10/28

Met with mentor again after getting forms back.

-Another project on light interaction?
-Fabricate perovskite?
        -No access to Yale this year for high school students
-Must be virtual, simulation again?
-Thermal cameras?
        -Decided this is best
        -Thermal cameras use infrared, potentially transmitting light better?
        -Want to detect humans better in 7-14 um range
        -Need to download Lumerical and get a license
        -Read paper that he sent and make Matlab script to extract permittivities of MoO3
        -Page 6, read the table, then compare to table in page 8

11/1
Met with mentor again about clarifications. Notes:

PROBLEMS FROM LAST SIMULATION:
log gives detailed steps
script file editor --> need to load scripts (the .lsf) drag and drop
-load file
-parameters include numbers to define (arrays gama = graphene permittivity)
-dont change cell to collect transmissions

permittivity = refractive index

understand the paper he sent with the figures and such. replace the images with our material

use this material with the peaks to design materials as optical horristors to enahnce absorption of human radiation
-want responses that match with black body radiation curve of human body

with graphing you get weak transmission, (high absorption). thin materials can absorb much light
        -electron hole pairs in thick materials cannot get out (so the external circuit wont see)
        -using graphene, or moo3, you can absorb with these thins materials, the electron hole pairs dont need to diffuse over long distances to be detected by external camera
        -MoO3 is very new, material can be greatly optimized
        -Moo3 is anistoscopic, a tensor (challenging read lumerical support) epsilon xyz rely on different parameters such as the chart in the paper

-once we have simulation. we can draw different structures (periodic discs, hole arrays [periodic holes, opssite of a disc array])

-z is missing in paper because material is not detected, rely on Ab initio calculation
-ignore images in paper since standing wave patterns show from electric field intensity from light illumination

-in final presentation draw crystal structures of these models to justify why I am using these

-take a look and understand their script language
        -define geometries and run (fine tune parameters is nightmare)
-make anisotropic material, first thing to try is to make the material an opsicripoc (x y and z to be the same) --> good example is gold or silver or any noble metals to use as benchmark material

larenz oscillators (just put in numbers from table into lumerical)
one thing to easily try is a note called materials to create your own materials (ANTHONY PLEASE TRY)

11/18

From the article I got, I started to write a Matlab script. Data seems to diverge, however. It is not accurate to the paper.

```
%doesnt work?
ey1 = ((wloy1.^2)-(wavelength.^2)-(1i.*yy1.*wavelength));
ey2 = ((wtoy1.^2)-(wavelength.^2)-(1i.*yy1.*wavelength));
ey3 = 6.07.*(ey1./ey2);
ey = real(ey3);

%works!
ez1 = (wloz1.^2)-(wavelength.^2)-(1i.*yz1.*wavelength);
ez2 = (wtoz1.^2)-(wavelength.^2)-(1i.*yz1.*wavelength);
ez3 = 4.47.*(ez1./ez2);
ez = real(ez3);

%doesnt work?
ex1 = (((wlox1.^2)-(wavelength.^2)-(1i.*yx1.*wavelength))./((wtox1.^2)-(wavelength.^2)-(1i.*yx1.*wavelength)));
ex2 = (((wlox2.^2)-(wavelength.^2)-(1i.*yx2.*wavelength))./((wtox2.^2)-(wavelength.^2)-(1i.*yx2.*wavelength)));
ex3 = (((wlox3.^2)-(wavelength.^2)-(1i.*yx3.*wavelength))./((wtox3.^2)-(wavelength.^2)-(1i.*yx3.*wavelength)));
ex4 = 5.78.*(ex1.*ex2.*ex3);
ex = real(ex4);
```

11/20

Met with mentor. Said the reason why my matlab script was not working was because of missing parentheses in the equations. Luckily things were fixed. Here it is now:

Permittivity of MoO3 in the x,y,z directions
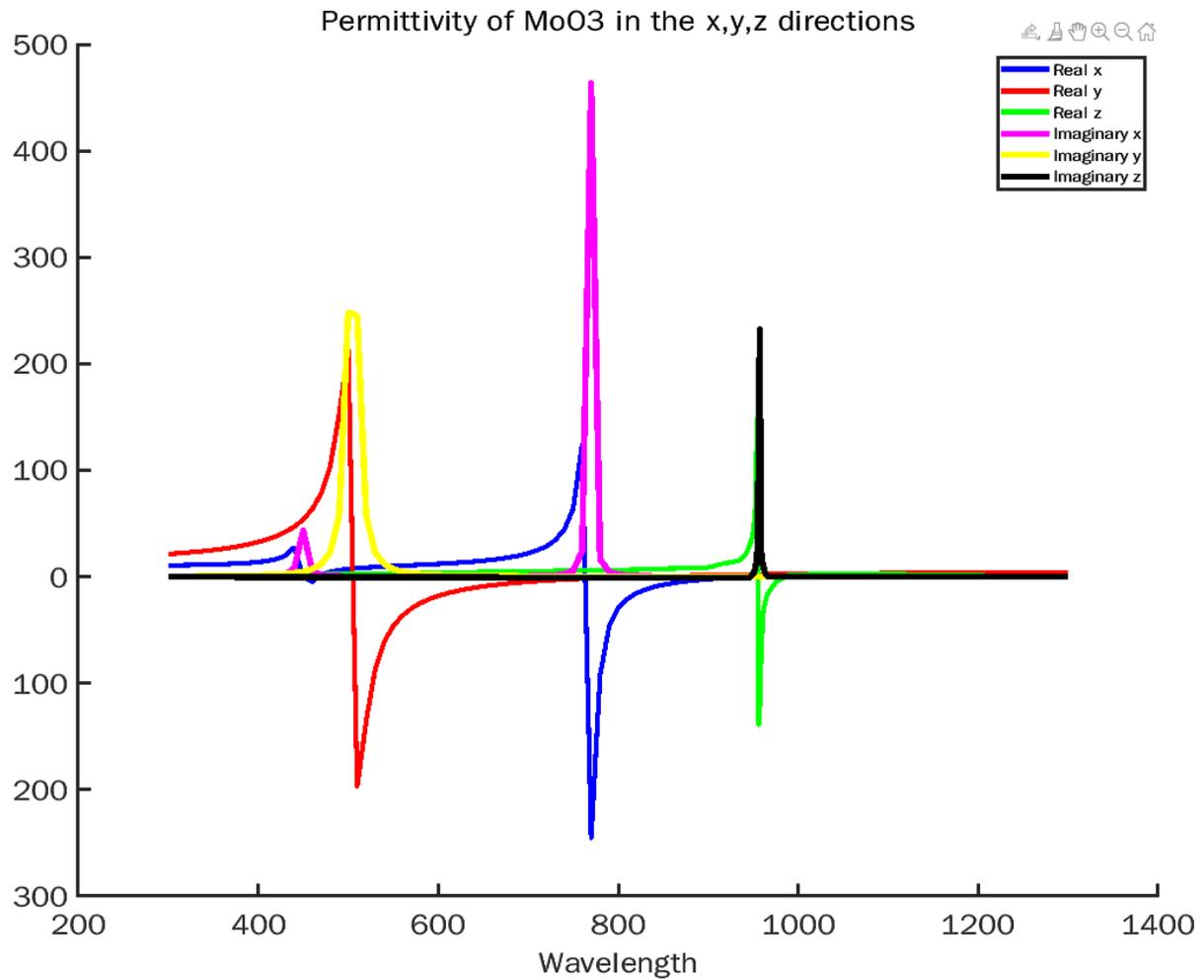
11/21
Got to start a 30 day free trial. Decided to read upon all of the controls and recreate model from tutorials.
https://support.lumerical.com/hc/en-us/articles/360045465193-My-First-Simulation-Setting-up-the-Simulation

Model seems to work, but I don't understand/know why it does not work:

-Transmission/Reflectance monitors
-How does FDTD even work?

-Transmission/Reflectance monitors measure the electrical properties in all three directions of light when it hits its mesh. 1-T-R spits out absorption, so use that in the script
-FDTD is just solver of maxwells' equations which gather lights propagation in materials or space. And how it is being absorbed by materials. Discritzes simulation box and time to solve tons of differential equations. Much more efficient to spend time and money before fabrication.

Next steps:
-Add MoO3 as 3D Sampled material, as per the data from the Matlab script
-Start getting data and mess around with the stuff to understand more

1/5:
Starting getting data:
Summary, lower the thickness of MoO3, then get more absorption. Best thickness is 0.035

0.035 WINNER

Absorption of MoO3

0.1

Absorption of MoO3

0.06
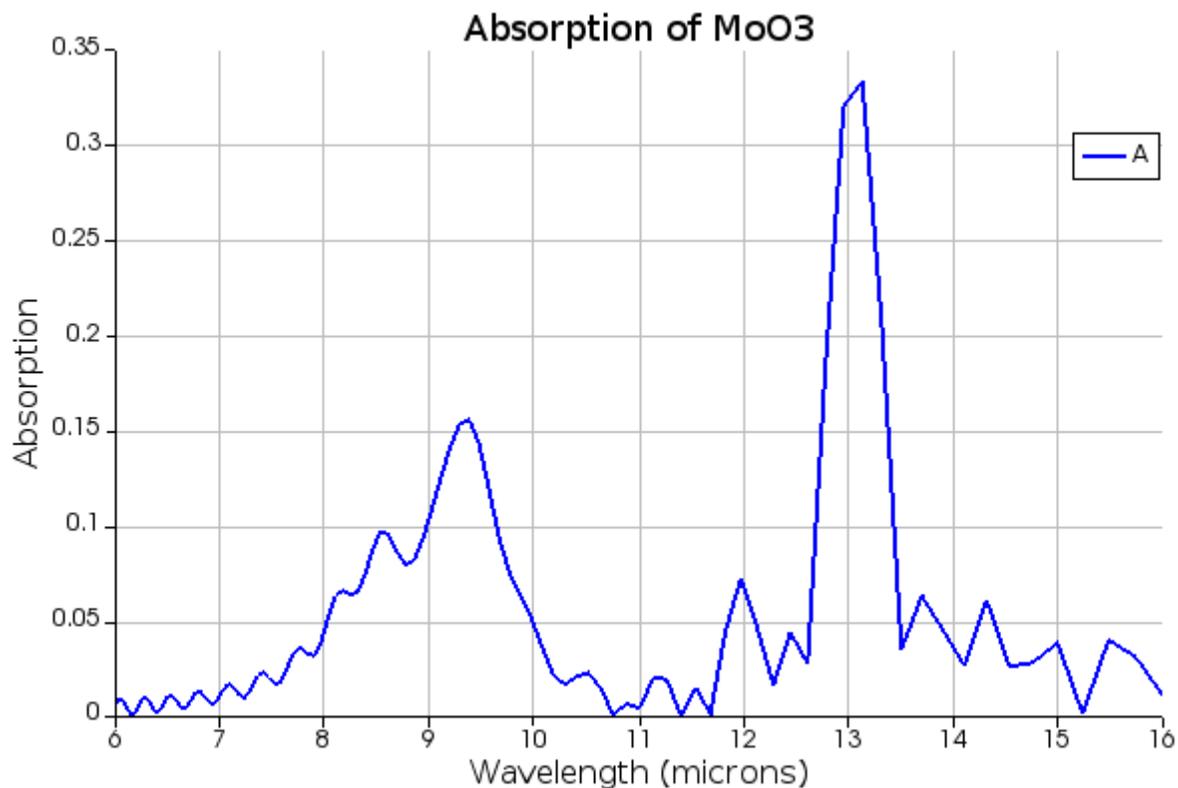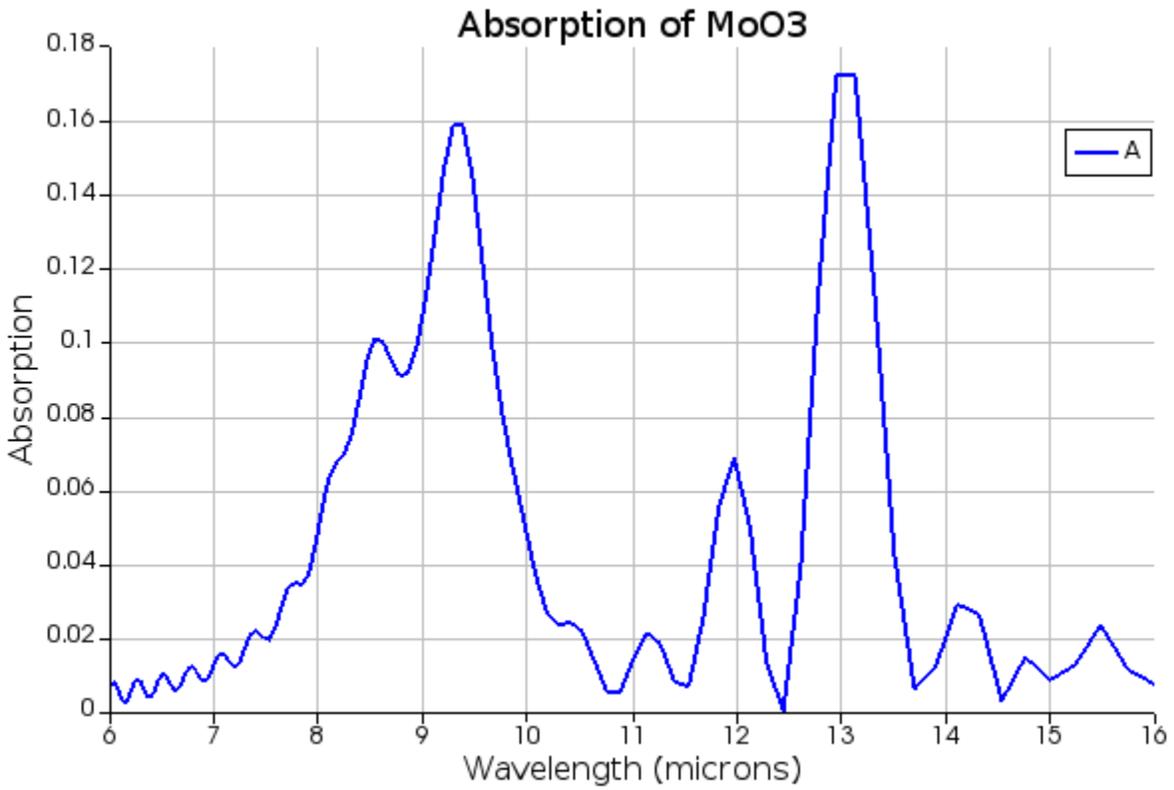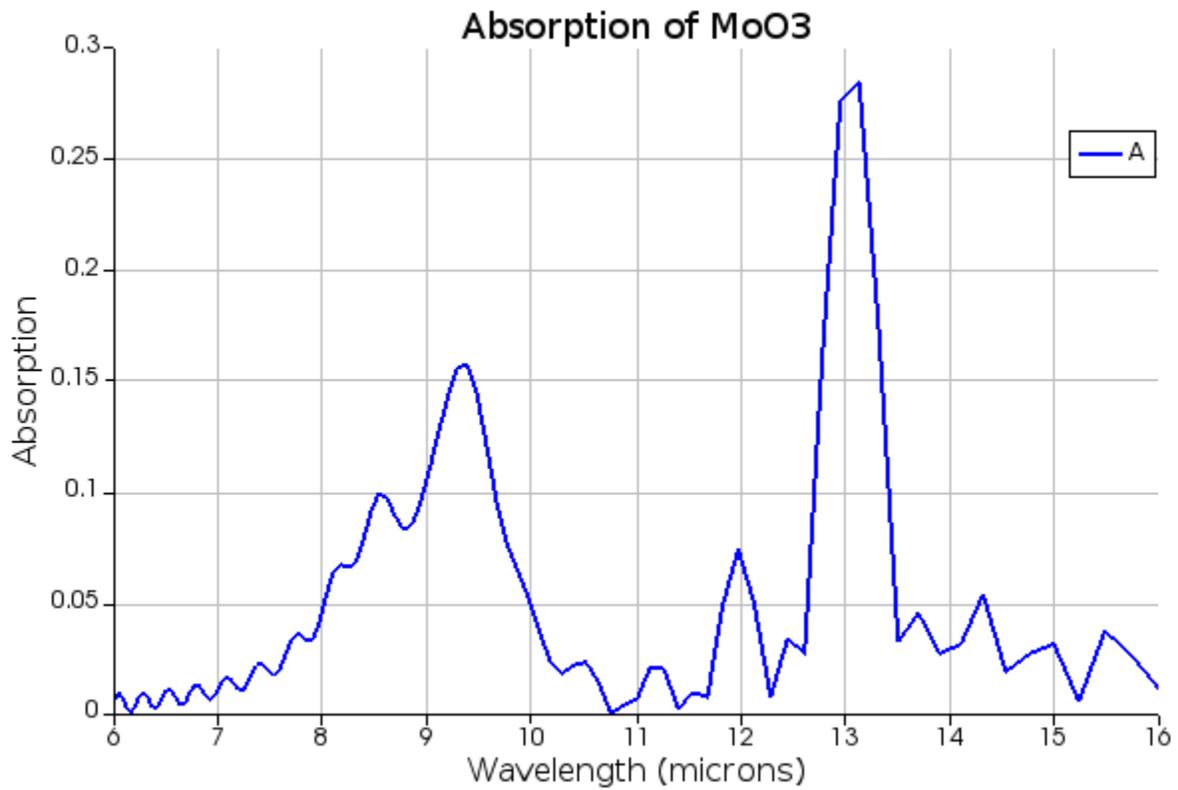
Absorption of MoO3

<u>Hole in MoO3 with varying radii</u>
Summary of results: A hole with radius 0.5 micron did best

0.1
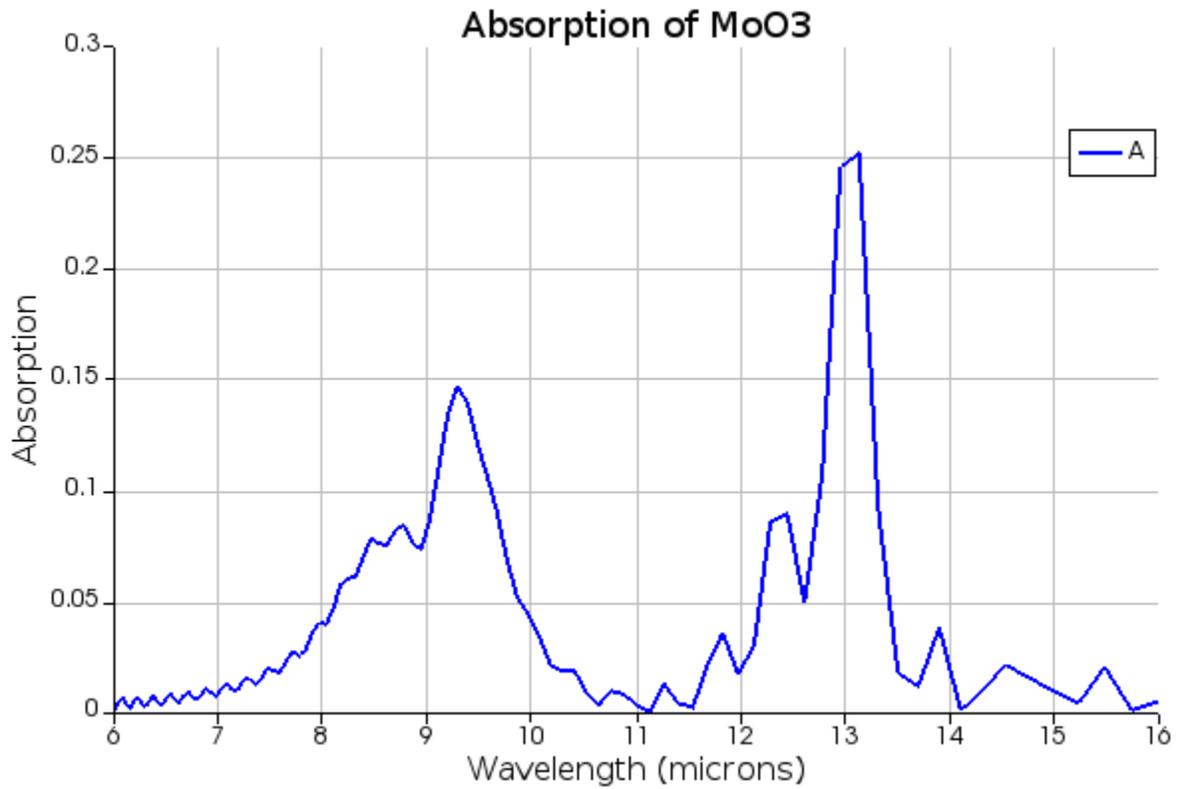
0.5
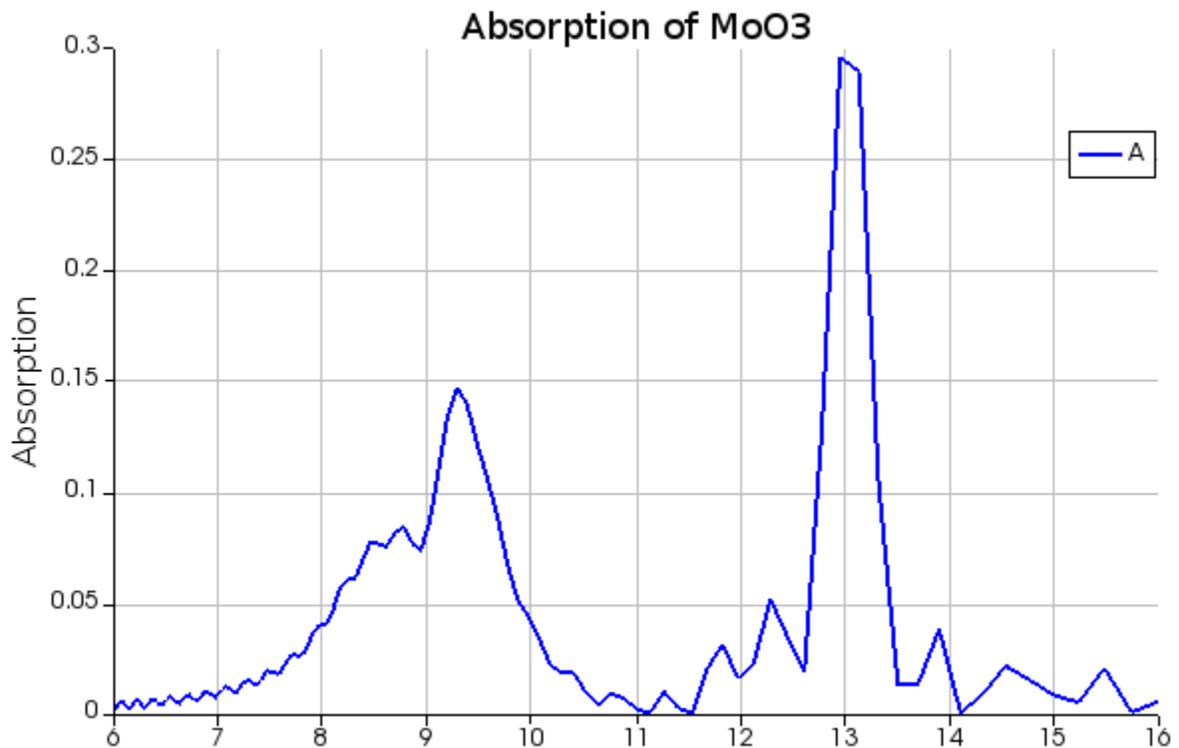
0.7

Absorption of MoO3
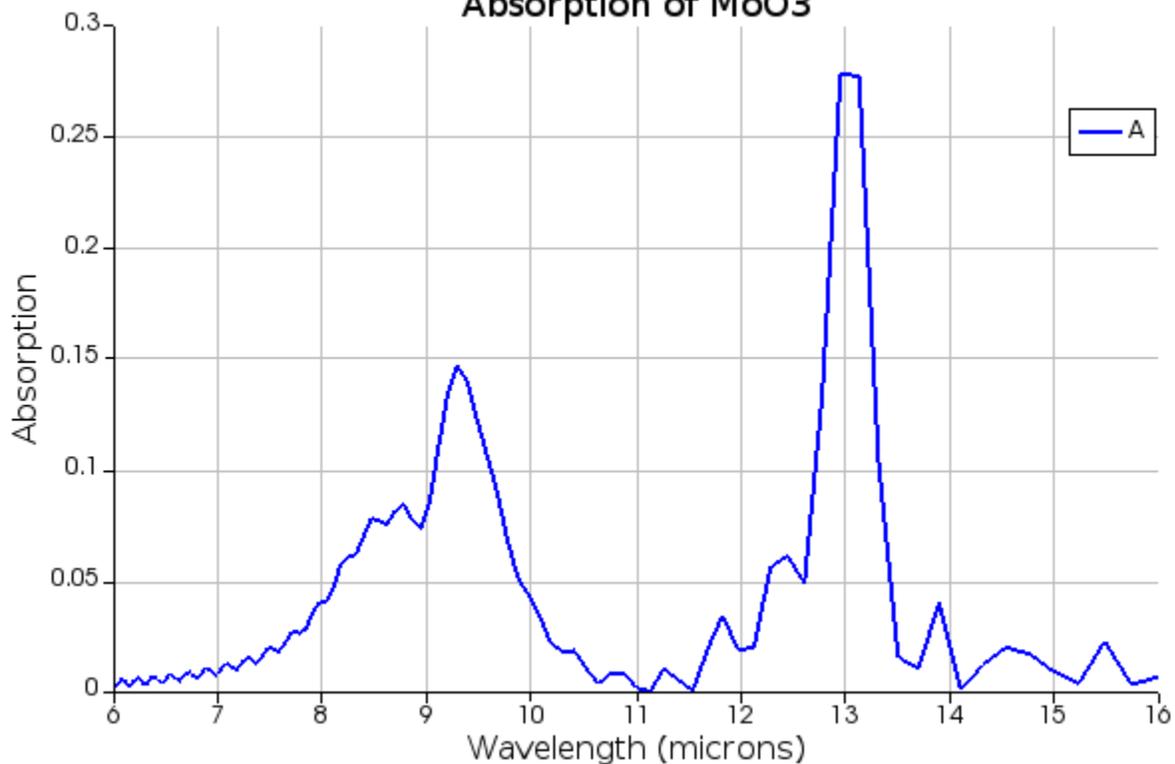
0.9

Absorption of MoO3
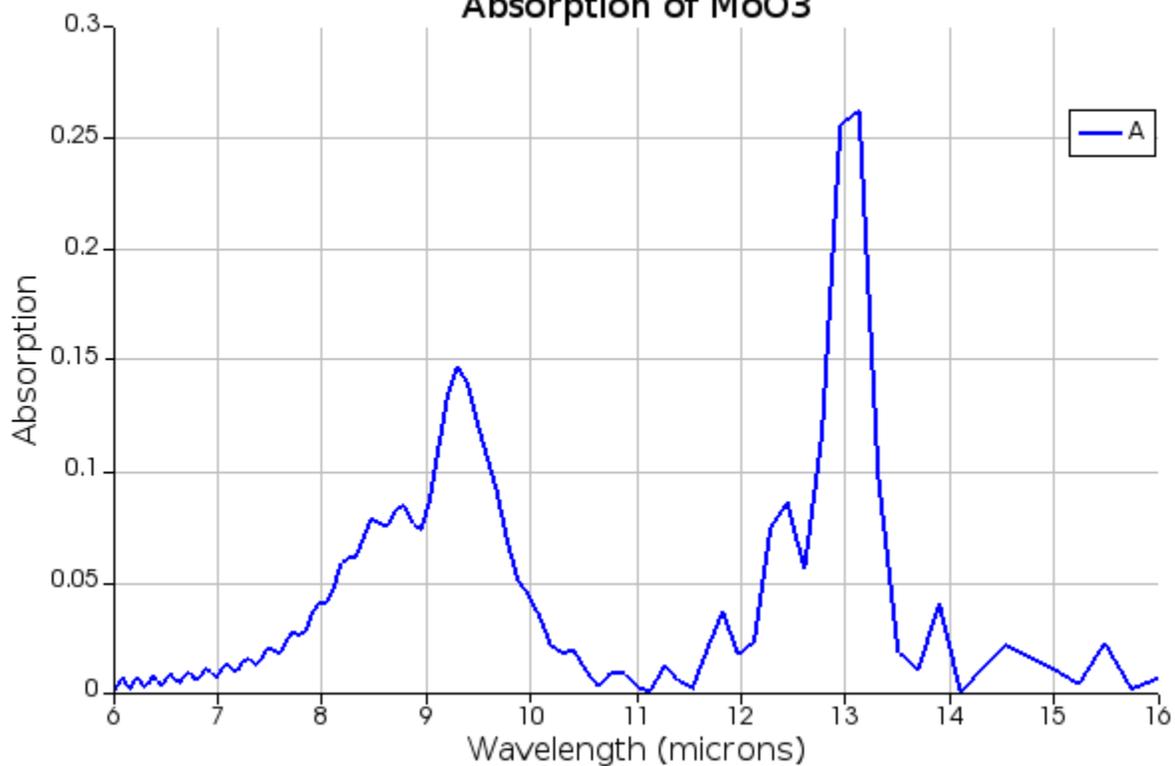
Summary of data: Periodic boundaries decrease absorption. On top decreased absorption. Embedded worked the best. Radius of 0.1 microns worked best for gold.
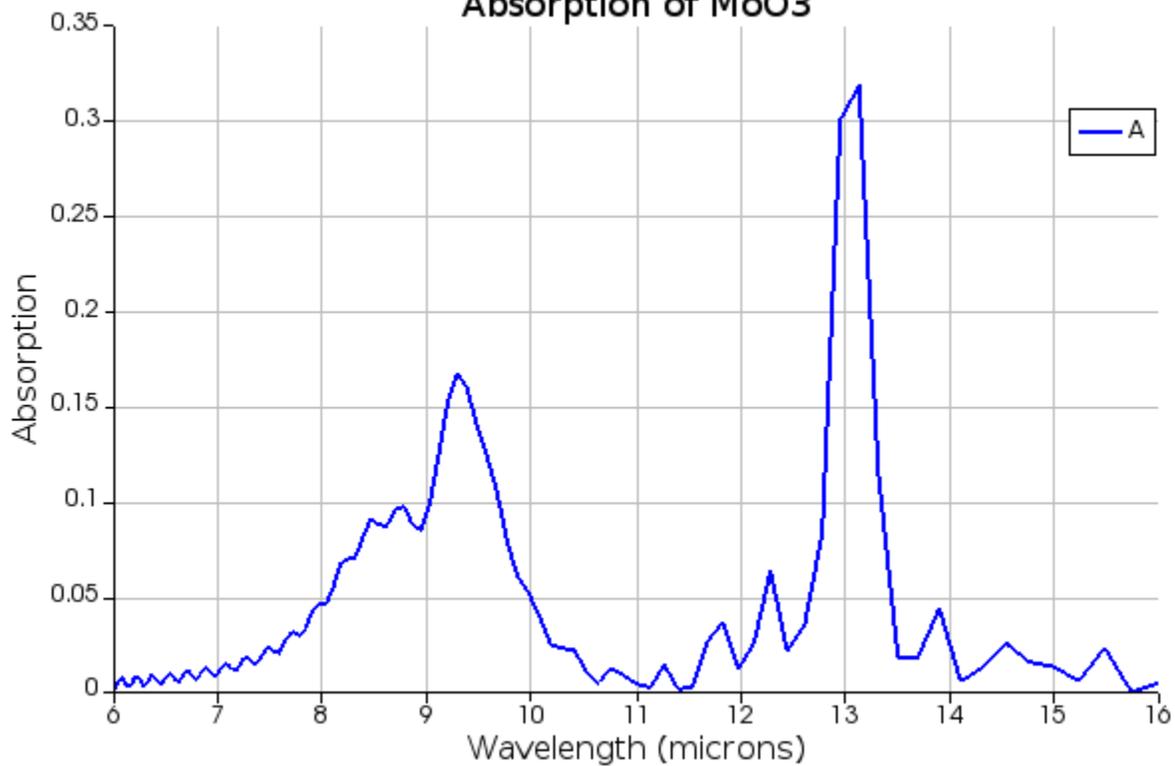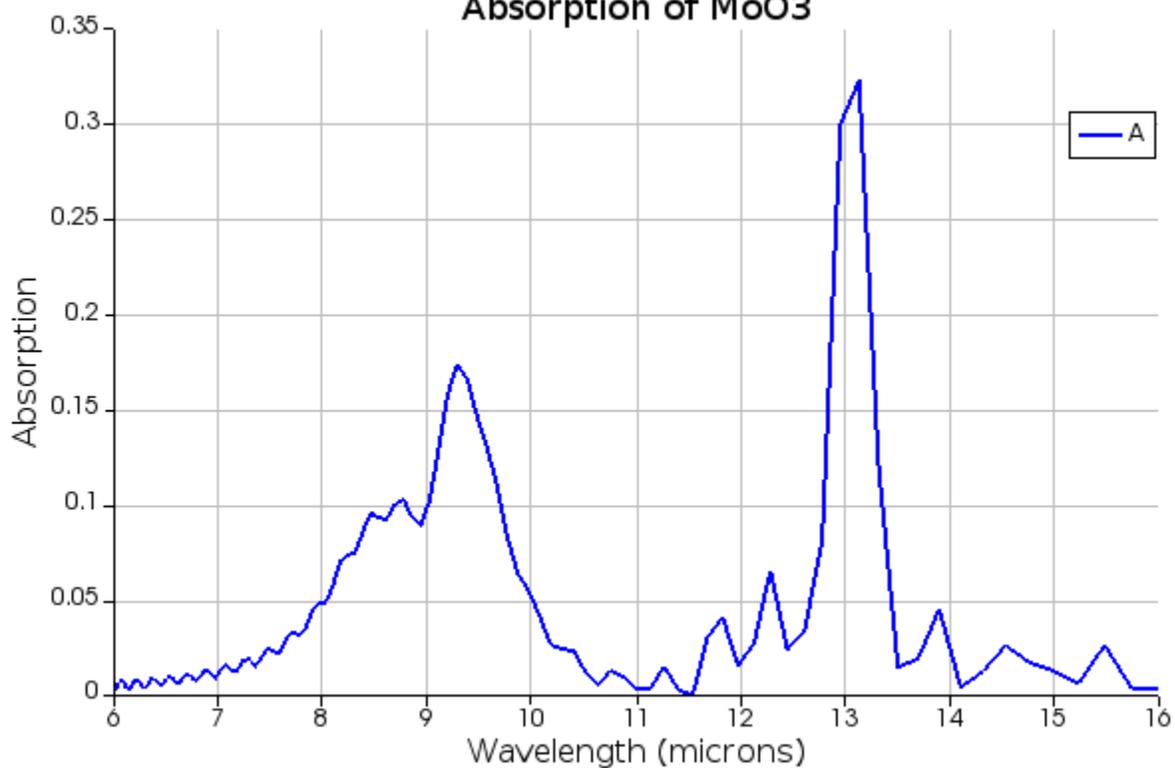
0.01 embedded, not periodic
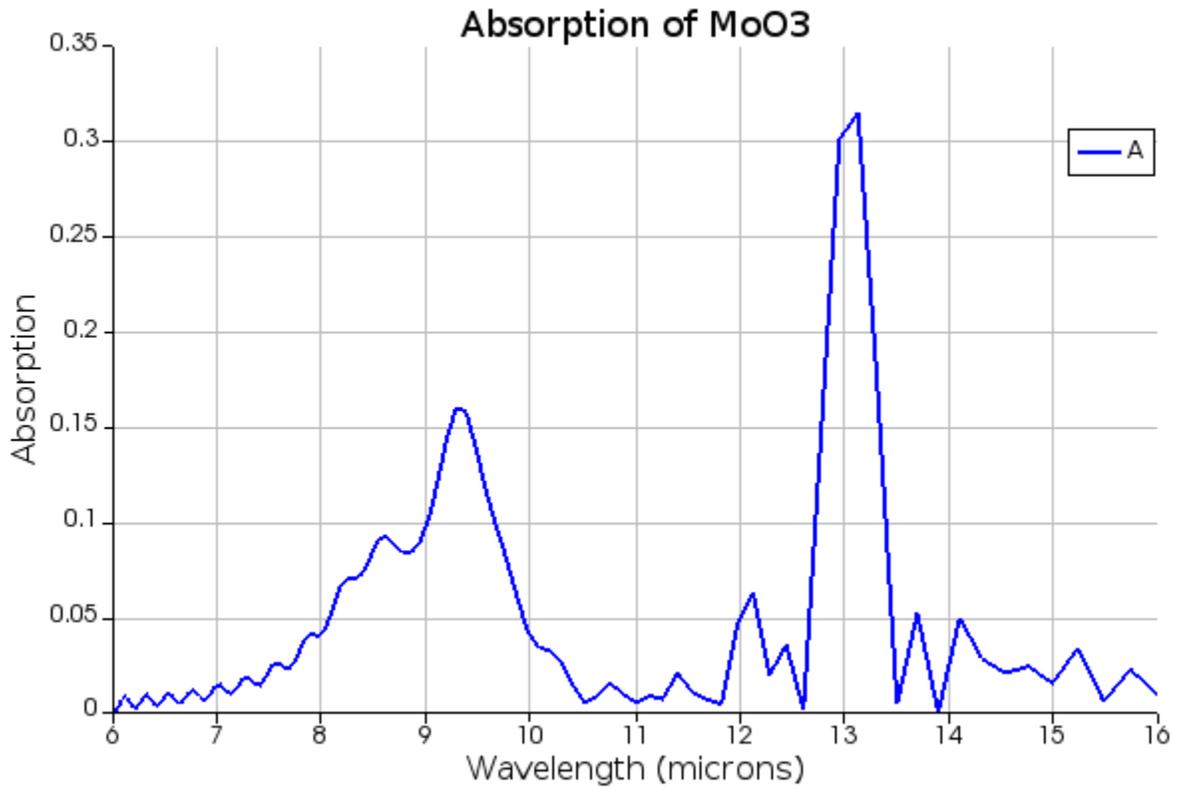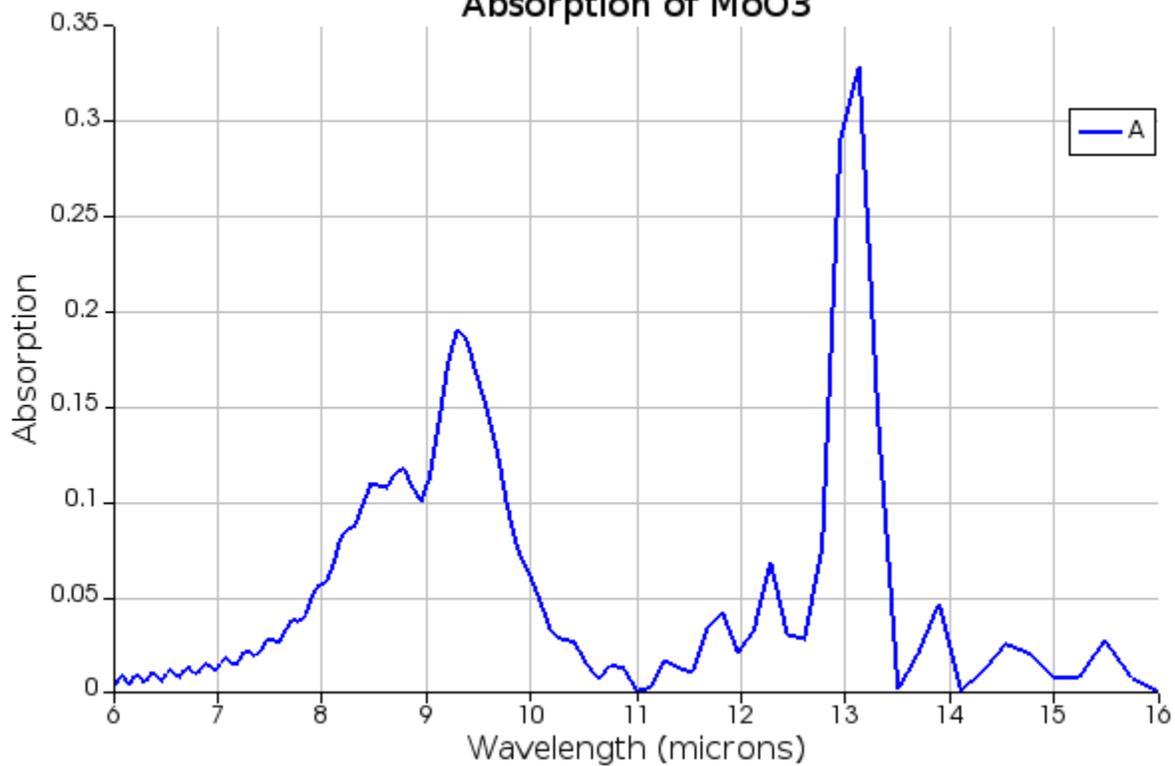

0.03 embedded, not periodic
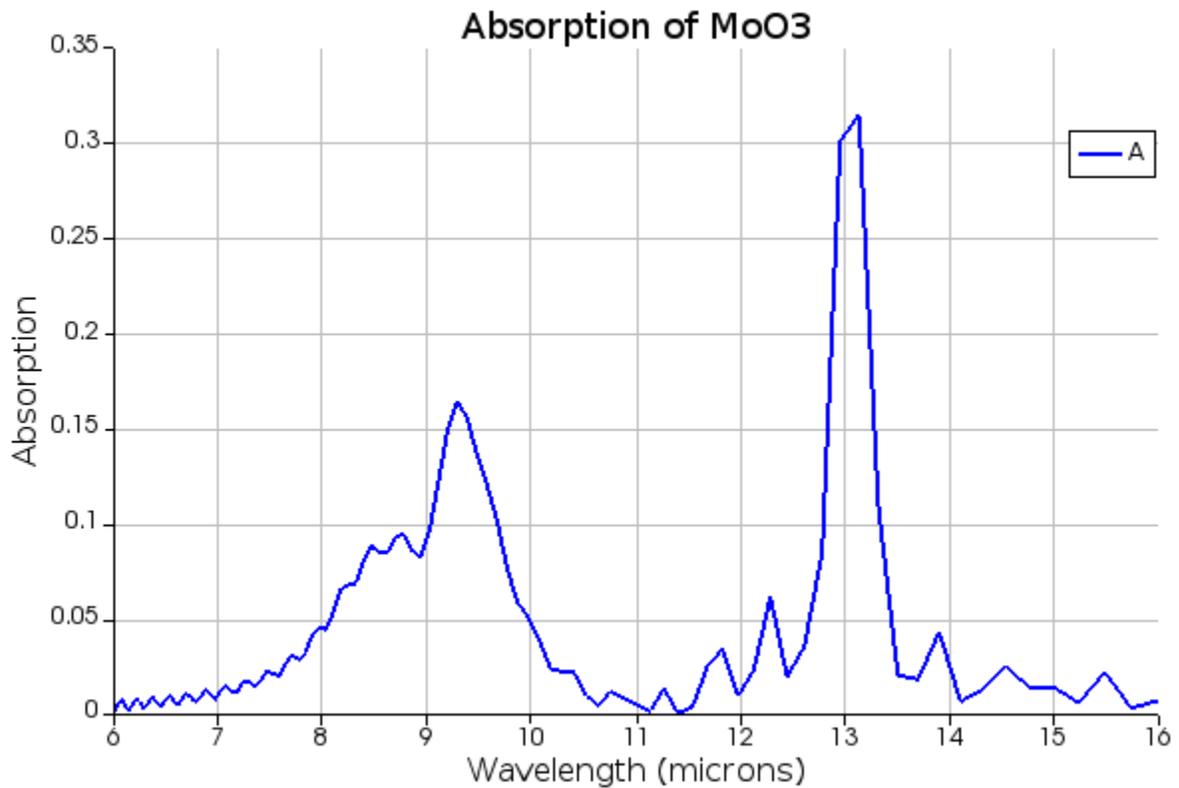
0.05, not periodic

Absorption of MoO3

0.07, not periodic

Absorption of MoO3

0.1, not periodic

Absorption of MoO3

0.01, periodic

Absorption of MoO3
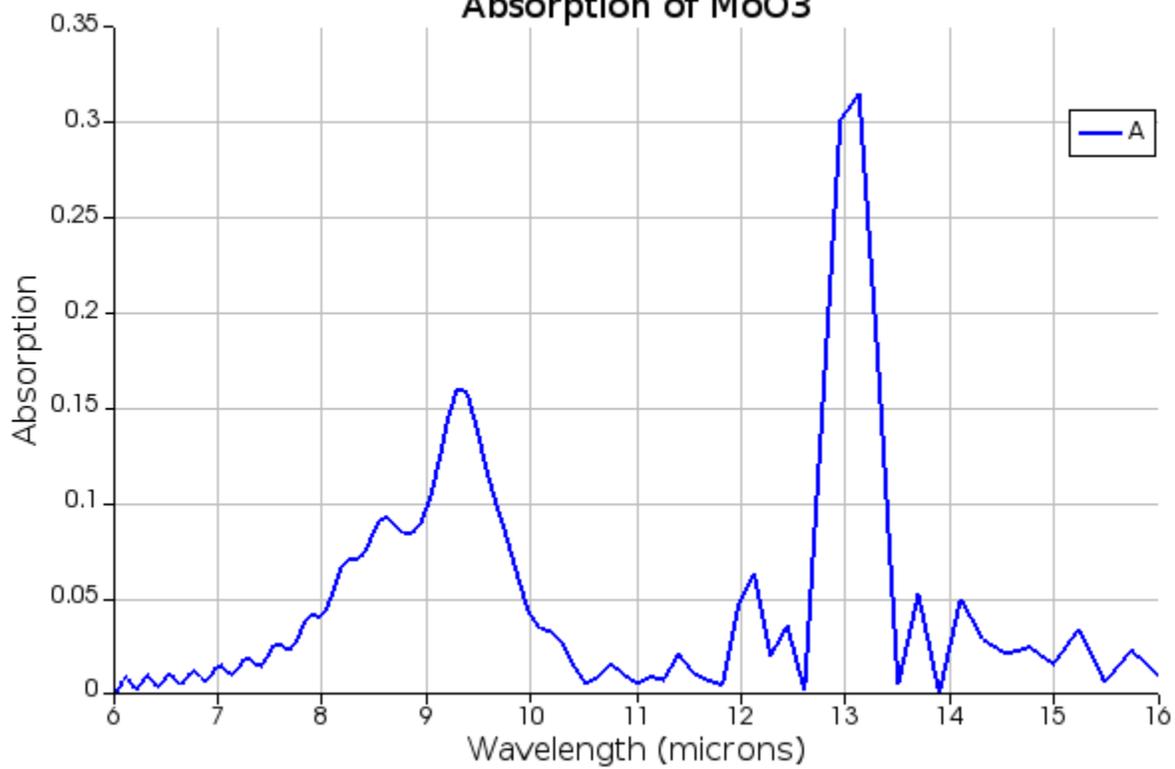
0.03, periodic

Absorption of MoO3
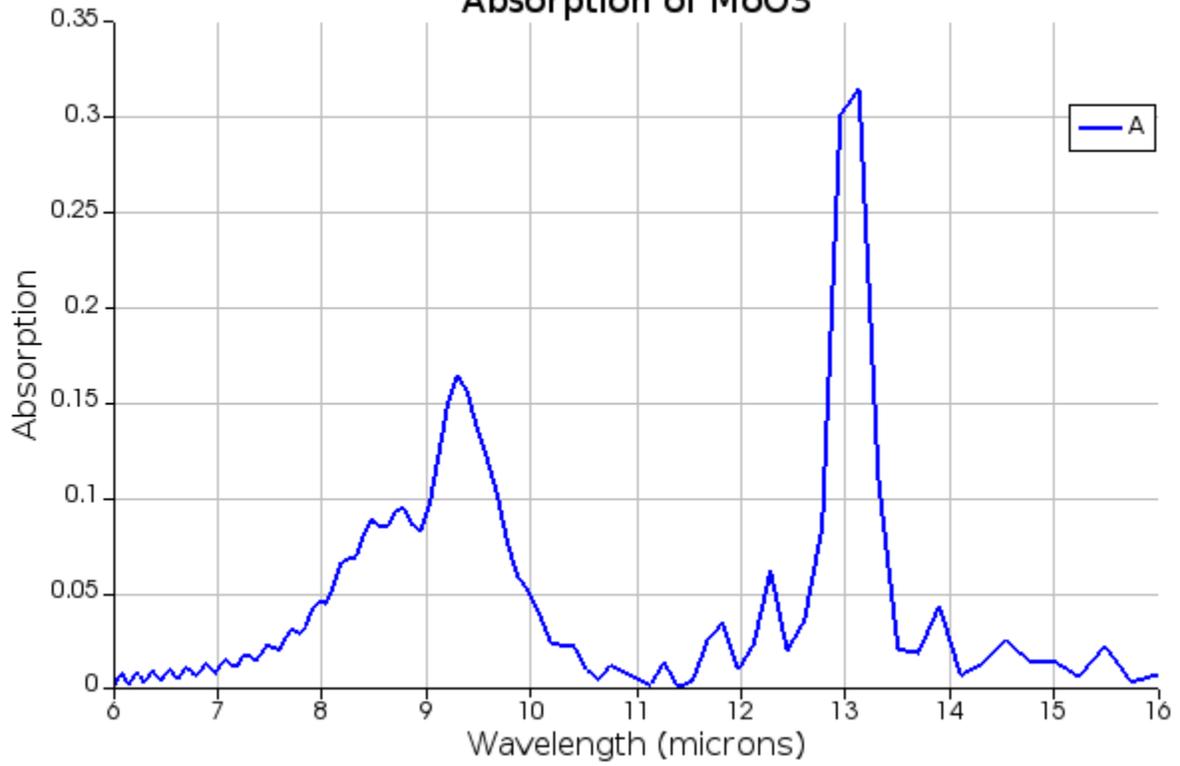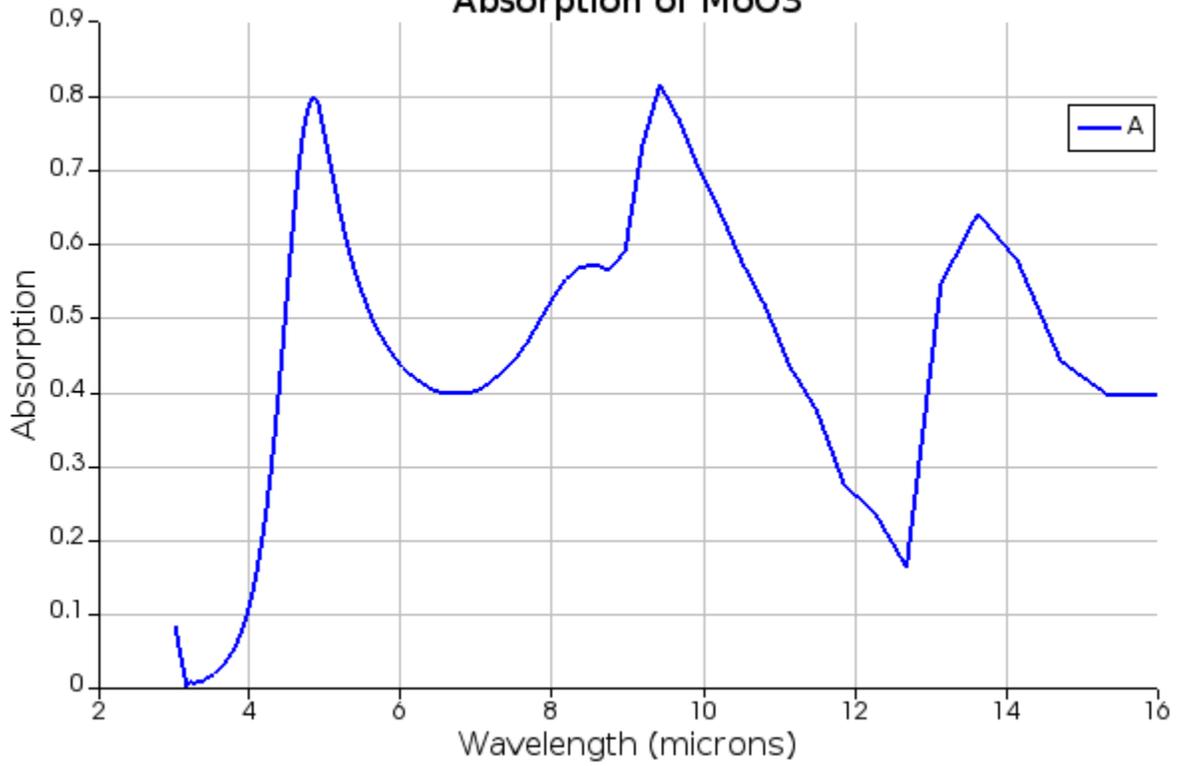

0.05 periodic

Absorption of MoO3
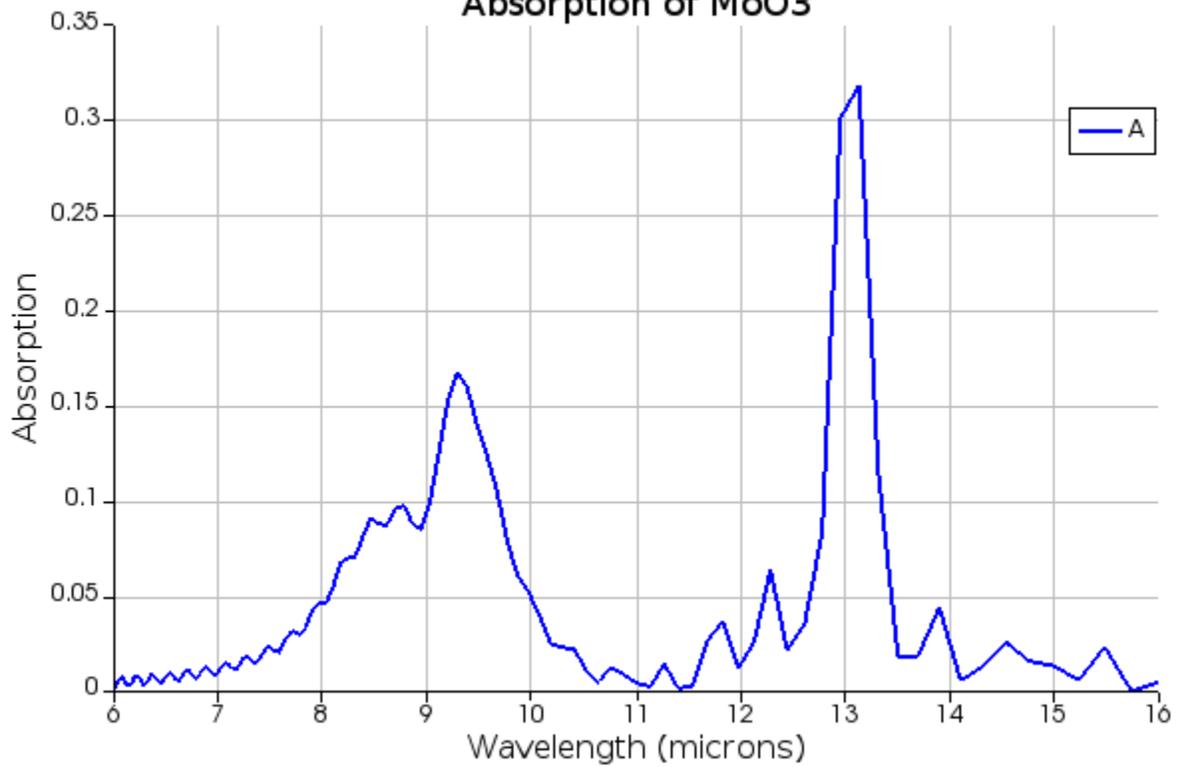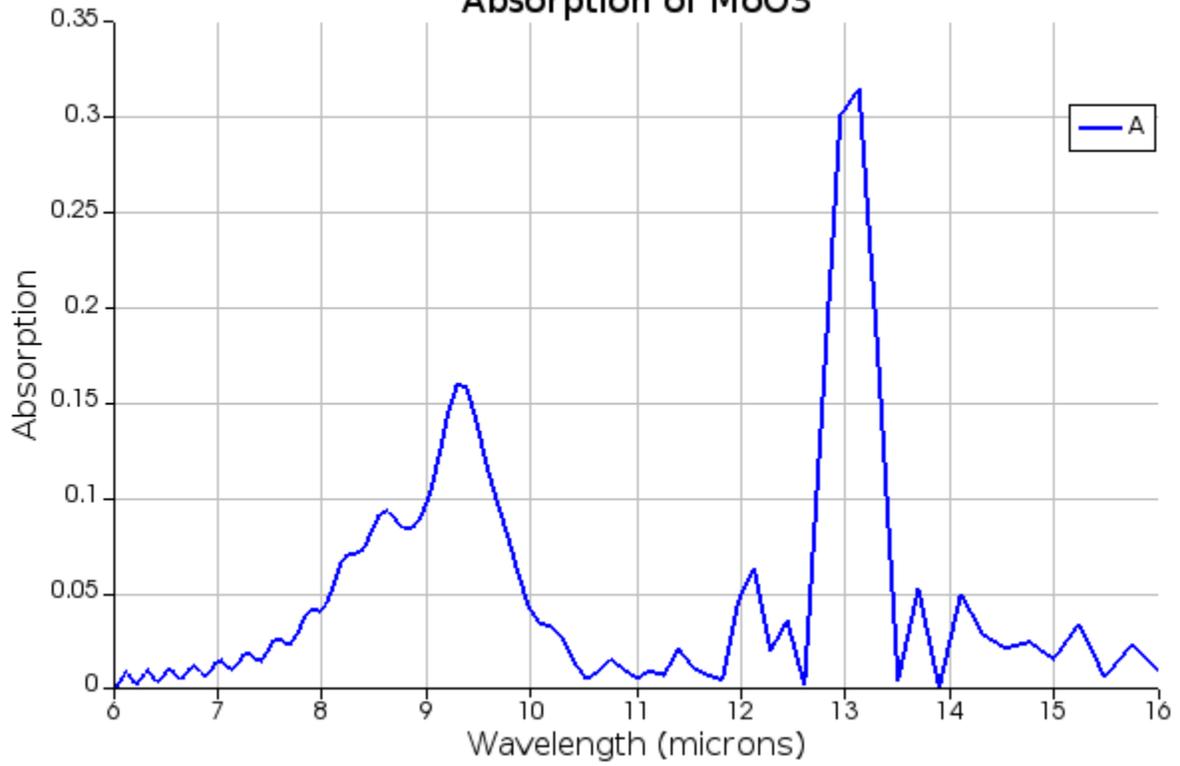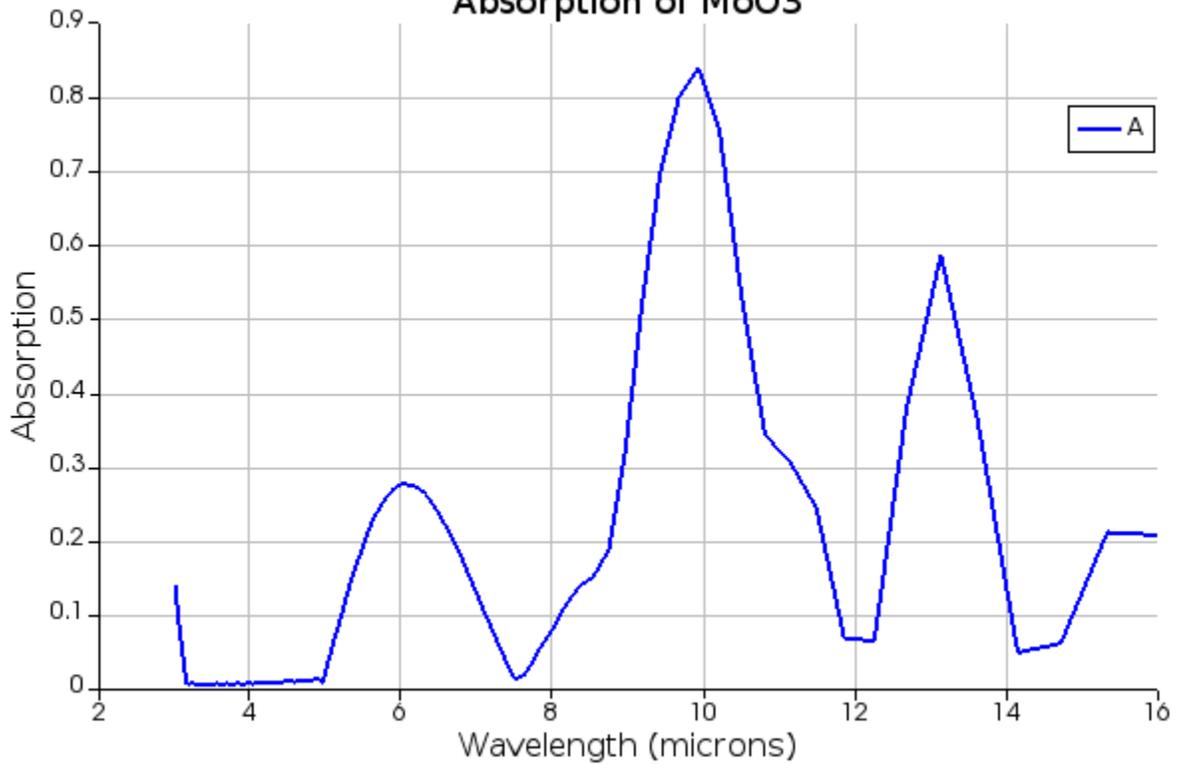
Absorption of MoO3
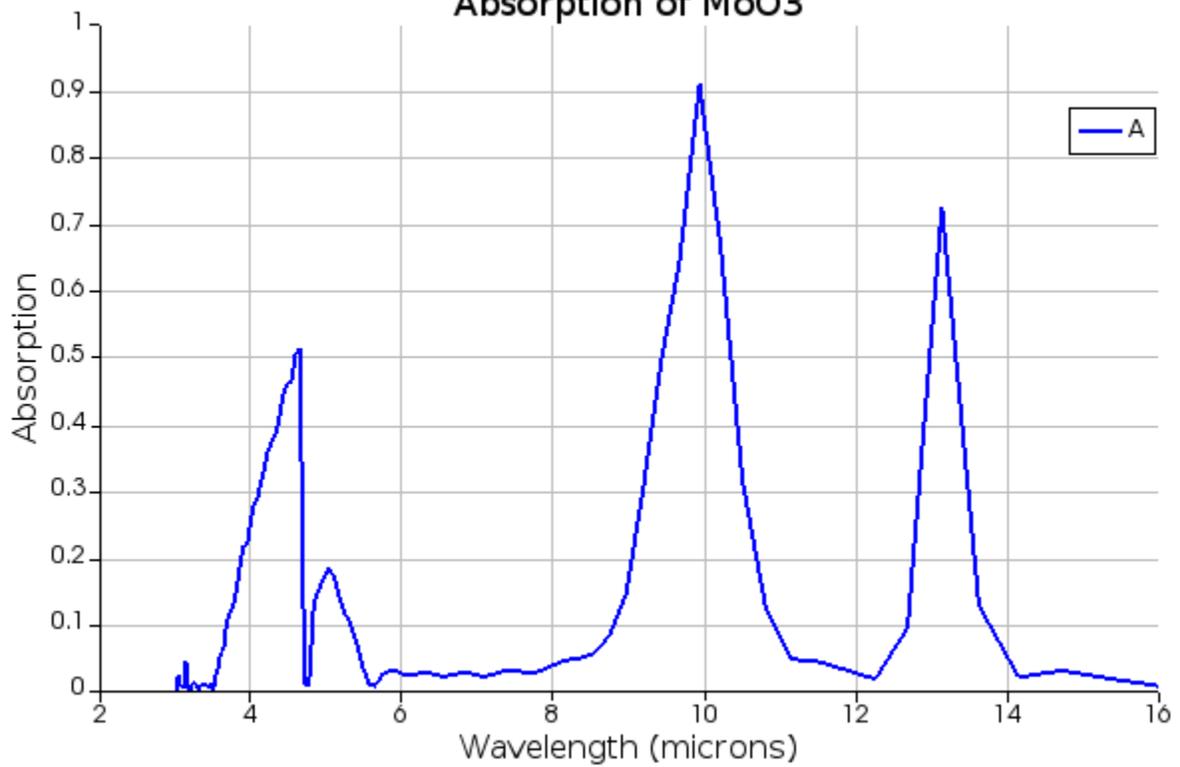
Absorption of MoO3

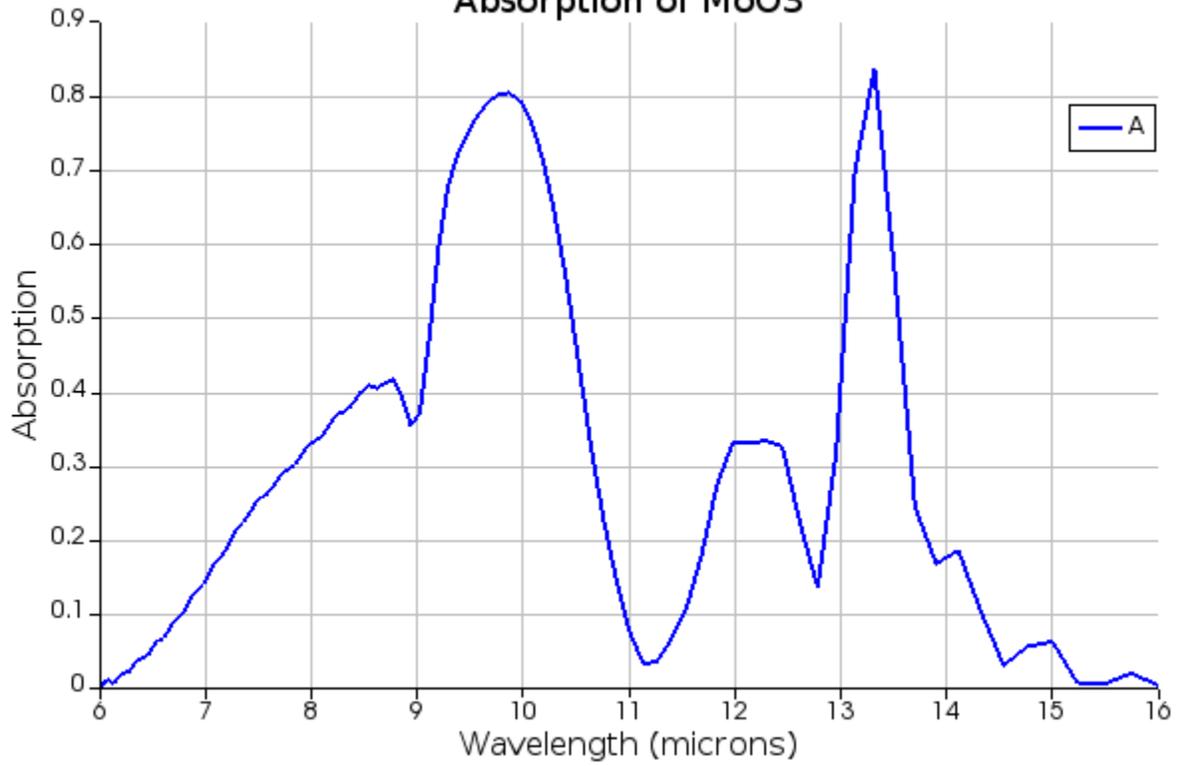Hexagonal gold on ring, with hole inside

Absorption of MoO3
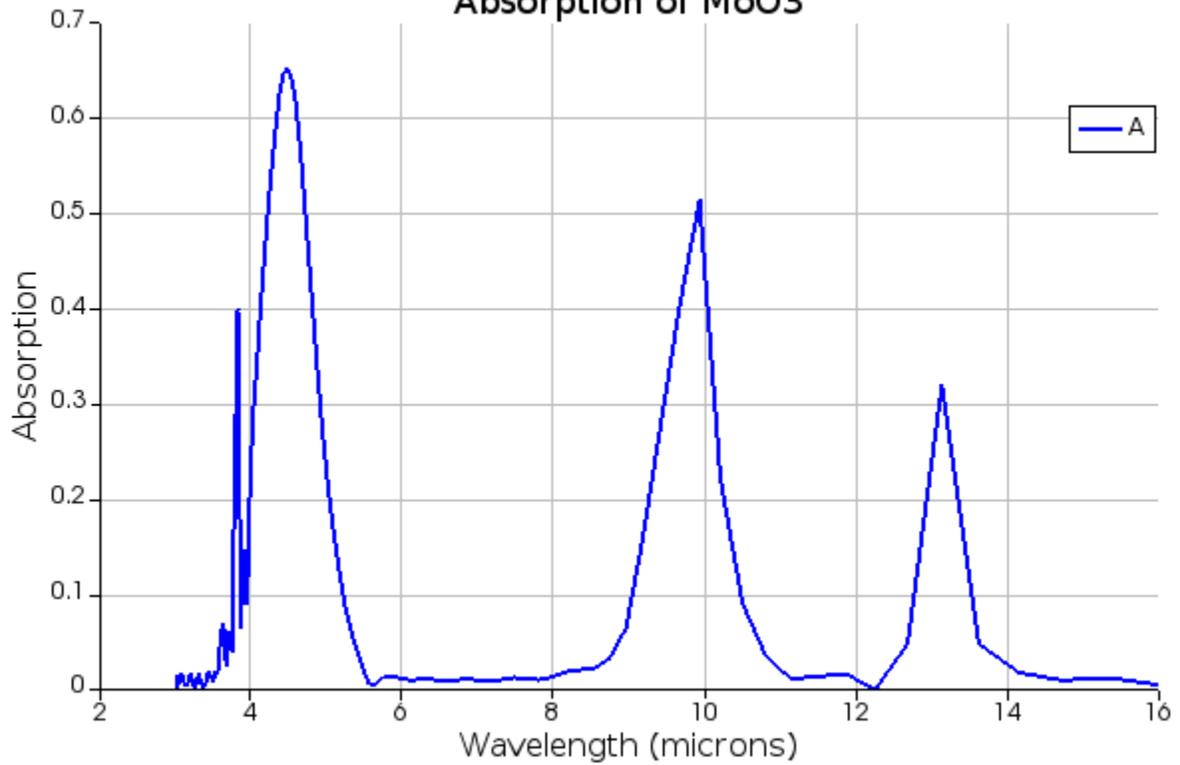

No gold, only thick silicon

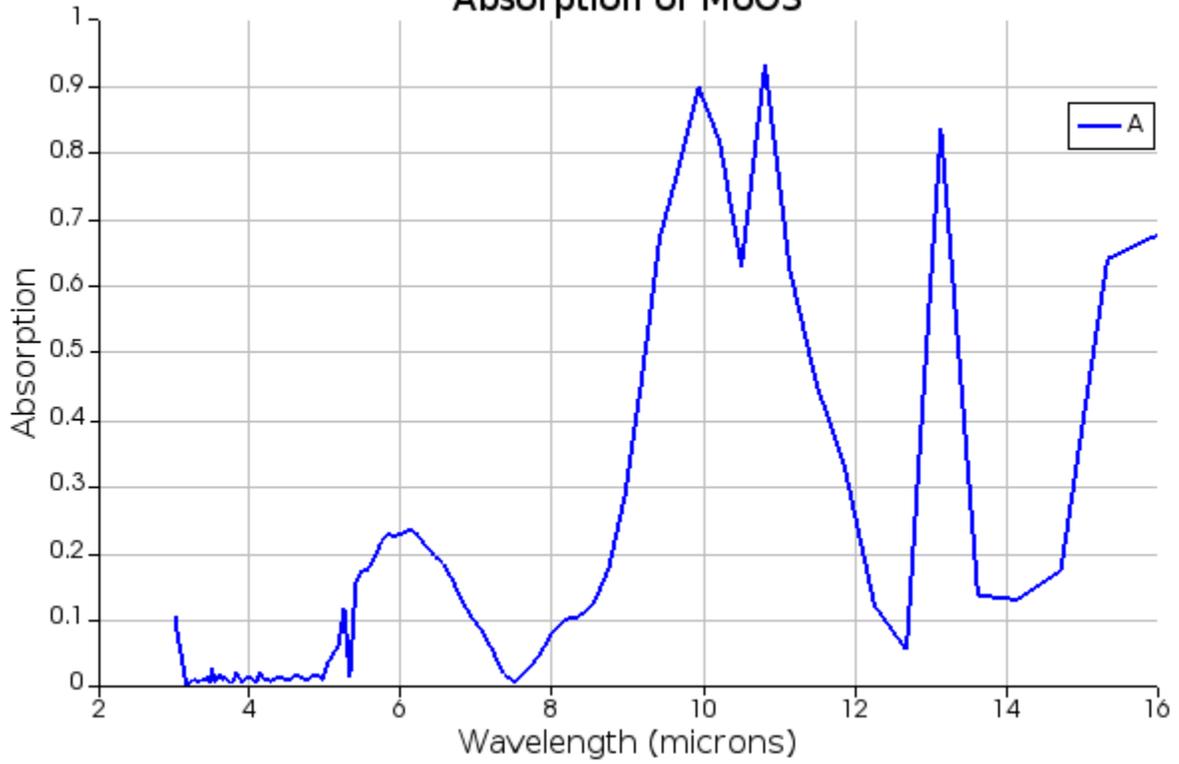## Absorption of MoO3

Gold layer with no ring

Absorption of MoO3

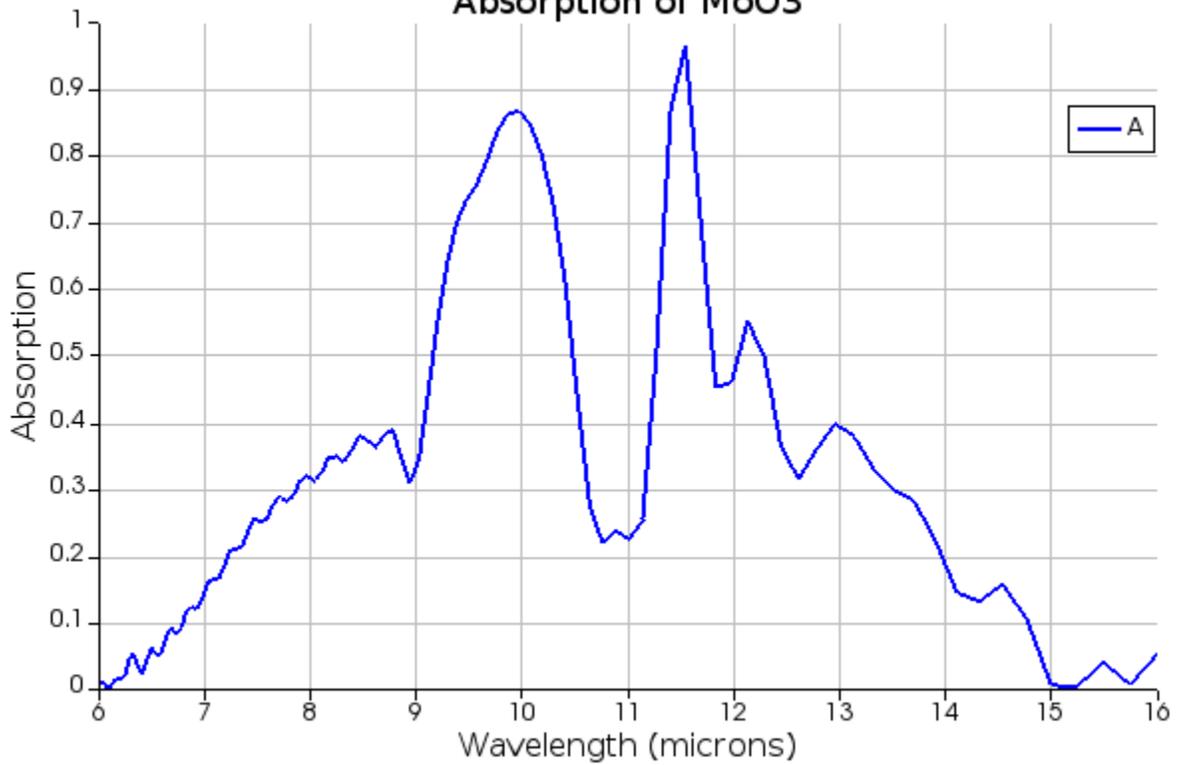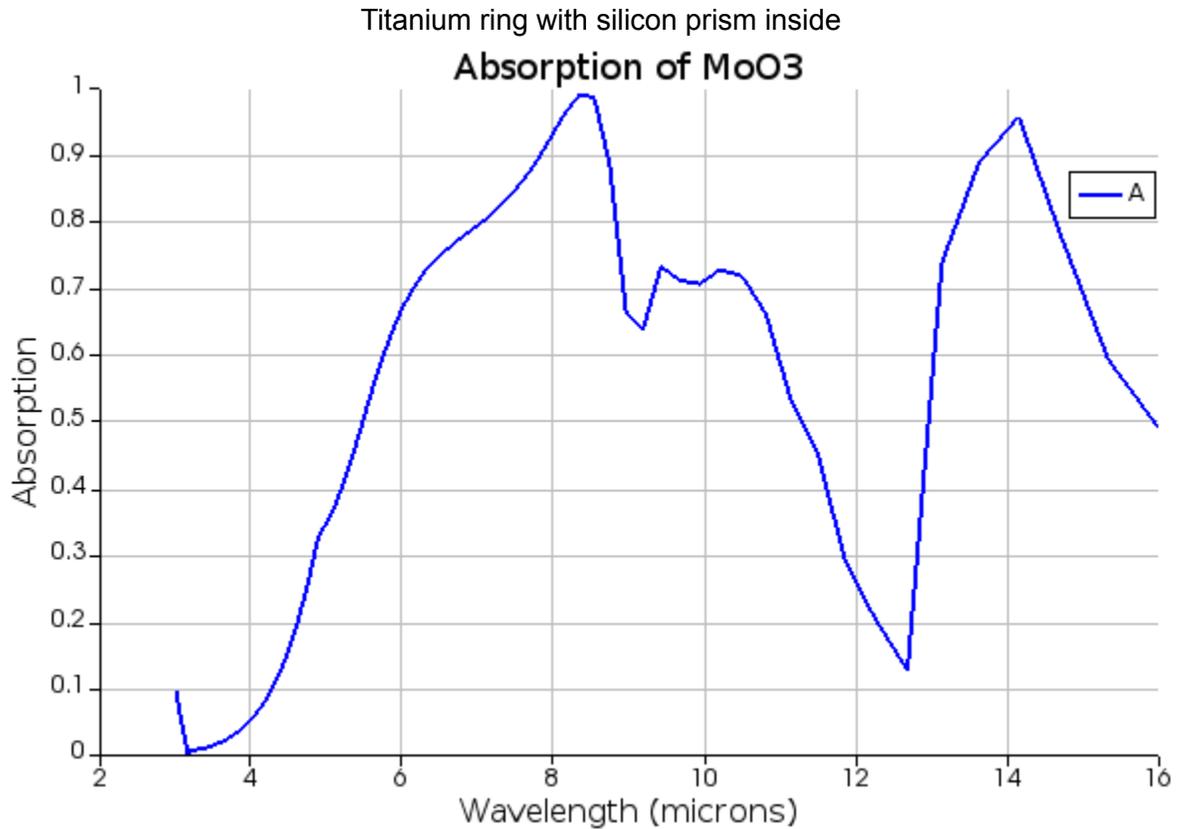Outer ring thick and tall, inner ring super thin and covers the two

Absorption of MoO3

Prism with gold around

Absorption of MoO3

Gold ring

Absorption of MoO3

Titanium ring with silicon prism inside

Absorption of MoO3

2/14
Things ultimately failed. The data was not what I was expecting. I wanted a singular peak with nothing else, but still got curves everywhere. It is time to talk to my mentor for advice.

2/16
Biggest culprit: Silicon dioxide! Created unnecessary curves. Best to get rid of other materials and have dielectric as the substrate. Dielectrics allow all light through them.
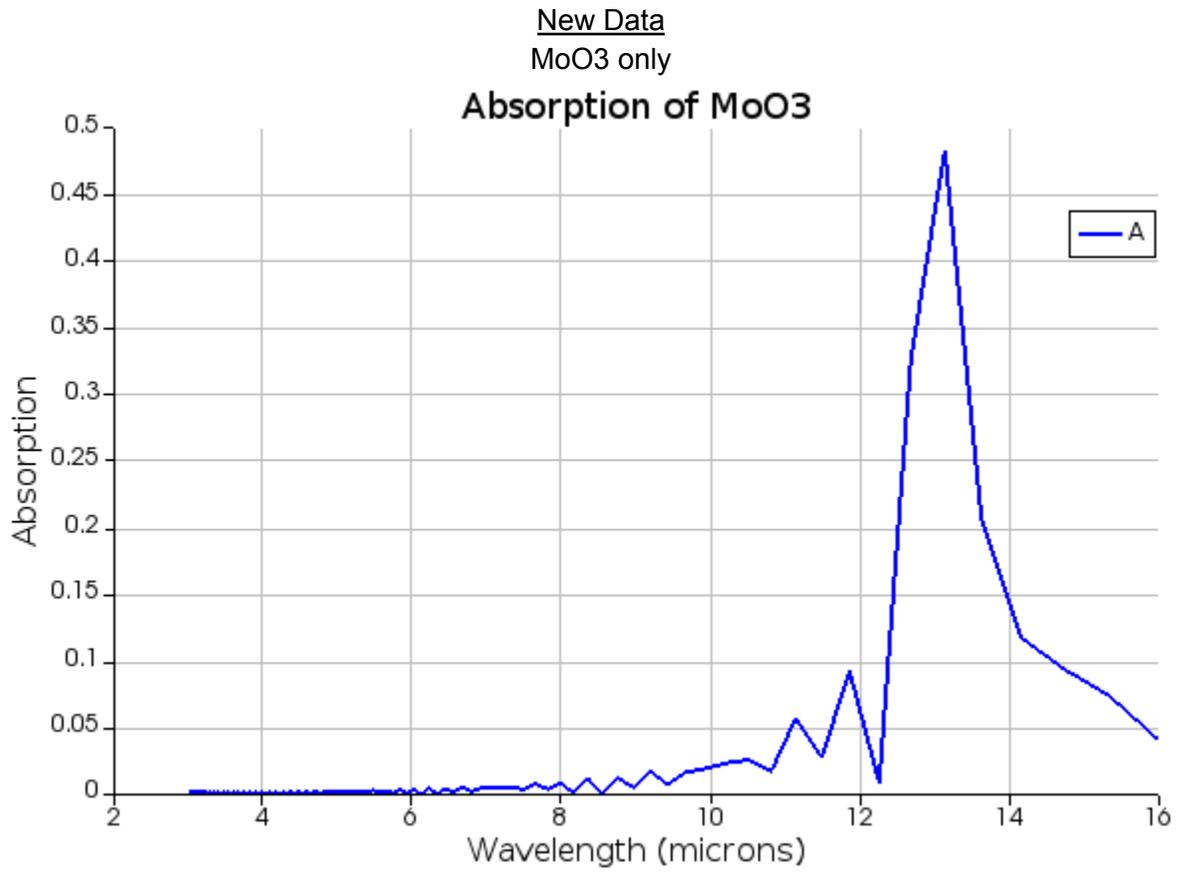Notes:
-Gold has perfect reflectivity, if placed on the bottom, light gets absorbed "twice"
-Need a dielectric with constant n value, and no k value at all. K = imaginary numbers = source for absorption
-For example, use MgF_2
-Since gold reflects all light, no bother to use a transmission monitor. Simply do 1-R to get absorption

Suggestions for poster:
-Same font, size, everything
-Include blackbody radiation
-Include other applications of MoO3
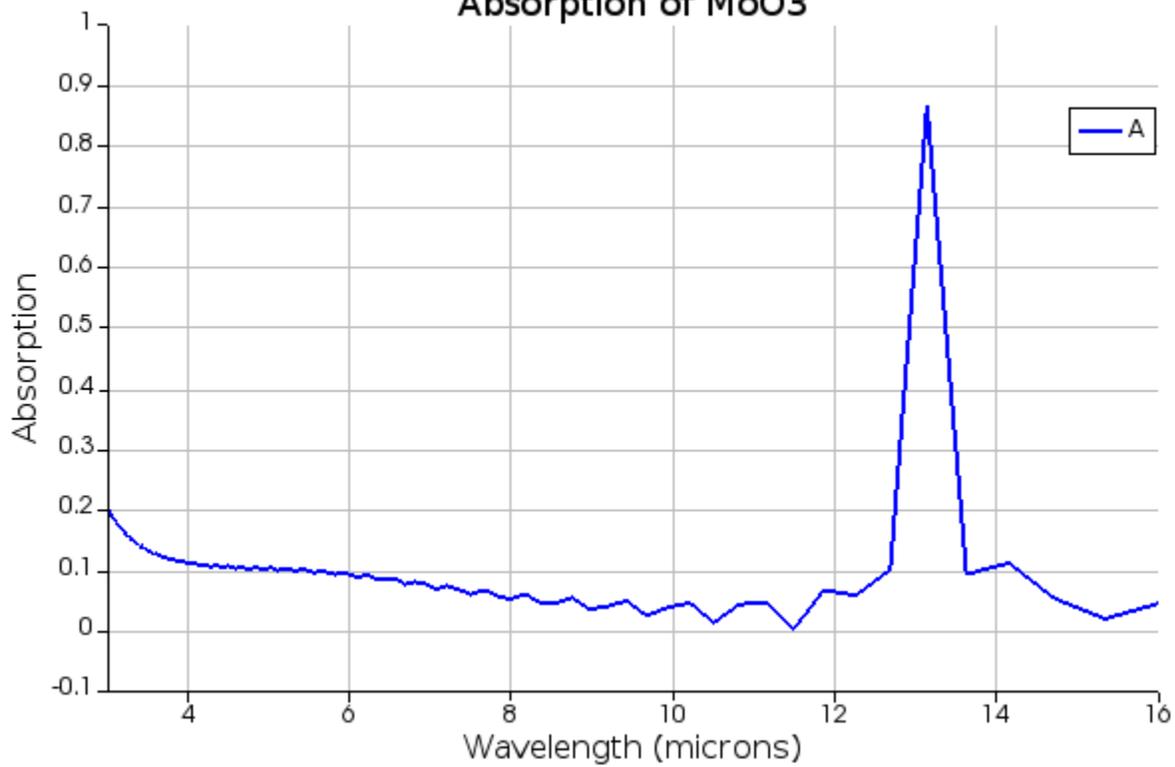-Mention the size of a hair to grasp how small these are

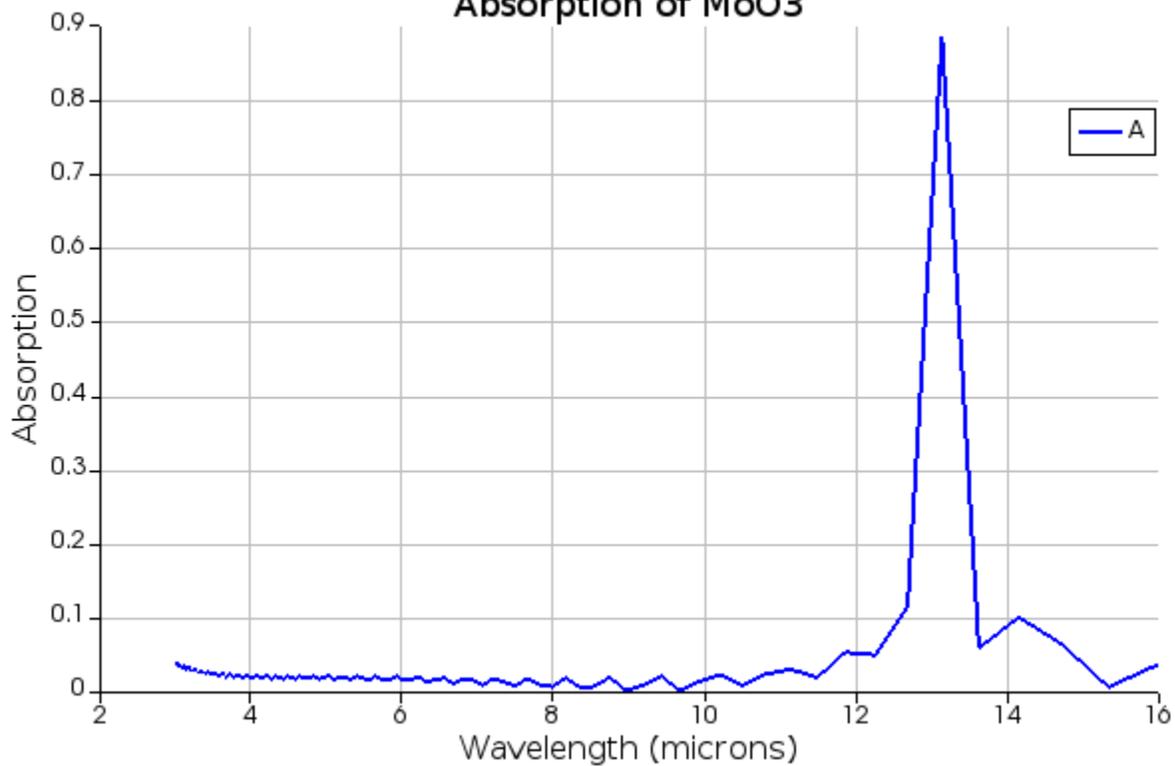-Mention future implication of photodetector
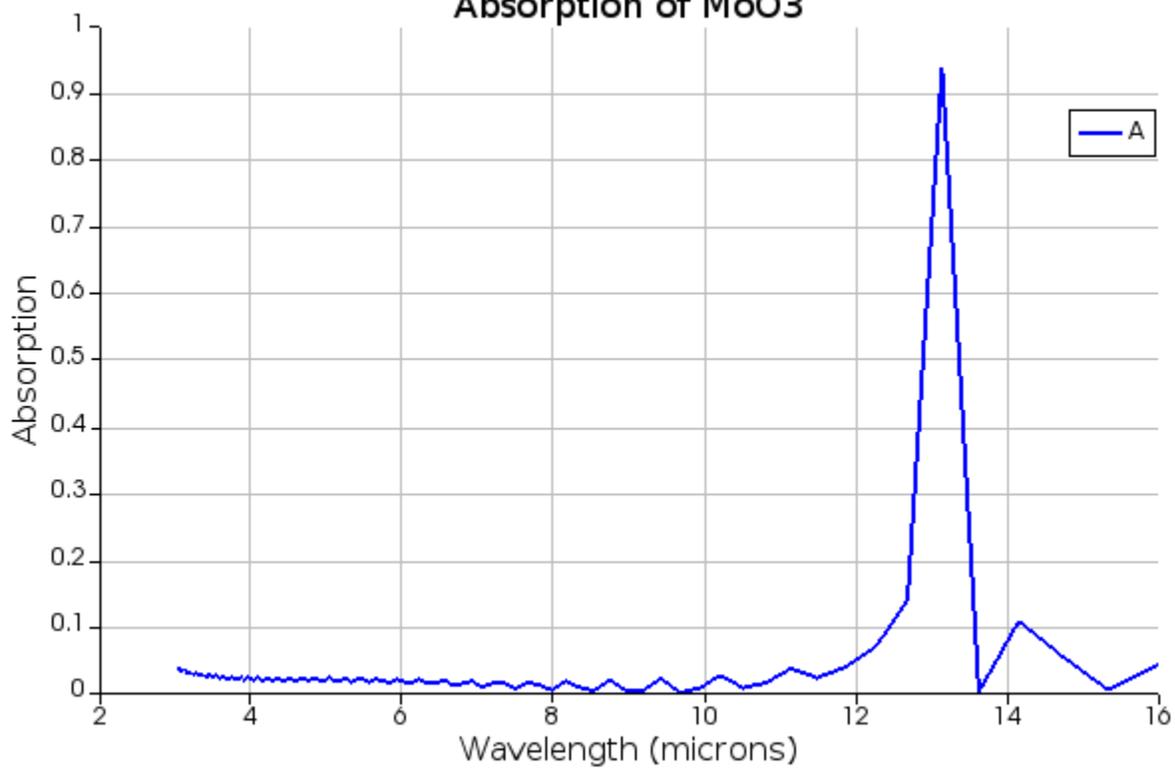-Use SMM to find metal costs

Absorption of MoO3

MgF2 added

Absorption of MoO3
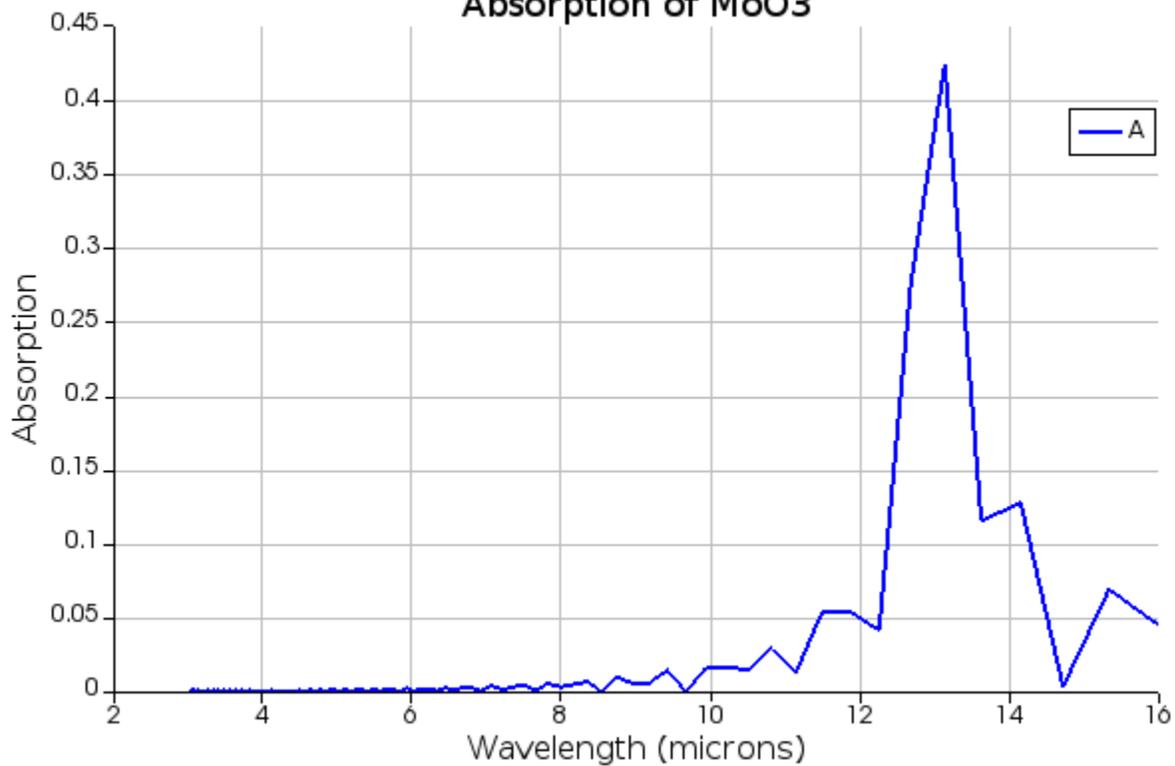
Gold added

Absorption of MoO3

Thicker gold

Absorption of MoO3

Decrease MoO3 thickness

Absorption of MoO3

2/26
Met with mentor. Notes:
Only need 14 nanometers
Change polarization of light to see if the absorption shifts. It's better, means to be good. Since anisotropic, x,y,z, the peaks are different on each. So changing the polarization of light you can determine see if its the same at peaks

Suggest to use the same font. Arial

Changing incidence angle will allow for similar data to permittivity (angle theta). Try 45-30 degrees and set polizaqtion to 0 or 90 (start at 0) to gain components from z direction. Have strong absorption by the z response which peaks at 10. It will be better matched. Light can come from different angles.

When putting multiple plots, if y is too high and stuff (say that y was scaled to a multiple by a factor of 1.3)
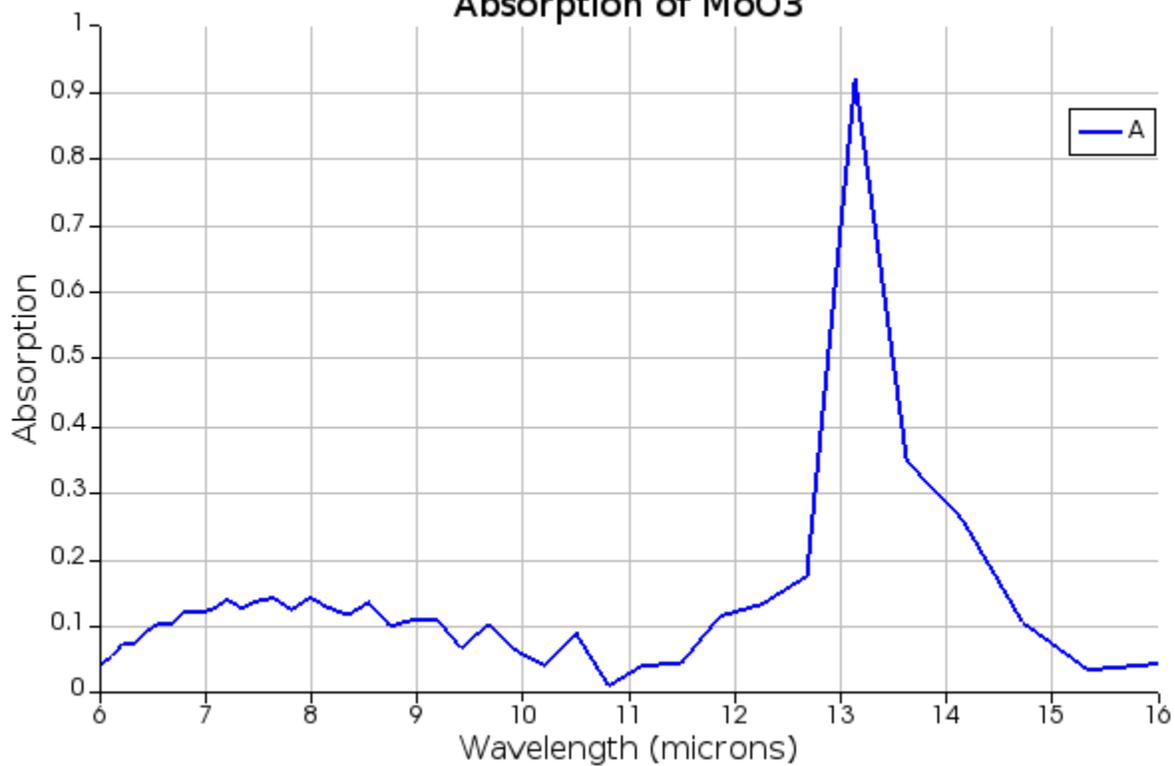
Change light to 8-16. Or piece together two curves.

Mention in conclusions that right now, it is far from a complete detector. Just a strategy to improve absorption. Need to then place on p-n junctions or semiconducting film. (Future research)
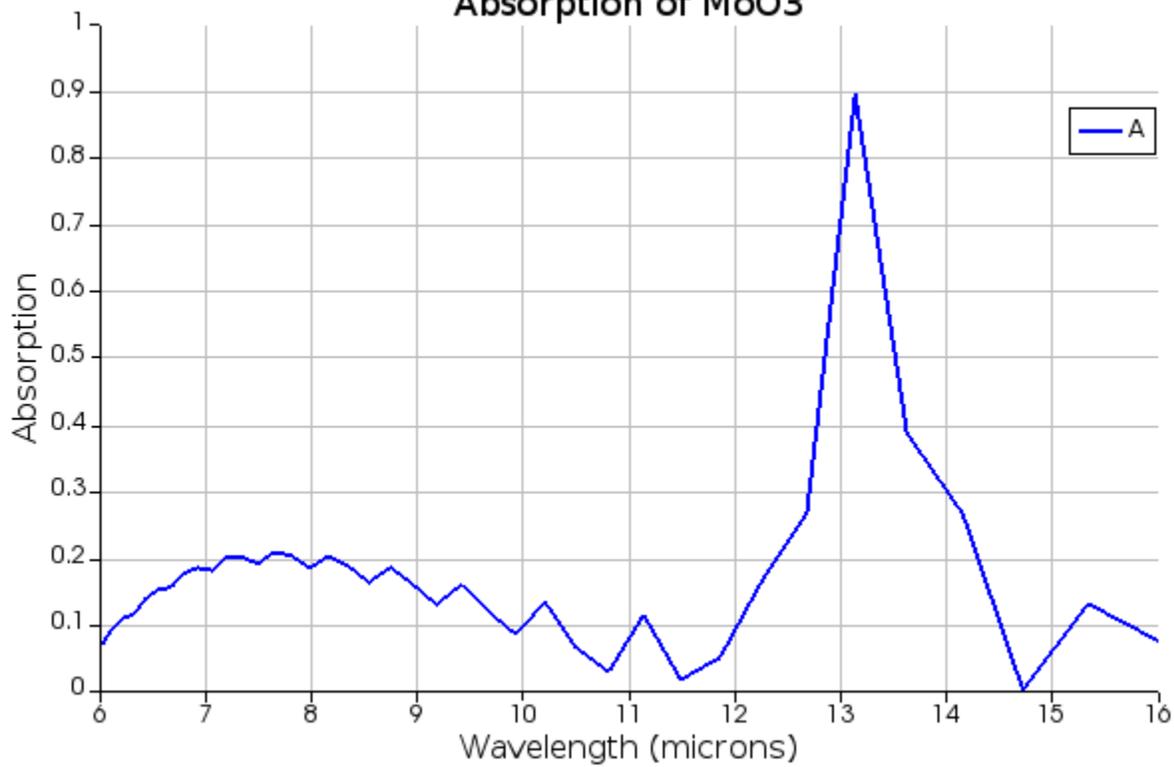
Generate more than one result at varying incidence angles and show the results.
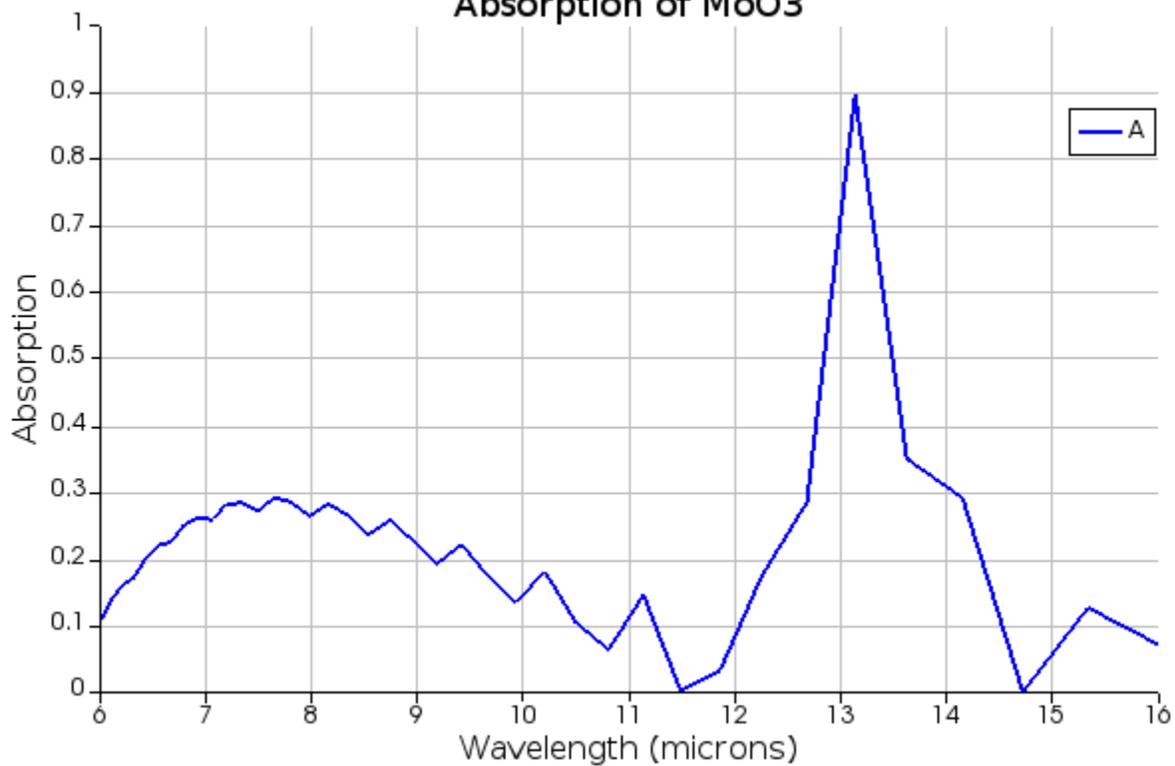
<u>Final Data:</u>

30 degrees

Absorption of MoO3

35 degrees

Absorption of MoO3

Absorption of MoO3

Absorption of MoO3