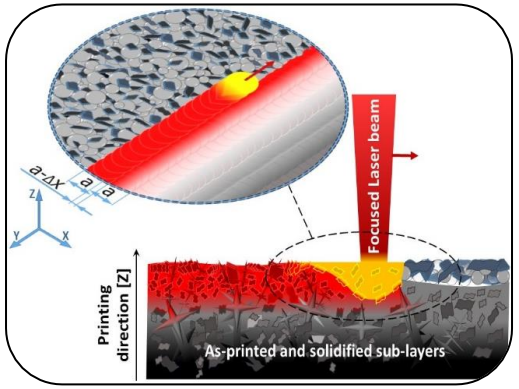

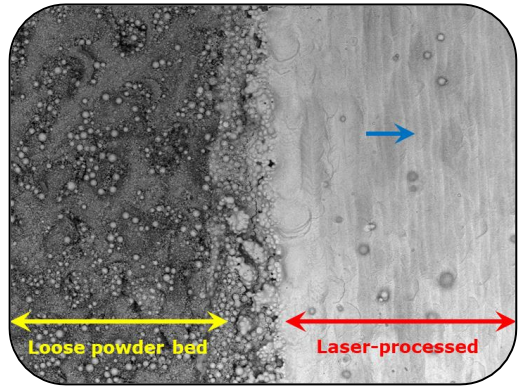

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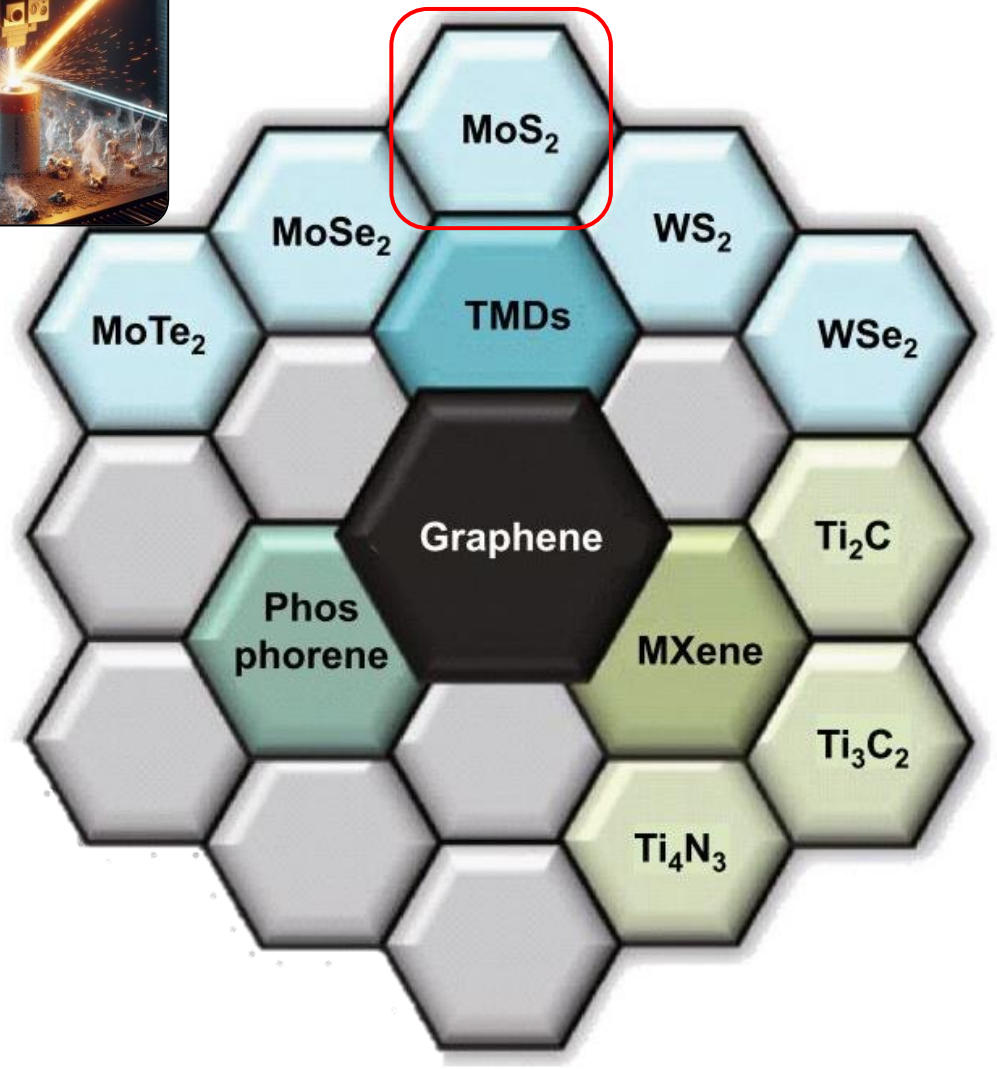

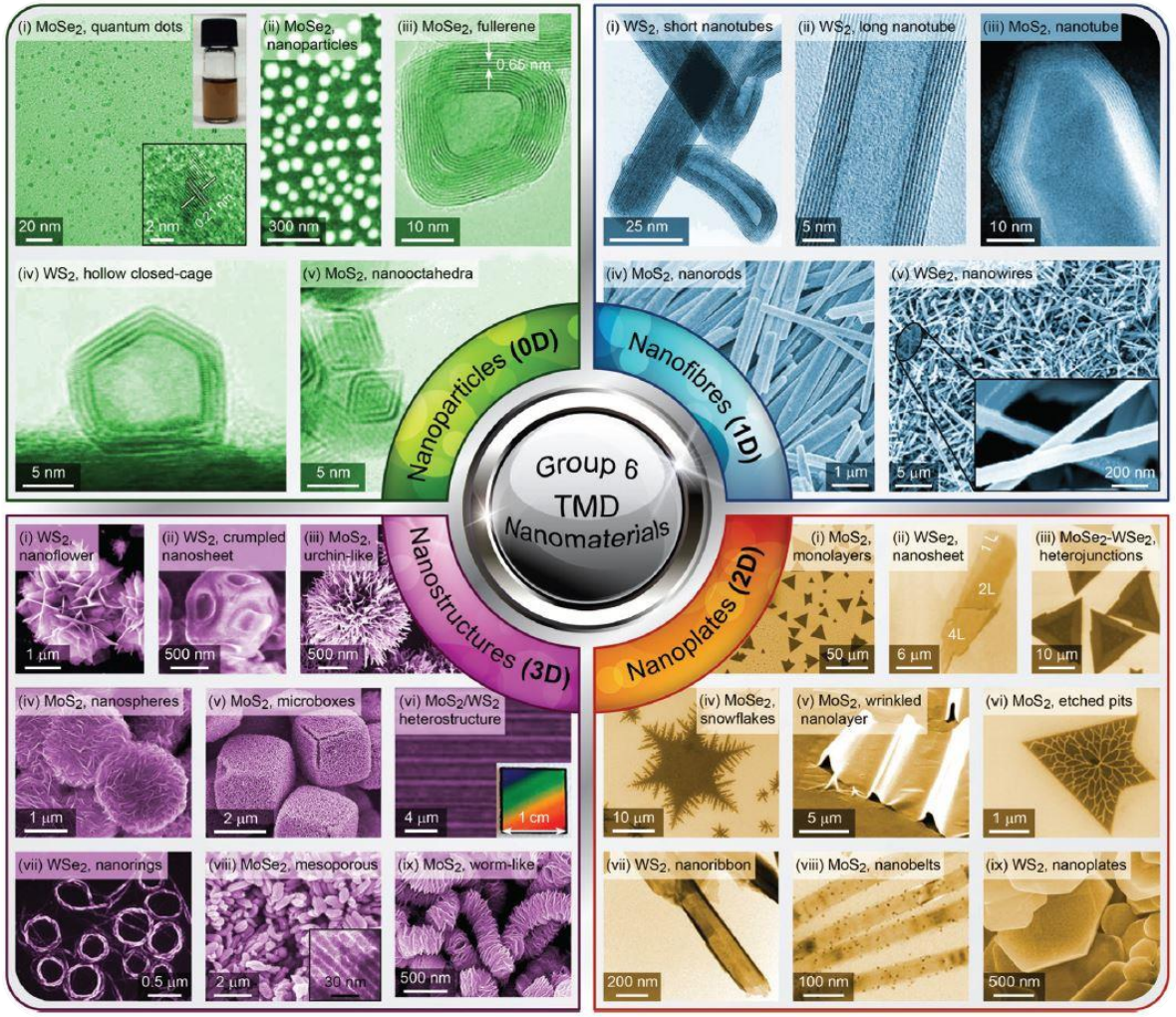

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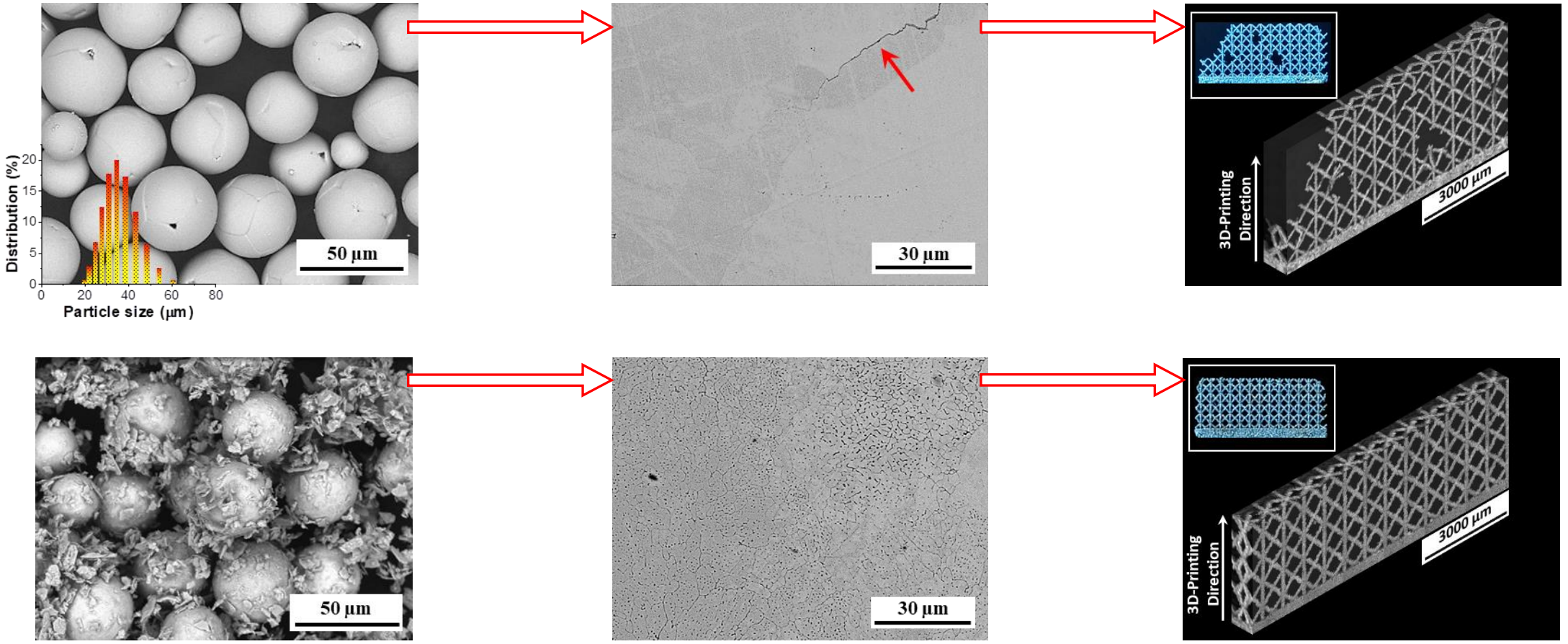
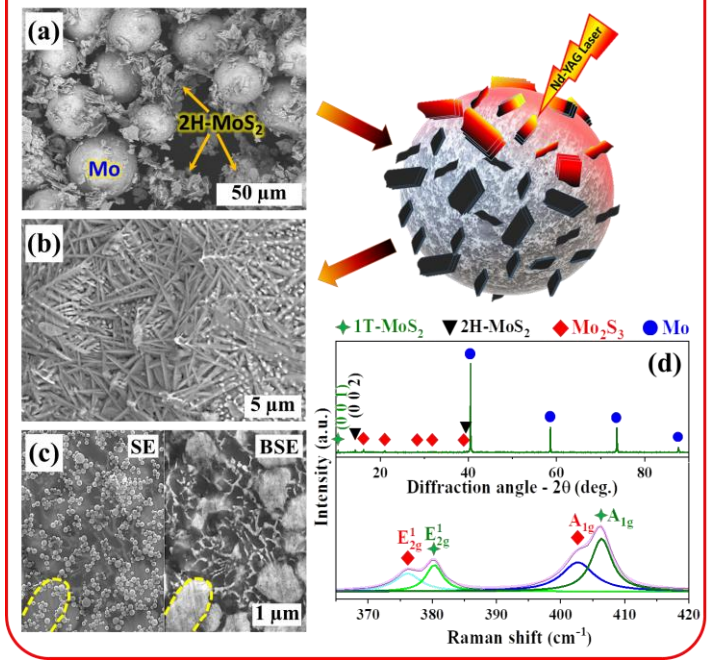
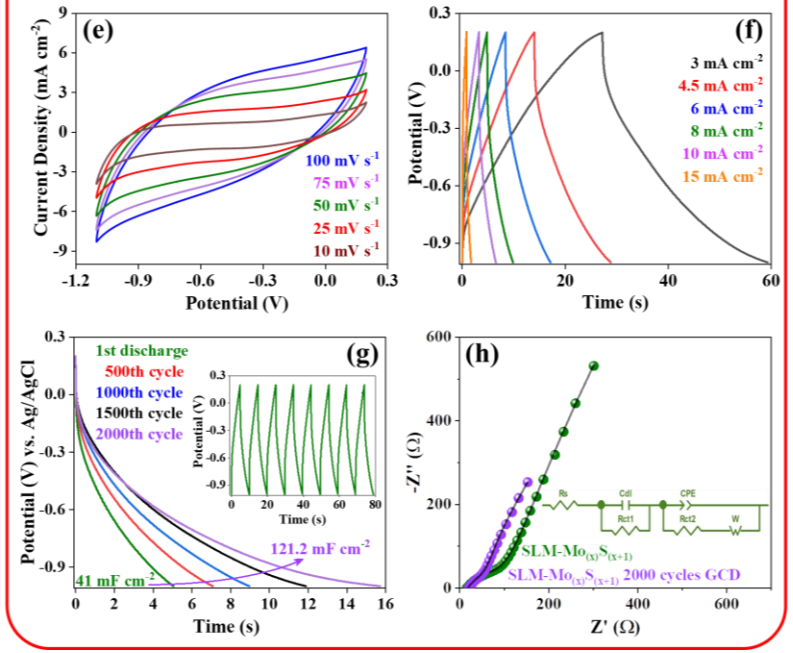


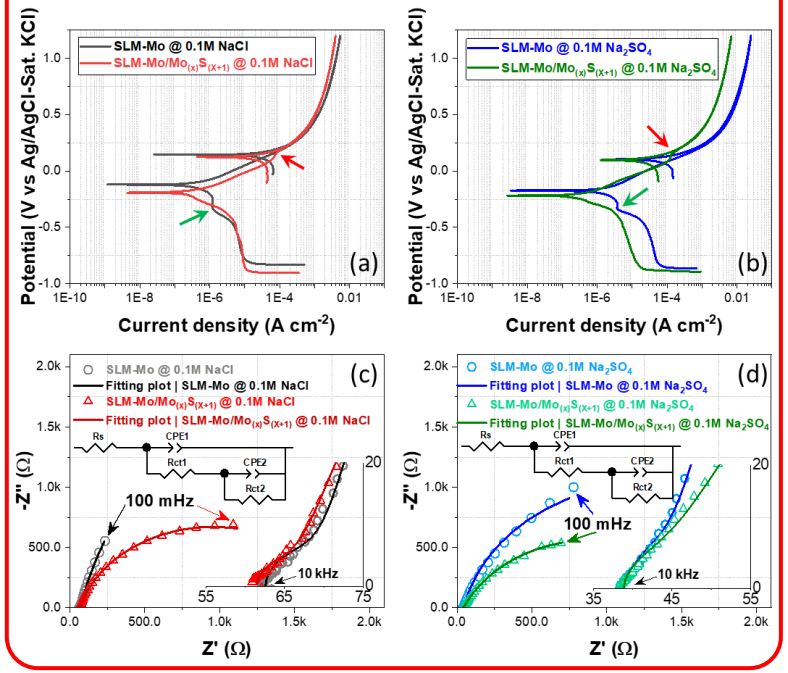
SLM-processed electrode



Electrochemical performances



Corrosion Characterization



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Recap.

Challenges and Directions

- **To Design**

✓ A functional structure for tailoring the properties (porosity, surface area, conductivity, capillarity, wettability, permeability, bubble dynamics, etc.)

- **To Fabricate**

✓ Multiscale additive manufacturing: cm to μm
✓ Coating: μm to nm
✓ Multi-Materials
✓ Functionally graded materials

INNOVATION POTENTIAL

✓ The **Technology** development for AM of composite and multi-material structures

✓ The **Fundamental** mechanisms for thermodynamics, kinetics, and transportation

✓ **Step-change** in heat transfer, electrochemical, and thermochemical systems

Appreciations For Your Attention Paid

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