# Implantable Light Source Development

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## Abstract

Our client is currently using optogenetics to study the immune cell response to tuberculosis in mice. The client has developed a method of photoconverting the cells in the left lung of the mice, but it is not effective. The team brainstormed and decided on a design, which uses a steel mat of LEDs to photoconvert the cells. The device has been tested effective in vitro and future collaborations are needed to test our device in vivo.

## Optogenetics

- Photoactivated fluorescent proteins have been developed whose fluorescence properties change depending on light exposure [1]
- Used as an imaging tool: can view living cells at nanometer resolution [2]
- Can photo-tag the cells in lung granulomas: to see travel path of cells and which dendritic cells are not working correctly [2]
- Granuloma cells are photo converted to red by 470 nm light and can be easily distinguished from green systematic cells in mice lungs [3]

## Problem Statement

Dr. Sandor's previous method of photoconversion was inefficient, and only affected small areas. A new device needed to be designed to allow for photoconversion of larger areas for 20 minutes with appropriate wavelength and intensity. The design must fit in the mice and safely photoconvert cells.

## Photoconversion Efficiency

- Current method is not optimal:
  - Tissue penetration of the light is ~ 2 mm and the light cannot reach the inner slices of lung tissue
  - The area of light emission is < 1 $cm^2$
- Current patents inspired our design:
  - Current design from Dr. Sandor's lab [2]
  - Wireless power transfer to implantable devices [4]
- Development of the light source can support other research

## Design Specifications

- Must photoconvert an area of 1 $cm^2$ by using 470 nm light
- Must fit between the skin and ribcage of the mice
- The materials inserted to the mice need to be biocompatible and emit little to no heat
- The light source needs to be switched on and off automatically
- The light strength should be at least 95 $mW/cm^2$

## Final Design

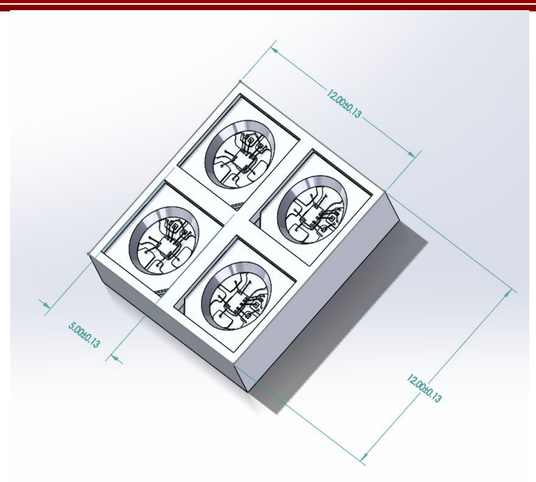


**Figure 1.** Top View of LED Mat
The LEDs will be enclosed in PDMS

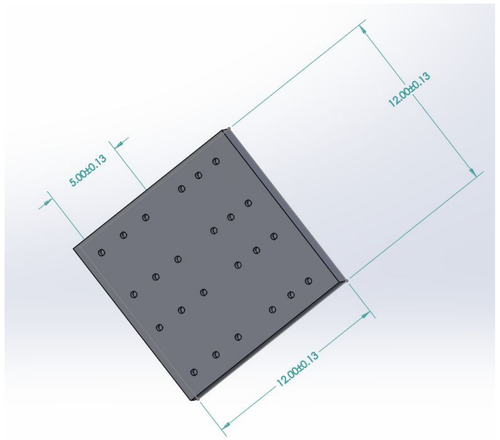


**Figure 2.** Bottom View of LED Mat
The LEDs sit on a steel plate which acts as a heat sink. The wires will pass through the cut holes and will be soldered onto the pins.

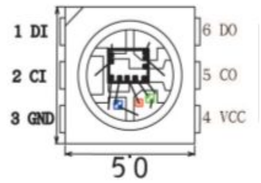


**Figure 3.** LED Pin Configuration [5]

## Material Costs

| Material | Quantity | Unit Cost | Cost |
|---|---|---|---|
| LED pack | 2 | $5.95 | $11.90 |
| Microcontroller | 2 | Student Shop | $0.00 |
| PDMS | - | McClean Lab | $0.00 |
| Circuit Board | 3 | $1.00 | $3.00 |
| Steel Plate | 1 | $11.99 | $11.99 |
| | | Total | $26.89 |

## Testing

- Device was tested using Ocean Optics Spectrometer (USB2000+)
- Tested the intensity and wavelength of light from the LEDs with and without PDMS
- Utilized Matlab to analyze and graph data acquired from OceanView software

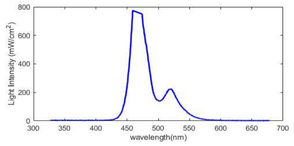


**Figure 4.** Wavelength and light intensity of a single LED

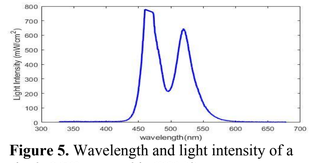


**Figure 5.** Wavelength and light intensity of a single LED covered in PDMS

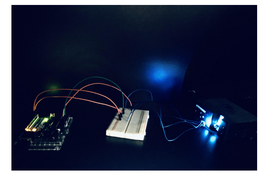

**Figure 6**. Testing setup in a dark environment

- At wavelength of 470 nm = max. intensity
- The light is oversaturated at 470 nm
- PDMS as a viable solution despite a shift in wavelength

## Discussion

Accomplishments:
- Fabricated a working prototype that leaves space for future improvement
- Found effective biocompatible material after testing

Constraints:
- Fabrication techniques
- Oversaturation of light detected by USB 2000+
- Biological features of the mice

Future Work:
- Enable remote wireless control to eliminate the use of wires
- Enclose the structure with PDMS on the steel plate
- Adjust the shape of the LED mat based on the biological features of the mice

## Acknowledgements

- Dr. Matyas Sandor and his lab members
- Dr. Melissa Skala and Steve Trier
- The McClean Lab

## References

[1] E. Iseri and D. Kuzum, "Implantable optoelectronic probes for in vivo optogenetics," Journal of Neural Engineering, vol. 14, no. 3, p. 031001, 2017.
[2] M. Sandor. Lab Information Lecture, Topic: "Photoconversion of KikGR33 Mice." SMI 516, University of Wisconsin-Madison, Sept. 21, 2018.
[3] Marcus, S., Herbath, M., Fabry, Z. and Sandor, M. (2018). *Dynamic changes in Mycobacterium tuberculosis-induced granulomas: developing new tools*. [online] The Journal of Immunology. Available at: http://www.jimmunol.org/content/200/1_Supplement/117.19 [Accessed 6 Dec. 2018].
[4] A. S. Y. Poon, J. S. Y. Ho, Y. Tanabe, A. J. Yeh, K. L. Montgomery, L. Grosenick, E. A. Ferenczi, V. Tsao, S. M. Iyer, S. L. Delp, K. Deisseroth. "Autofocus wireless power transfer to implantable devices in freely moving animals." U.S. Patent 20170065828A1, mar. 25, 2017.
[5] DotStar Addressable 5050 RGB LED w/ Integrated Driver Datasheet retrieved from https://www.adafruit.com/product.