

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

**Sponsoring Company/ Organization: MSU/Fraunhofer Center for Coatings and Diamond Technologies (CCD)**

**Contact Information:**

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**Background Information:**

**Business Case:**

- Explain why is this an attractive opportunity for your company to pursue now.

CCD grows diamond by a chemical vapor phase process. The process deposits diamond on a starting diamond substrate. CCD wants to develop a technique to monitor the surface of the diamond growth while the growth is taking place. If the top surface of the diamond growing can be measured for its slope and direction of the slope during growth a feedback control loop can be implemented to improve the process. The technique envisioned is a laser reflection system to monitor the surface of the diamond during growth. No such monitoring system is yet existing in the market for use in diamond deposition systems. A provisional patent has been submitted for the idea and how it would be implemented. This project is to assemble such a system outside a diamond deposition system for testing and it should include both the hardware and the software.

- Describe the discontinuity creating the competitive opening in the marketplace that makes this project timely. (Competitive action, Legislation, Regulation, etc.)

There is interest in growing larger sized diamond substrates for use in electronic and optical applications. The use of diamond electronics allows more efficient use of electricity.

- Explain how this product / service will be positioned as a commodity (low cost to serve) or a differentiated (value priced) offering. Why?

The product will allow higher quality diamond to be grown with more repeatability. It will also allow high quality diamond to be grown to larger sizes.

- Outline the competitive barriers to marketplace entry the Design Team needs to take into consideration.

The key desired result is a demonstrated laser based system to monitor the surface of diamond during its growth.

- What is the hypothesized basis of for a sustainable competitive advantage?
  - Patents, Trade Secret, Low cost, privileged relationships?
 A provisional patent has been submitted for the technology.

**Project Intellectual Property Considerations:**

- Will the student Design Team be required to sign a Non-Disclosure Agreement?  
No
- Will the Design Team be able to post their work on the course web site?  
Yes
- Will the student Design Team be working with technology contained in pending patents not yet granted?

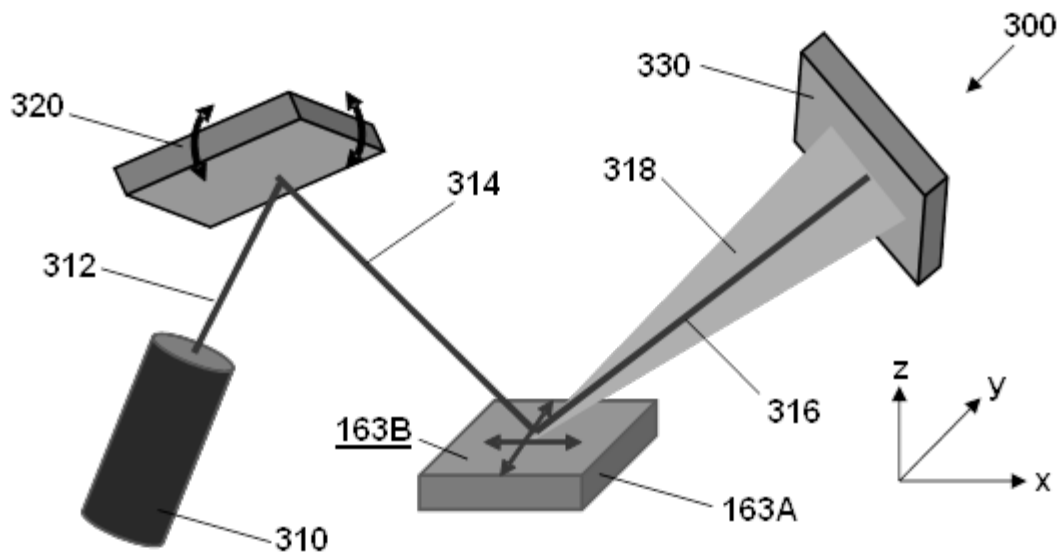
Yes, A provisional patent was submitted March, 2016

- Can the electronic design be shown, but the embedded software protected?  
Yes

**Opportunity Statement:**

- What **clearly defined Customer Problem** you hope to solve with this project?
  - Is this problem solvable in a 13 week working semester with students?
  - Does the design challenge need to be run across two back-to-back semesters?

The goal is to develop the system shown below that scans a laser beam (314) across a diamond substrate (163A) and monitors the reflection so that data on the sloped and roughness of the diamond substrate can be measured. The project should be doable in one semester.



- Does this problem exist now, or in the future?
  - How long will the window of opportunity be open to alternative solutions?

The problem to monitor the surface of diamond while it grows is an open opportunity now and a solution has been proposed. This project is to develop a first prototype for the proposed solution.

- What will drive the window of opportunity closed in the future?  
Not known.
- Who is the customer?
  - Who makes the buying decision?  
Companies that grow diamond and the manufacturers of machines to grow diamond by the chemical vapor deposition process.
  - Who will the ECE 480 Design Team deliver their project to at the end of the semester?  
Timothy Grotjohn
  - Describe the benefit to the end Customer for this project.  
This project will build the first prototype for a system to monitor the surface of diamond during its growth.

**Deliverables:**

- Describe what is to be delivered at the end of the semester.

- Proof-of-Concept design? (Bread-boards, wires connecting sub-systems, etc., ugly looking – but functional, development software non-user-friendly interface)
- Working prototype? (PC boards, cabling between sub-systems, refined software and user friendly interface)
- Sub-system ready to fit into the overall system?
- Final solution ready for end use deployment?
- The final deliverable will be the system shown in the figure provided above. This includes the hardware and the software. The software should develop an image of the slope of the diamond surface versus spatial position and an indication of the surface roughness. The software should run on a pc/laptop. All code and the documentation should be provided.

### Goals:

- Describe what success will look like at the end of the semester.
- Goals should be SMART
  - **Specific** – Exactly what is to be delivered?
  - **Measurable** – Describe the measurement system that will determine the degree of success.
  - **Attainable** – Can a student team, with little to no industrial experience complete this project in 13 weeks to your satisfaction?
  - **Relevant** – Limited to this design challenge.
  - **Time Bound** – 13 week working semester (Students lose a week getting organized and a week preparing for Design Week presentations.)

The system should be able to measure substrates of size from 3mm x 3mm up to 25 mm X 25 mm. The substrate is in a fixed position and can not move. The laser beam must scan the substrate. With the laser beam being of approximately 1 mm in diameter the spatial resolution of the image of the substrate should be 1 mm or better. The key quantity to be measured is the slope of the top diamond surface. The repeatability of the measurement for a given spatial location should be repeatable to 0.25 degrees and accurate to 0.25 degrees for the slope of the top diamond surface. The range of slopes to be measured will be up to 5 degrees in any direction from the flat plane of the surface that the substrate sits on. The slope will be different for various positions on the substrate. (Consider a system that measures the slope and the direction of the slope of the top surface of a convex or concave mirror with a spatial accuracy of 1 mm). The time to complete a measurement for a 10 mm x 10 mm substrate should be 200 seconds (or an average of 2 seconds per measurement point). The parts that the students should plan to use for the project are a laser, a way to scan the position of the laser beam on the substrate, a way to image the scattered/reflected laser beam (camera) and software to control the entire system and generate an image on the computer

screen of the slope and direction of the slope on the top surface of the diamond sample versus spatial position. The system should also have the capability to capture the reflected/scattered laser light image for display on the computer screen. As a bonus the design team can consider extracting surface roughness data from the scattered image. However, the analysis of the scattered image is not a requirement of the project beyond determining the slope of the substrate surface at the measurement point. At the end of the system a working prototype should be delivered. This includes all the hardware and software. The team will work with the customer to make sure the system works on the customer's laptop (MS Windows system) at the end of 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?
- 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 project will provide test substrates of size from 3 mm x 3 mm up to larger sizes up to 25 mm x 25 mm. Some substrates with known slopes will be provided for testing the accuracy of the system constructed.

**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.

The goals listed above contains some constraints.

**Project Team:** (Completed once semester begins)

Name	Responsibility

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

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