

Michigan State University
College of Engineering; Dept. of Electrical and Computer Eng.
ECE 480 Capstone Design Course Project Charter

Team 11: Sensor/System for Monitoring Environment: The “SpartanStat”, a miniature instrument capable of measuring toxic metal concentrations in environmental and biological samples.

Sponsoring Company/ Organization: Fraunhofer USA, Inc. Center for Coatings and Diamond Technologies

Contact Information:

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Background Information:

Business Case:

- Explain why is this an attractive opportunity for your company to pursue now.
 - We are currently developing an array of sensors capable of measuring toxic metal concentrations in both environmental and biological samples. We are in the late stages of the development of the materials we need for efficient sensing of several toxic metals; however, we are currently lacking a small, portable instrument capable of applying the electrochemical waveforms necessary for detection.
- Describe the discontinuity creating the competitive opening in the marketplace that makes this project timely. (Competitive action, Legislation, Regulation, etc.)
 - Portable sensing of a variety of contaminants is becoming a hot area of research. While there are several products on the market, many of them incorporate aspects that are generally not necessary for certain applications, thus driving up the price. If we keep this instrument focused for one specific application, we can keep the components simple and keep price low.
- Explain how this product / service will be positioned as a commodity (low cost to serve) or a differentiated (value priced) offering. Why?
 - This product will be combined with our electrochemical sensors, thereby creating a portable sensing “package” capable of field measurements (if necessary).
- Outline the competitive barriers to marketplace entry the Design Team needs to take into consideration.
 - Nothing substantial to consider; these instruments are being developed by a number of companies and groups. However, many of these miniature potentiostats do not include pulse voltammetric methods (needed for ultra-trace determination of metal ions < 1 ppb).

- What is the hypothesized basis of for a sustainable competitive advantage?
 - Patents, Trade Secret, Low cost, privileged relationships?
 - **If we could create a Bluetooth connectable instrument capable of pulse voltammetry there could be considerable intellectual property when combined with our diamond-based electrochemical sensors.**

Project Intellectual Property Considerations:

- Will the student Design Team be required to sign a Non-Disclosure Agreement?
 - **No, not needed.**
- Will the Design Team be able to post their work on the course web site?
 - **Absolutely.**
- Will the student Design Team be working with technology contained in pending patents not yet granted?
 - **Some of the electrode materials are being patented, this is something that we would have to evaluate as the semester progresses.**
 - **We could and will certainly publish peer-reviewed research articles using the instrument and electrochemical sensing package.**
- Can the electronic design be shown, but the embedded software protected?
 - **If necessary or required, absolutely.**

Opportunity Statement:

- What **clearly defined Customer Problem** you hope to solve with this project?
 - **Portable instrumentation controllable by a phone-app is an especially attractive business field. If we can demonstrate that this instrumentation can be developed, it's possible that we generate a sensing package capable of measuring lead (Pb) concentrations right at the tap. This will create an immediate feedback loop for customers and their respective water quality.**
 - Is this problem solvable in a 13-week working semester with students?
 - **I believe it is. To my knowledge, the electronic components in a potentiostat are relatively basic. It will be necessary, however, to measure currents in the single-digit microampere range but this still should not be an issue. I envision including the Bluetooth connection while trying to eliminate noise (non-faradaic current) for low current applications to be the most challenging aspect of the project.**
 - Does the design challenge need to be run across two back-to-back semesters?
 - **Its possible that the instrument components are developed in the fall semester and the Bluetooth connection developed in the spring semester.**
- Does this problem exist now, or in the future?
 - **This is a currently existing problem that will be of great assistance to us.**
 - How long will the window of opportunity be open to alternative solutions?

- I am open to all alternative solutions and opportunities. This is how you foster innovation.
 - What will drive the window of opportunity closed in the future?
 - Not applicable.
- Who is the customer?
 - Customers sprawl across academia and industry. Such an instrument will be used for government funding applications as well.
 - Who makes the buying decision?
 - Fraunhofer CCD management
 - Who will the ECE 480 Design Team deliver their project to at the end of the semester?
 - A presentation would be welcomed by the MSU-Fraunhofer CCD staff at the end of the semester.
 - Describe the benefit to the end Customer for this project.
 - Field measurements would be possible, allowing for an immediate feedback loop for results.

Deliverables:

- Describe what is to be delivered at the end of the semester.
 - A miniature potentiostat capable of applying several electrochemical waveforms including linear sweep voltammetry and pulse voltammetry. The instrument will be able to measure currents of at least 1 microampere and above. The first designs can be wire-connected to the electrochemical sensors for quantitative measurements of metal ions in environmental and biological samples. In conjunction with this, a read-out platform should be developed (cell phone app preferred). Depending on progress throughout the semester, a Bluetooth connection from the instrument to the phone app would be desired.
 - Proof-of-Concept design? (Bread-boards, wires connecting sub-systems, etc., ugly looking – but functional, development software non-user-friendly interface)
 - If the instrument is functioning, that is all that matters. We can develop a housing later, so aesthetics is not an issue at all.
 - Working prototype? (PC boards, cabling between sub-systems, refined software and user friendly interface)
 - As stated above, a working prototype capable of wire-connection to an electrochemical sensor would be desired. Bluetooth connection would be a significant added benefit, but this would not be expected to be delivered in one semester.
 - Sub-system ready to fit into the overall system?
 - We will test the instrument side-by-side with commercially available potentiostats. While performance of the instrument developed by the design team does not need to exceed the performance of the commercial potentiostat, the ability to

measure currents in the low-microampere range should be comparable.

- o Final solution ready for end use deployment?
 - This is not expected but would certainly be an added bonus.

Goals:

- Describe what success will look like at the end of the semester.
 - o A side-by-side comparison of the instrument developed by the design team with a commercially available will be completed and similar results will be obtained with both.
- Goals should be SMART
 - o **Specific** – Exactly what is to be delivered?
 - A portable potentiostat to be used in conjunction with diamond-based electrochemical sensors.
 - o **Measurable** – Describe the measurement system that will determine the degree of success.
 - Results will be compared with commercial potentiostats that Fraunhofer CCD currently owns and uses.
 - o **Attainable** – Can a student team, with little to no industrial experience complete this project in 13 weeks to your satisfaction?
 - The instrument itself can be completed by a student team. In 13 weeks, I am not sure that the Bluetooth connection can be fully developed.
 - o **Relevant** – Limited to this design challenge.
 - Portable electrochemical sensing takes advantage of the intrinsic advantages of the method. Instrumentation is inexpensive, yet still sensitive enough for quantitative measurements of toxic metal ions in an array of solution matrices.
 - o **Time Bound** – 13 week working semester (Students lose a week getting organized and a week preparing for Design Week presentations.)
 - 13 weeks should be enough time to complete the project. I will be happy to work with the student design team to set benchmarks and goals throughout the semester.

Scope:

- Clearly define what is IN and OUT of Scope for the Design Team. What are the clearly defined boundaries to prevent the project from getting too large and complicated?
 - o Focus should remain on creating an instrument capable of pulse voltammetric methods for low current measurements. While there are many electrochemical waveforms useful for different applications, I believe keeping the focus somewhat narrow in this niche of electrochemistry will enable a more efficient approach to the problem.

- Clearly list chipsets, software, equipment, test set-ups, working systems, etc. that will be supplied to the Design Team to facilitate their efforts and keep project cost reasonable.
 - The student design team will have access to all the electrochemical instrumentation available in the lab at MSU-Fraunhofer CCD. In addition, the student design team may be interested in collaborating with the Systems Group at Fraunhofer CCD (a team of skilled electrical engineers aware of this project).

Constraints:

- List all constraints on the project team.
 - Examples include: Equipment the team must interface with, past Capstone Designs the team must build upon previous results, chip sets / software team must use in the design, etc.
 - No specific requirements

Project Team: (Completed once semester begins)

Name	Responsibility

Faculty Advisor: (Assigned by ECE Dept . based on project requirements)
