

DEPARTMENT OF MECHANICAL AND MATERIALS ENGINEERING
COLLEGE OF ENGINEERING AND APPLIED SCIENCES

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PROJECT TITLE: Design and Development of Reference Electrode for Electrochemical Additive Manufacturing

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Project Description

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The UC Micro and Nano Manufacturing Laboratory
The mission of the UC Micro and Nano Manufacturing Laboratory is to expand the horizons of what is possible in manufacturing at increasingly small size scales. Each new process studied is intended to pave the way for new technology to meet the increasing demands of performance and portability across various industries (medicine, consumer products, electronics, aerospace, automotive, defense, and many others). For example, the massive computers of the mid-20th century have come a long way to the much smaller and more powerful smartphones of today, with the possibility of quantum computing coming in the future. Such shifts in technology have been made possible by ongoing research on the harnessing of scientific phenomena to perform material addition, removal, and/or modification at increasingly small size scales. These may range from that of hair (micro) down to individual

atoms (nano). The UCMAN lab studies each process using a two-fold experimental and computational approach to build knowledge on its behavior.

Introduction:

Electrochemical additive manufacturing (ECAM) is a novel, emerging method of additive manufacturing that uses electric current to deposit metal on a substrate through electrochemical reduction of metal ion in the electrolyte. Mechanical, physical properties and morphology of the deposit can be controlled by changing the electrochemical parameters.

This process uses a 3-electrode system with counter electrode, working electrodes and a reference electrode. Working electrode is an electrode on which the electrochemical reaction occurs. It is cathodic or anodic depending on the reaction on the electrode. It usually is made of inert materials. Counter electrode or auxiliary electrode works with the working electrode by passing the required current to balance the observed current at the working electrode. The potential of the counter electrode is not measured, and an inert material is chosen which will not interfere with the reactions.

Reference electrode: It is an electrode which has a stable and known electrode potential against which the rest of the system's potential is measured. It is required to measure and control the working electrode's potential and not pass any current. Therefore, it is critical for qualitative and quantitative data analysis that the reference electrode be unchanged during the experiment. Reference electrodes are developed bearing the aqueous or non-aqueous nature of the electrochemical environment. Single junction reference electrode has only a single junction which is in contact with the sample. This is not favorable for highly metallic conditions. Double junction reference electrode has two junctions, only one is in contact with the sample. The other is not directly in contact with the electrolyte and acts as a pre-contamination buffer and the electrode lasts longer.

Project Scope

The goal of the project is for the student to design and build a double junction reference electrode capable of withstanding in a metallic environment. Construction of a single junction reference electrode is readily available through many sources and the students have access to them in the lab which they can work with to make a double junction reference electrode. The design effort is to comply with relevant engineering standards and codes; e.g. ASME, ANSI, OSHA, . . .

Final deliverables will include:

- A working prototype of the reference electrode. Students will gain exposure to:

- Providing new knowledge on an emerging manufacturing technique

• Conducting a literature review

• Hands-on experiments with an electrochemical setup and hardware

• An excellent opportunity to exercise your initiative, creativity, critical thinking, scientific judgment, scientific knowledge, problem solving, and teamwork skills

Contact

Please contact Dr. Sundaram (murali.sundaram@uc.edu) if you are interested in selecting this as your project.