In Vivo Spectroscopy of Cancerous Skin Cells using Raman Spectroscopy

L.A.S.E.R.S. - Live-Action Safe Examination Raman Spectrometer

Group 8 CREOL

Stephen Esposito	Computer Engineering
Michael Gonzalez	Electrical Engineering
Chelsea Greene	Electrical Engineering
Megan Melvin	Photonic Sciences and Engineering

Senior Design 1

Initial Project Document and Group Identification

College of Optics and Photonics, Department of Electrical Engineering and Computer Science

University of Central Florida

Dr. David Hagan, Dr. Lei Wei

Advising from Dr. Kyu Young Han

& Dr. Peter J. Delfyett

Project Narrative

It is estimated that 87,110 new cases of invasive melanoma will be diagnosed in the U.S. in 2017, and melanoma only accounts for 1% of skin cancers (American Cancer Society). These patients have to visit a dermatologist to have freckles, moles, or other abnormal patches of skin checked for the potential of being cancerous. This usually results in a biopsy of the skin to be sent to a pathologist who uses a microscope to check if the skin sample is cancerous or noncancerous -- a process that may take several days to receive results. A biopsy is performed by cutting out or excising an area of the skin under consideration. This can be painful for the patient and may result in scarring. Further biopsies may need to be performed if the biopsy sample did not contain the abnormal cells, if the concentration of the cells was not high enough for an accurate diagnosis, or if the skin appears to change after the biopsy. Therefore the motivation of this project is to provide a non-invasive alternative to a biopsy, all while maintaining the same standard of accuracy and reliability.

The overall goal for this project is to design and build a compact, accurate, portable Raman spectrometer that can be used to identify cancerous versus noncancerous skin cells in vivo. It entails designing a Raman spectrometer that operates at a wavelength range known to obtain the identifying features of the Raman spectra of cancerous versus normal cells. The Raman spectra is analyzed to help diagnose the possibility of skin cancer as an early detection measure. This system offers patients and medical offices a more efficient and cost effective option compared to expensive Raman spectrometers and traditional biopsies. Patients will be able to see day-of results, faster when compared to a biopsy that must be sent away and processed in a lab. The use of a Raman spectrometer is less invasive for patients, as a biopsy requires the removal of skin cells from the potentially impacted body part.

Medical technology is always relevant in the industry with new solutions always needed and improved upon. This project implements the range of talents across the team together and as individuals. It will use a combination of our knowledge from education as well as experiences at internships and careers, tying together traditional and practical knowledge.

This compact option is less expensive than typical on-the-market Raman spectrometer systems. A less expensive option for a doctor's office to buy and operate reduces patient fees. On average, a portable Raman spectrometer can cost anywhere from $2,500 to over $50,000, a range that varies with the purpose and accuracy of the system. The average biopsy without insurance costs approximately $200, which adds up for a high risk patient that may need to have many biopsies performed. Lower fees mean that a patient may be more likely to have potentially life-saving testing done with less of a financial burden. Providing a reliable, safe, affordable, and effective option compared to current methods will prove this design as a success.

Project Specifications and Standards

Working with medical technology and optics brings a challenge of specific design considerations as well as safety protocol that must be followed. Considerations must be made in order to meet the cost and design goals that allow the final product to be accurate, safe, and reliable. This project considers each design specification individually and as they contribute to the complete system. The following design, engineering, and safety goals define the focus of the research process and the overall goals of the project.

- Collection optics and detector, either CCD or CMOS, will receive the scattered light effectively.
- Software to accurately and reliably analyze the Raman spectra of the scattered light read in with a sensor.
- In order to increase the attractiveness of this option to a patient, sample time must be relatively short. A measurement time with a five minute maximum is ideal, as the sample is on a human.
- It will have a compact size to more easily analyze skin at different locations on the body, while still attaining high throughput. The size is not to exceed what is reasonable for a desktop space. The dimensions of the completed system must fit within a 3.5’ by 3.5’ space.
- Enclosed housing for all electronic and optic parts to prevent stray light from affecting results and to prevent eye damage for both the user and the “patient”.
- Successful functionality means that the overall system must be reliable, deliver fast results, be accurate enough to replace a biopsy, and be safe.
- Flexible design that allows for simple and effective troubleshooting.
- Low and efficient power consumption and distribution is essential.
- Material selection for the outer casing must consider the heat distribution of all electronic and optical parts.
- Data transfer must be fast and secure. Results must be viewable within the time limit of a presentation.
- Attractive overall design for the users of the system.
- The overall spectrometer system must be cost efficient.
- HIPAA (patient privacy) and ANSI (laser safety) standards must be studied, understood, and followed.

The major elements of the device include but are not limited to:

- PCB
- Spectrometer
- Java/C

- CAD
- Device shell/housing of all electronic and optical aspects
- Microcontroller

Optics Key Design Considerations:
- Focal lengths of optics
- Numerical aperture
- Optical resolution
- Pixel resolution
- Cooled or uncooled detector
- Diffraction grating length and density
- Slit size
- Laser excitation source & delivery optics (lenses and/or mirrors)
- Spectral range

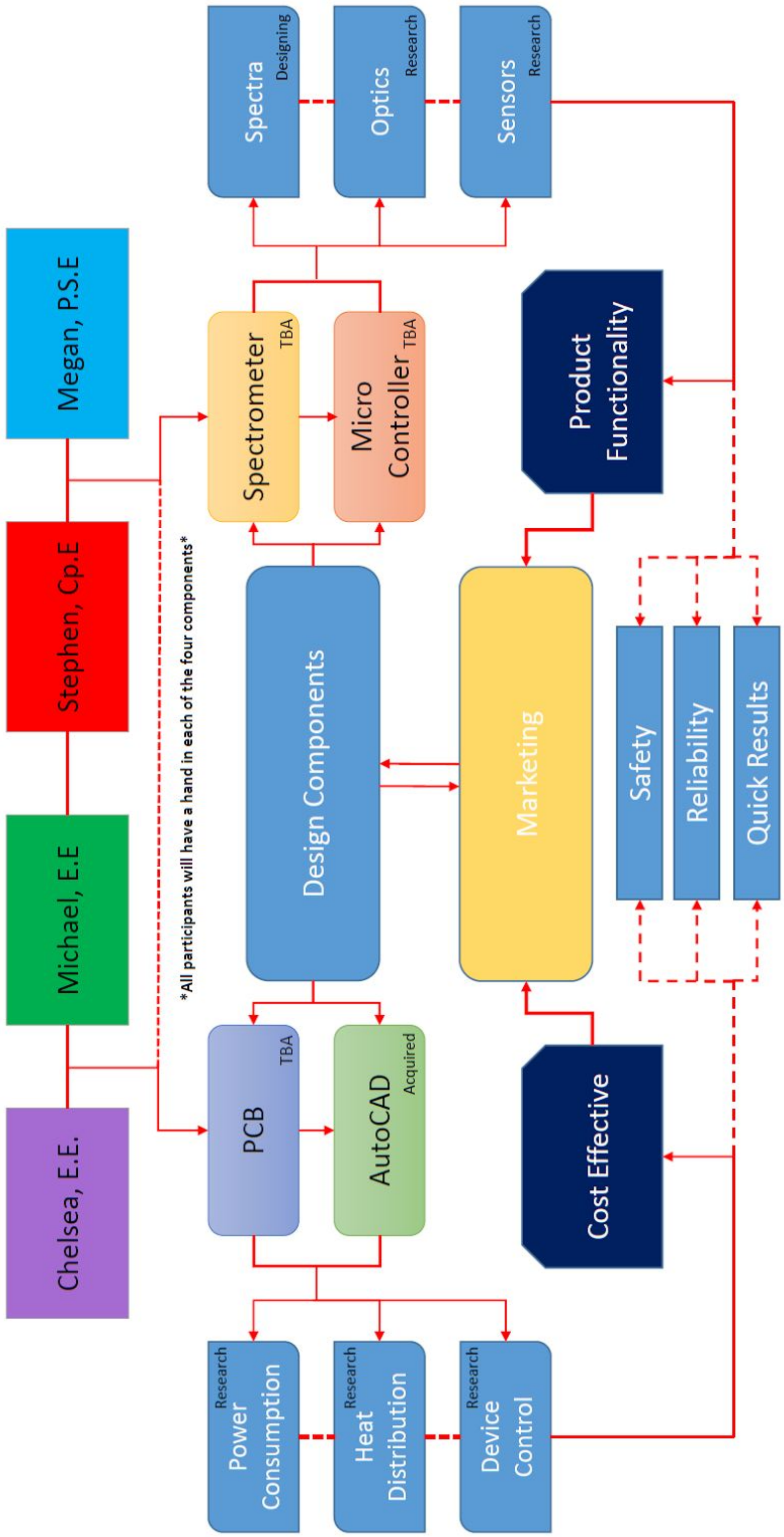
User Interface Design Considerations:
- Ability to run on a variety of market available devices
- Ease of use
- Informational without oversharing
- Appearance

House of Quality

	Accuracy	Safety	Data Transfer	Power Distribution	Material (Heat)
Reliability (+)		↓	↑	↑	
Result Time (-)	↑		↑		
Design (+)	↓			↓	↑
Cost (-)	↓	↓	↓	↓	↓

This project is intended to be cost effective, safe, reliable, and provide quick results.

Block Diagram



Block Diagram Legend:
TBA: To Be Acquired
PCB: Printed Circuit Board for electronic components
AutoCAD: Computer-aided design and drafting software for designing the spectrometer system
Spectrometer: Optical instrument to measure light intensity as a function of wavelength; the Raman spectrum obtained will provide the Raman shift of the skin being sampled.
Microcontroller: Will be used to receive the optical data from the sensors and transfer the data to the main computer to be graphed and analyzed.

Block Diagram Status:
As of now, the majority of components are being research, including the power consumption, heat distribution, device control, and the optics and sensors. The specifications of the spectra are being designed. The PCB, microcontroller, and parts for the spectrometer are to be acquired. The AutoCAD software is already acquired.

The Electrical Engineers are responsible for the PCB and AutoCAD. The Computer Engineer is responsible for the microcontroller. The Photonic Sciences Engineer is responsible for the spectrometer design. Each team member will participate in the design of all four components.

Estimated Project Budget and Financing

The initial estimate for this project is approximately $915.00. This value would cost less than the average price point of five biopsies. The breakdown of this budget is as follows:

Item Description	Estimated Cost ($)
Microcontroller	40.00
Computer	200.00
Detector (CCD or CMOS)	175.00
Wire and Encasing	30.00
3D Printing Filament	60.00
Lead Foil	20.00
Optics Parts	350.00
PCB	40.00

Total Estimated Cost	915.00

No sponsors are confirmed at this time. The team plans to contact companies that specialize in medical technology, optics supplies, microcontrollers, laser technology, and 3D printing services. Possible technology sponsors include OptiGrate, Ocean Optics, and Raytheon.

Note on Skin Sample Acquisition:
As part of our proof-of-concept testing phase of the project, we will also need to acquire known cancerous and noncancerous skin samples. A second sponsor, even in a non-financial sense, will need to be a dermatology/skin cancer research center. Possibile sponsors include the UCF Health Research facility at Lake Nona, or a large cancer research center such as the Moffitt Center in Tampa. Once a sponsor is confirmed, we can then provide a gauge as to how many samples are needed, their cost, and a solution to create a more time effective scan.

Initial Project Milestones

Milestone	Milestone Date
Divide and Conquer V.1	02/03/2017
Overall design finalized	Mid February 2017
Divide and Conquer V.2	02/17/2017
Parts and materials finalized	Mid March 2017
Table of contents	03/24/2017
Initial draft of documentation	03/31/2017
Sponsors contacted	March 2017
CAD design	Late March 2017
Optics system design	Late March 2017
PCB design	Late March 2017
User interface design	Late March 2017
Pseudocode for overall system	Late March 2017

Vendors Contacted	04/01/17
Parts ordered	April-May 2017
120 page final document	04/28/2017
Begin building	Late April/May 2017
Conference paper	June 2017
Midterm demo	Late June 2017
Final presentation and demo	Late July 2017