INTERNSHIP-M1

OBSERVATIONS

OPTICAL FIBER REFRACTOMETER: FROM THE DESIGN

INTO GAS SENSING TECHNOLOGIES

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M1-SATCOM

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DEFINITIONS

PHOTONIC CRYSTAL FIBER: A Fiber with a pattern of air holes with the central hole missing made of pure fused silica an arrangement of very tiny and closely spaced air holes which go through the whole length of the fiber.

SNELL'S LAW: Snell's Law is a fundamental principle that explains how light waves, change direction when passing from one medium to another.

Snells Law expressed as

$$n1\sin(\theta 1)=n2\sin(\theta 2)$$

Critical Angle (θc):

The critical angle is the angle of incidence beyond which total internal reflection occurs. For total internal reflection to occur, the angle of incidence of the light must be greater than the critical angle, which depends on the refractive indices of the core and cladding. It is expressed as

$$\sin(\theta c)= n_{Cl}/ n_{cO}$$

Return Loss: Return loss is a measurement of the light reflected back to the source at an optical interface.

Angled-polished connectors: Fiber connector that minimizes back-reflection due to a 8° angle-polish applied to end faces.

Green Color Coded

EXPERIMENTAL PROCEDURE

WEEK 1:

PREPARATION OF LIQUID FOR EQUIVALENT CLADDING:

Mixed Glycerol with Water and measured in digital refractometer to get below Brix values

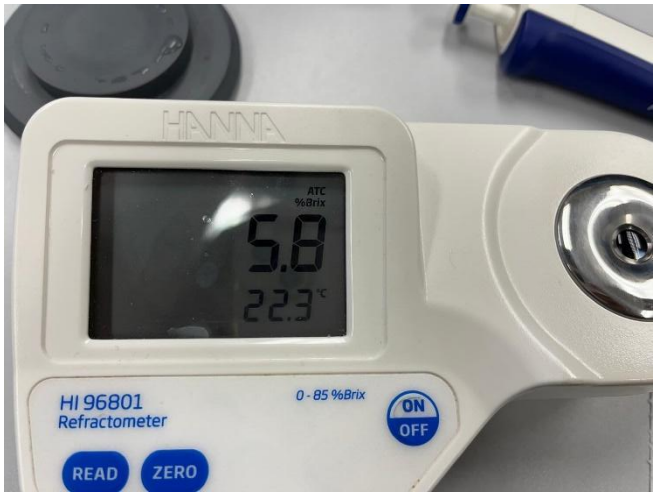
APPARATUS: Digital Refractometer for Brix value

5.5% 1.34026 RIU

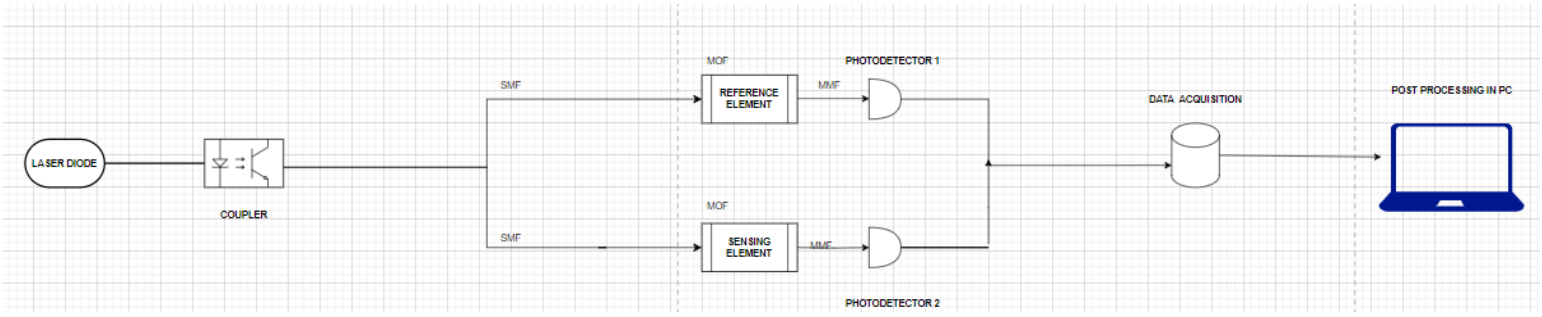
14.8% 1.35408 RIU

15.1% 1.35568 RIU

Results:



EXPERIMENTAL SETUP:



Post preparing the liquid, the experimental is setup and offset of the photodetector is calculated before recording the power measurements.

1.OFFSET CALCULATION OF PHOTODETECTOR

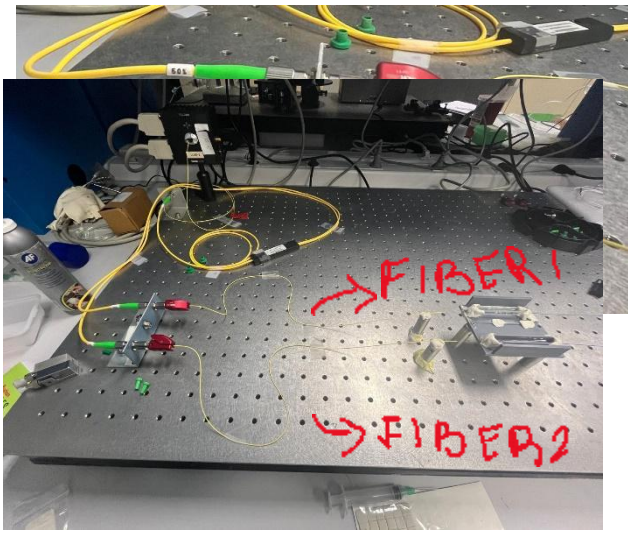
LASER	P1(mW)	P2(mW)	P3(mW)	Average	Ratio
Laser1	2.025	2.026	2.017	2.022667	
laser2	1.792	1.798	1.8	1.7966667	1.1257885
Fiber1	1.926	1.928	1.925	1.926333	
Fiber2	1.619	1.621	1.622	1.62066667	1.18860551

Cross verify value	PI(mW)	P2	P3
Laser	1.982097	2.011903	2.073999
Fiber	1.92435232	1.92672954	1.92791814

Photodetector	Gain-0dB	Gain-10dB
PD1	2.68V	8.43V
PD2	2.38V	7.45V

Three values of power are measured using power meter at the end of each laser using a APC Connector and using ideal SMF fiber end point and ratio of the average value is calculated

Power measured at Laser1 and Laser2:



Power measured at Fiber1 and Fiber2:

Power measured at Photodetector1 and Photodetector2:

The photodetector used is PDA50B-EC from Thorlabs is a Germanium gain amplifier that detects light in the range 800 to 1800 nm and variable gain from 0-70 dB.

Checking the datasheet, for the Gain of the Photodetector 60dB, the Bandwidth given is 705 Hz, hence sampling frequency should be 1.4KHz in accordance to the Shannon-Nyquist Theorem, and Input signal from the function generator is modulated at 350Hz.

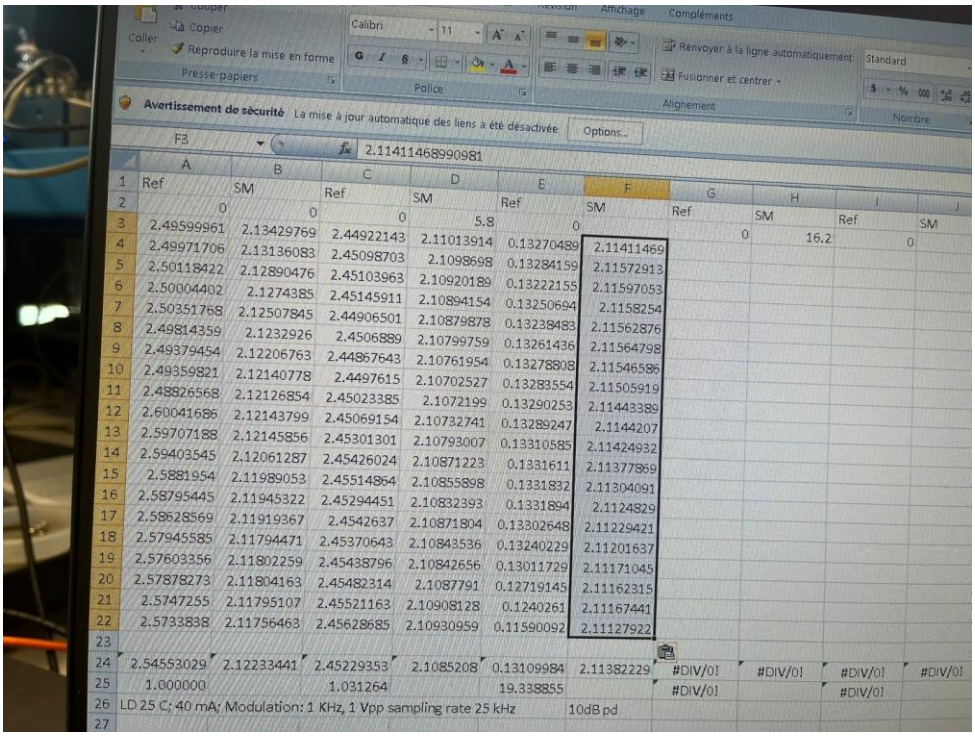
2. The SMF-Capillary Fiber of thickness 20 microns is spliced with MMF by removing the cladding, cleaved, and then joined using the splicer. The sensing element and the reference element of length 5 cm are placed inside a tube filled with water of Refractive index 0 on the Reference side and another filled with a Glycerol-water mixture of various refractive indexes to study the variation of power.

3. The spliced Fiber is placed on the test bench connected to the laser source and photodetector which is in turn connected to Data Acquisition System and Oscilloscope.

4. The refractive index used for the measurement is 5.8 and 3 sets of readings were taken to ensure stability of the setup.

5. Laser source is given at 40mA and sampling frequency should be 1.4KHz

Result:



	A	B	C	D	E	F	G	H	I	J
1	Ref	SM	Ref	SM	Ref	SM	Ref	SM	Ref	SM
2	0	0	0	5.8	0		0	16.2	0	
3	2.49599961	2.13429769	2.44922143	2.11013914	0.13270489	2.11411469				
4	2.49971706	2.13136083	2.45098703	2.1098698	0.13284159	2.11572913				
5	2.50118422	2.12890476	2.45103963	2.10920189	0.13222155	2.11597053				
6	2.50004402	2.1274385	2.45145911	2.10894154	0.13250694	2.1158254				
7	2.50351768	2.12507845	2.44906501	2.10879878	0.13238483	2.11562876				
8	2.49814359	2.1232926	2.4506889	2.10799759	0.13261436	2.11564798				
9	2.49379454	2.12206763	2.44867643	2.10761954	0.13278808	2.11546586				
10	2.49359821	2.12140778	2.4497615	2.10702527	0.13283554	2.11505919				
11	2.48826568	2.12126854	2.45023385	2.1072199	0.13290253	2.11443389				
12	2.60041686	2.12143799	2.45069154	2.10732741	0.13289247	2.1144207				
13	2.59707188	2.12145856	2.45301301	2.10793007	0.13310585	2.11424932				
14	2.59403545	2.12061287	2.45426024	2.10871223	0.1331611	2.11377869				
15	2.5881954	2.11989053	2.45514864	2.10855898	0.1331832	2.11304091				
16	2.58795445	2.11945322	2.45294451	2.10832393	0.1331894	2.1124829				
17	2.58628569	2.11919367	2.4542637	2.10871804	0.13302648	2.11229421				
18	2.57945585	2.11794471	2.45370643	2.10843536	0.13240229	2.11201637				
19	2.57603356	2.11802259	2.45438796	2.10842656	0.13011729	2.11171045				
20	2.57878273	2.11804163	2.45482314	2.1087791	0.12719145	2.11162315				
21	2.5747255	2.11795107	2.45521163	2.10908128	0.1240261	2.11167441				
22	2.5733838	2.11756463	2.45628685	2.10930959	0.11590092	2.11127922				
23										
24	2.54553029	2.12233441	2.45229353	2.1085208	0.13109984	2.11382229	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
25	1.000000		1.031264		19.338855		#DIV/0!		#DIV/0!	
26	LD 25 C; 40 mA; Modulation: 1 KHz, 1 Vpp sampling rate 25 kHz					10dB pd				
27										

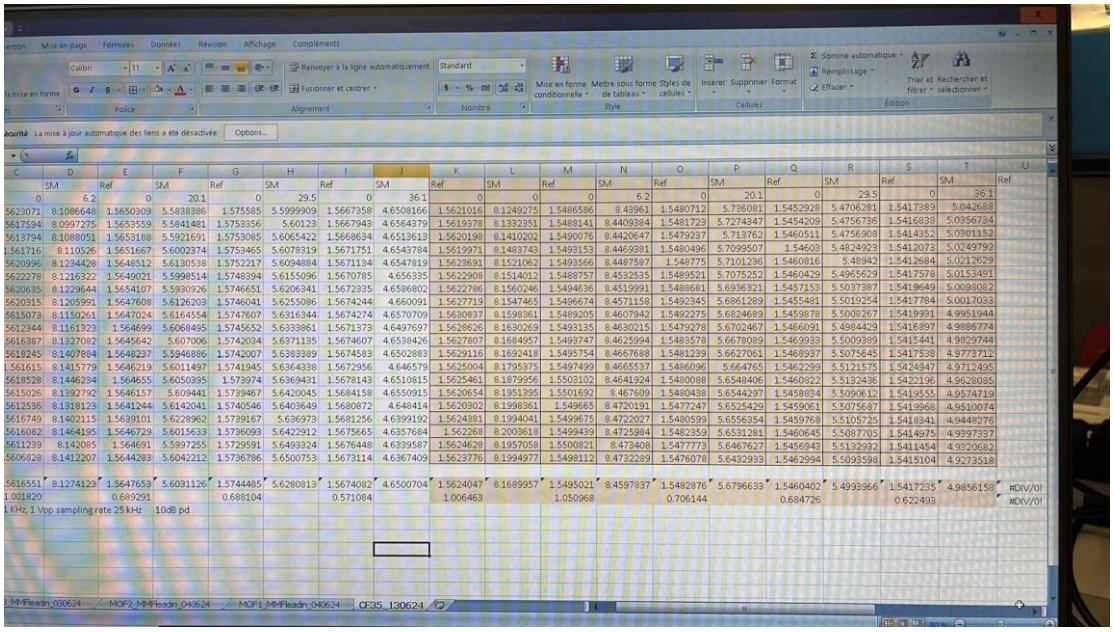
12June:

Observations for the experiment were carried out for solvents with Brix values 6.2, 20.1, 29.5, 36.1 for 35um of capillary fiber.

Below is the screenshot of the reading recorded. Ref column indicates the power in terms of mV for the Reference element and SM indicates for sensing element, two sets of readings were taken to ensure the stability of the setup.

Analyzing the power of the sensing element, it is concluded that power gradually reduces when the viscosity of the liquid increases.

Result:



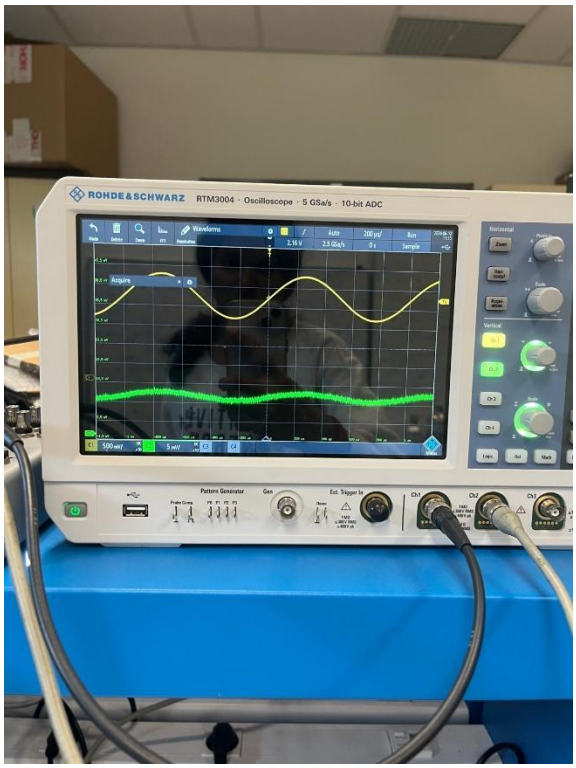
CHARACTERIZATION OF NOISE:

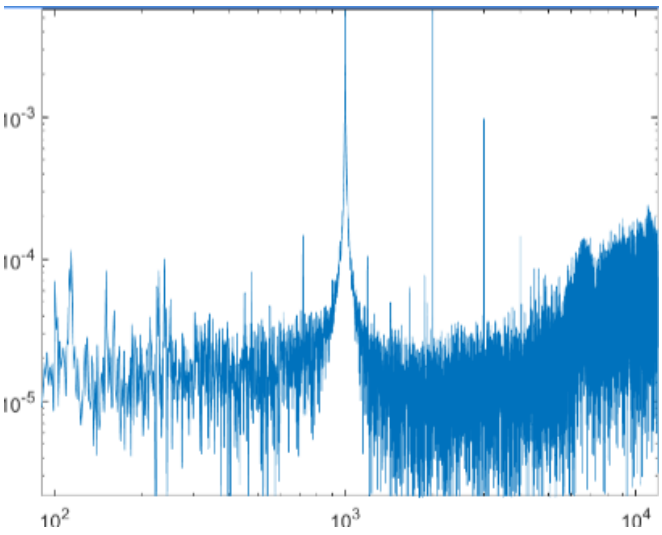
The SNR can be calculated by considering the ratio of signal values in first cell of PSD to the average of noise values in same column. The SNR is calculated for each set of readings. The snippet of the program below.

MATLAB CODE:

```
i=0;
for i=1:N/20:N
    [freq1(i,:),psdx0(i,:)] = PSD_simple(freq,ai_00(:,i));
    [freq2(i,:),psdx1(i,:)] = PSD_simple(freq,ai_01(:,i));
end


a0=nonzeros(psdx0);
a1=nonzeros(psdx1);
psd0=reshape(a0,[],12501)';
psd1=reshape(a1,[],12501)';


signal=(psd1(1,:))';  %data in 1st row
r=(psd0(2:end,1:end))'; %excluding 1st cell for noise
```

```
i=psd0(2:end,1:20)
noise=(mean(i))';


signal_tonoise=10*log10(signal./noise) %SNR for each column
```

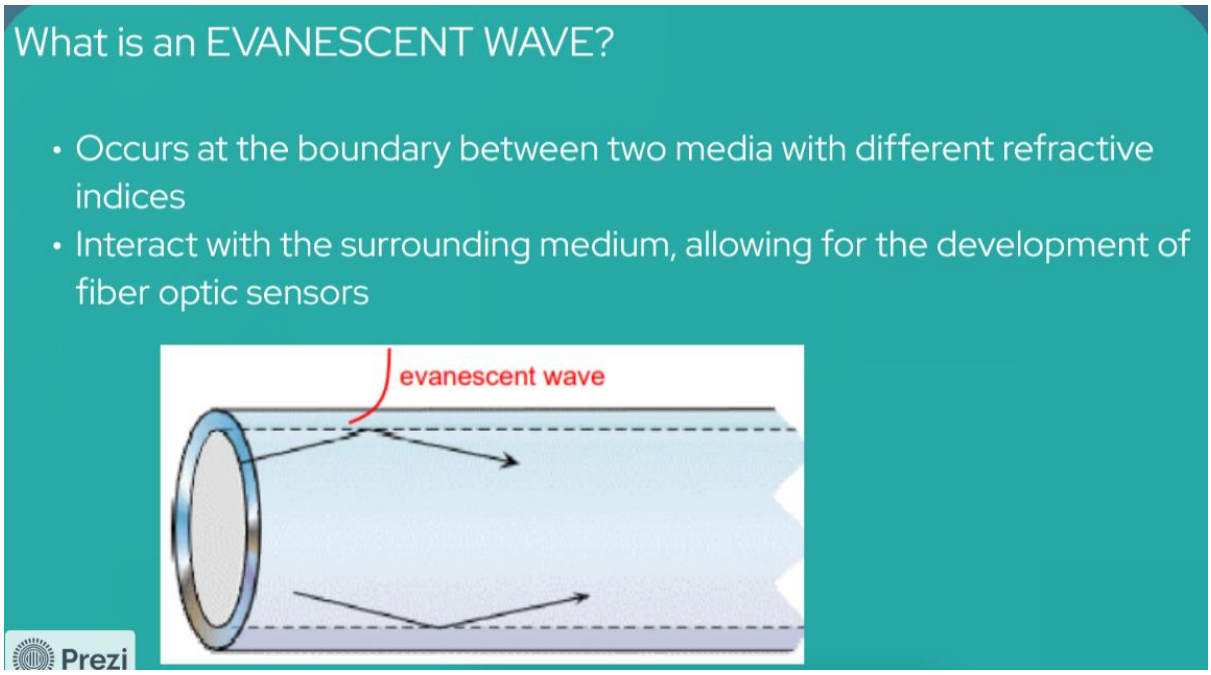




WEEK 2:

COMSOL APPLICATION

DEFINITION:



GOAL: To design a Photonic Crystal Fiber of 3 Layer HEXAGON SHAPE using COMSOL Application

PARAMETERS:

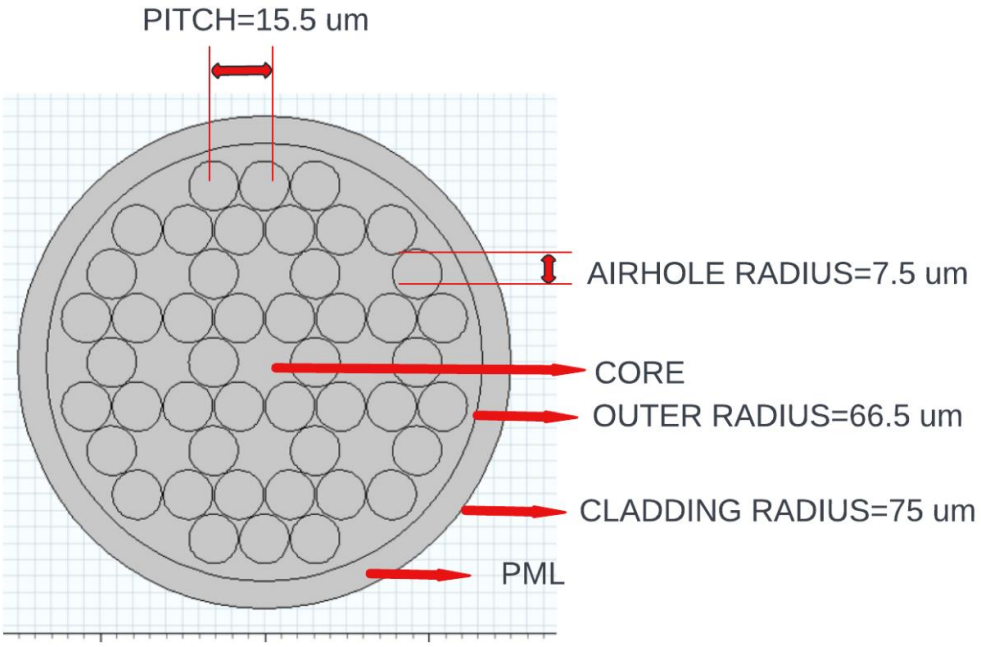
Airhole radius: 2.2 um

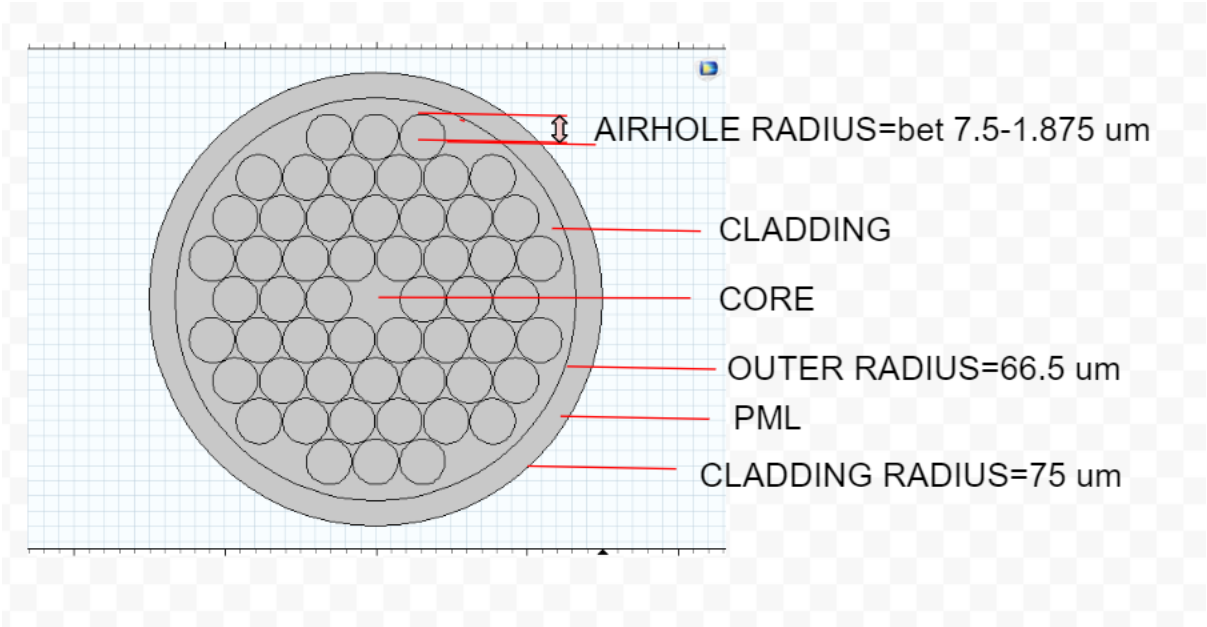
Pitch: 10 um Distance between 2 airholes

Outer Diameter: 105 um

PHOTONIC CRYSTAL FIBER: A Fiber with triangular pattern of air holes with the central hole missing. An optical fiber made of pure fused silica and obtains its waveguide properties not from a spatially varying glass composition but from an arrangement of very tiny and closely spaced air holes which go through the whole length of the fiber.

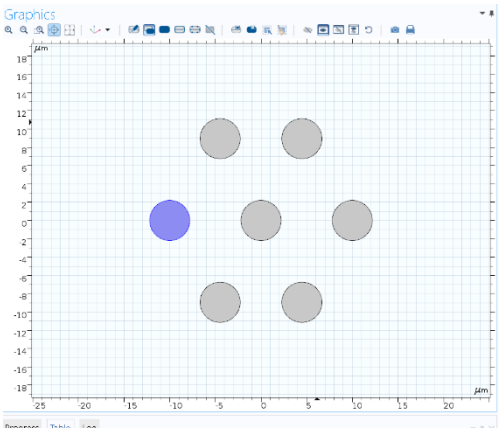
STRUCTURE DESIGN:



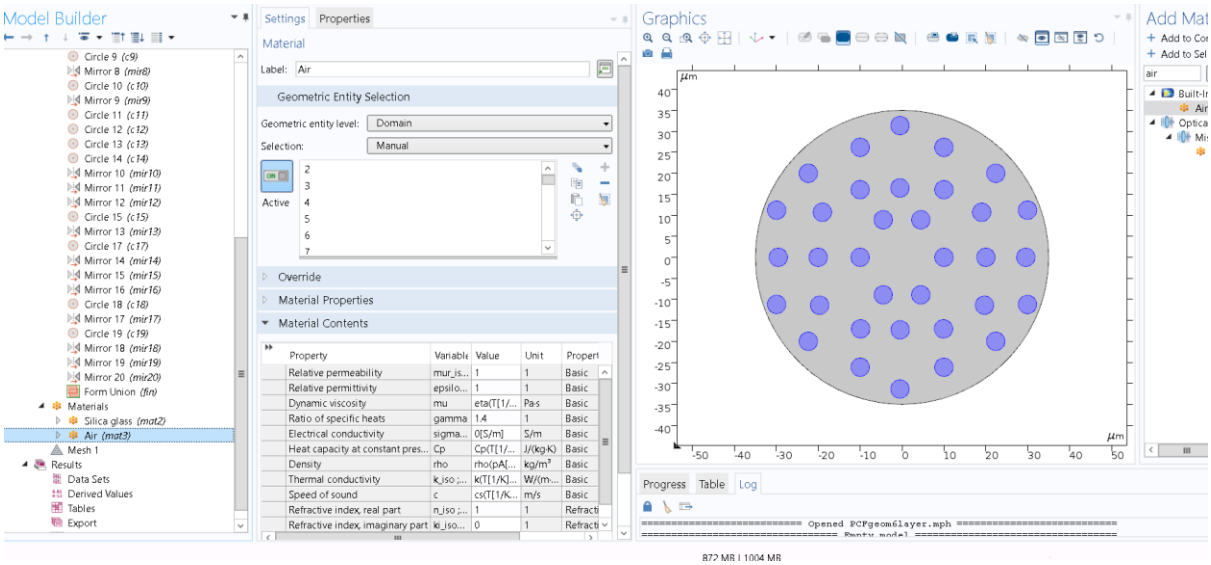

AIRHOLE RADIUS=bet 7.5-1.875 um
CLADDING
CORE
OUTER RADIUS=66.5 um
PML
CLADDING RADIUS=75 um

Results:

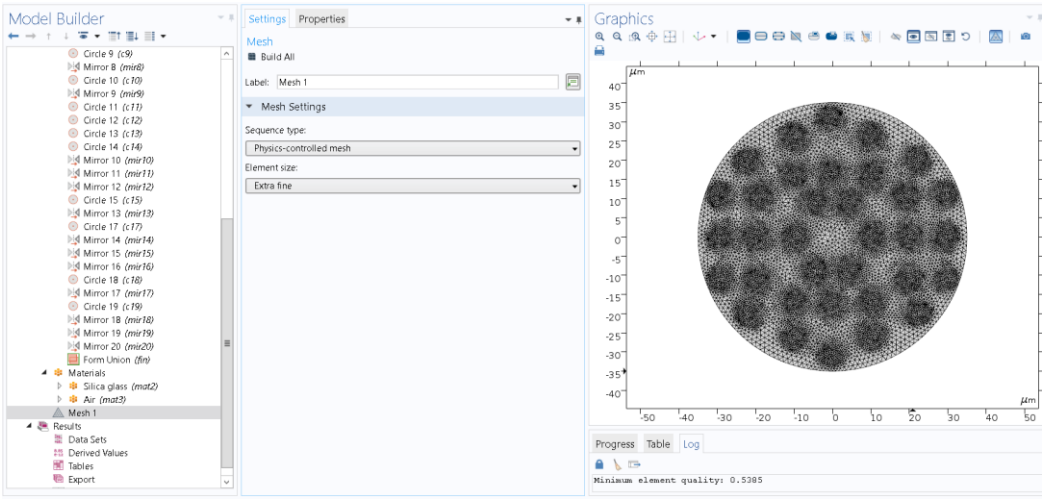
LAYER 1:



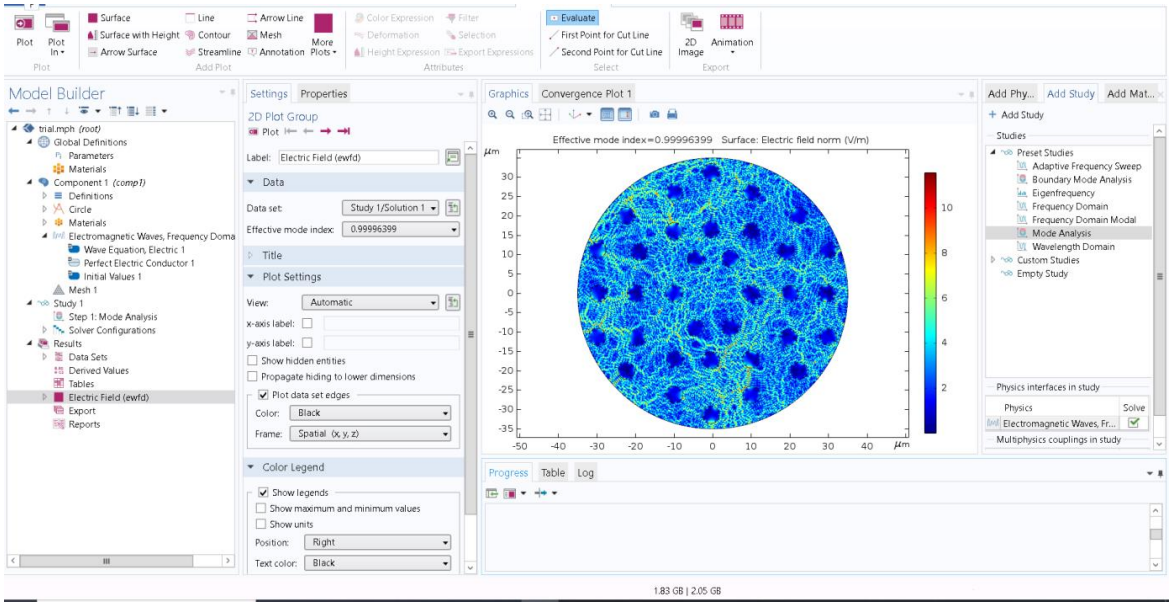
MATERIALS:



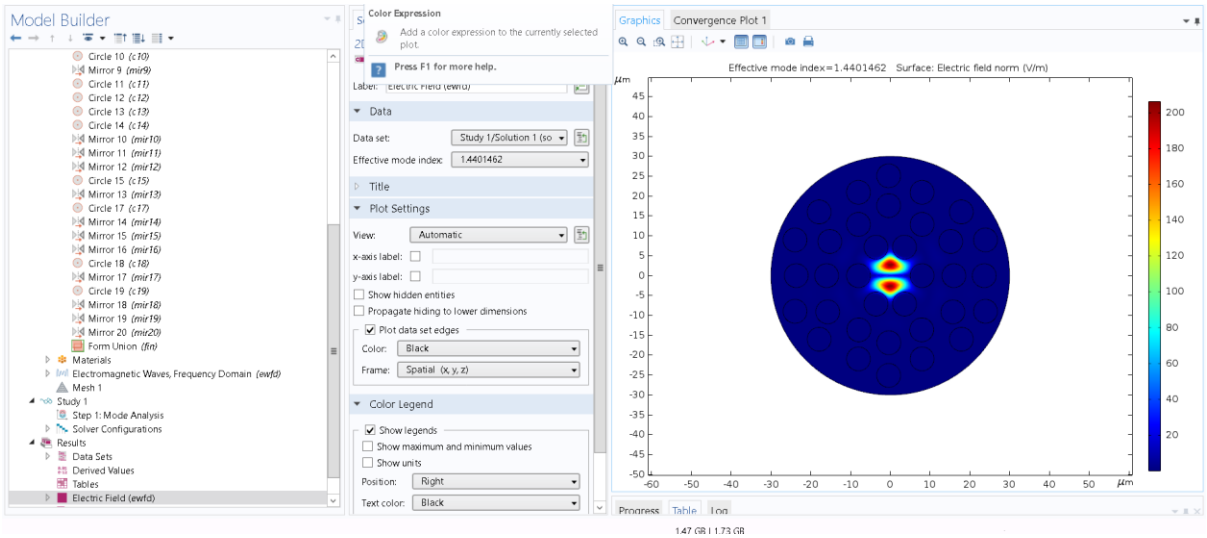
MESH:



Adding PHYSICS: EMF



STUDY:



COMSOL:

GOAL: To design a Photonic Crystal Fiber of 2 Layer CIRCLE SHAPE using COMSOL Application

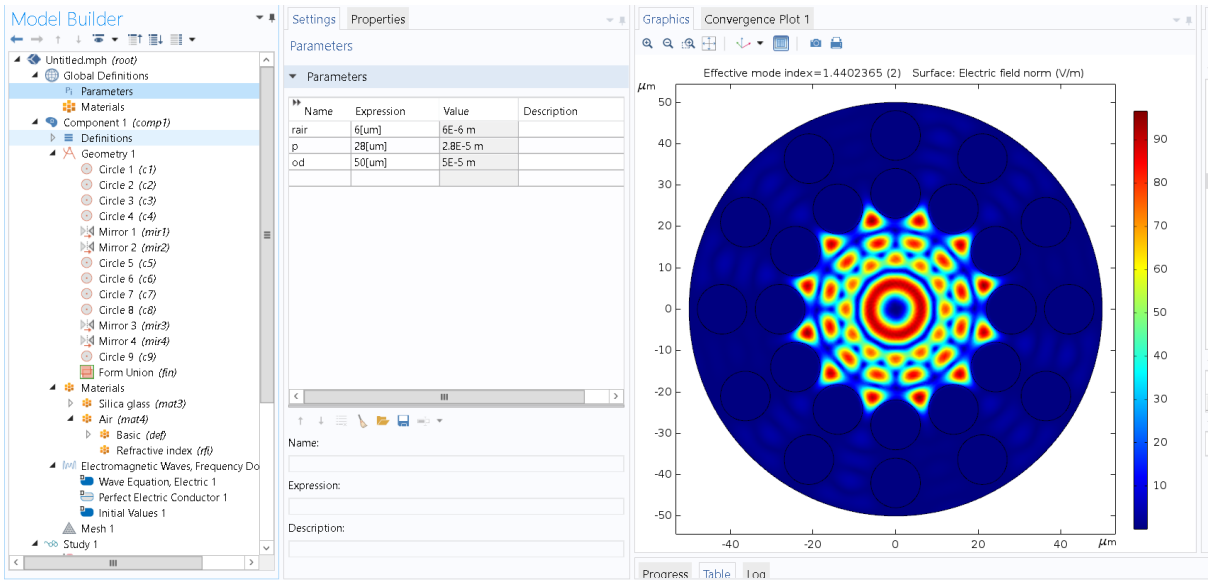
PARAMETERS:

Airhole radius: 6 um

Pitch: 28 um Distance between 2 airholes

Outer Diameter: 50 um

RESULT:



LP modes, or Linearly Polarized modes, are specific types of modes in optical fibers, particularly in single-mode and multi-mode fibers. These modes describe the distribution of the electromagnetic field within the fiber and how light propagates through it.

In the above simulation result, the electric fields of the light wave are linearly polarized and appears to be leaky modes.

In fiber optics, polarization refers to the orientation of the electric field vector of the light wave. In LP modes, the electric field is linearly polarized, and an optical fiber supports various modes, which are distinct patterns of light propagation.

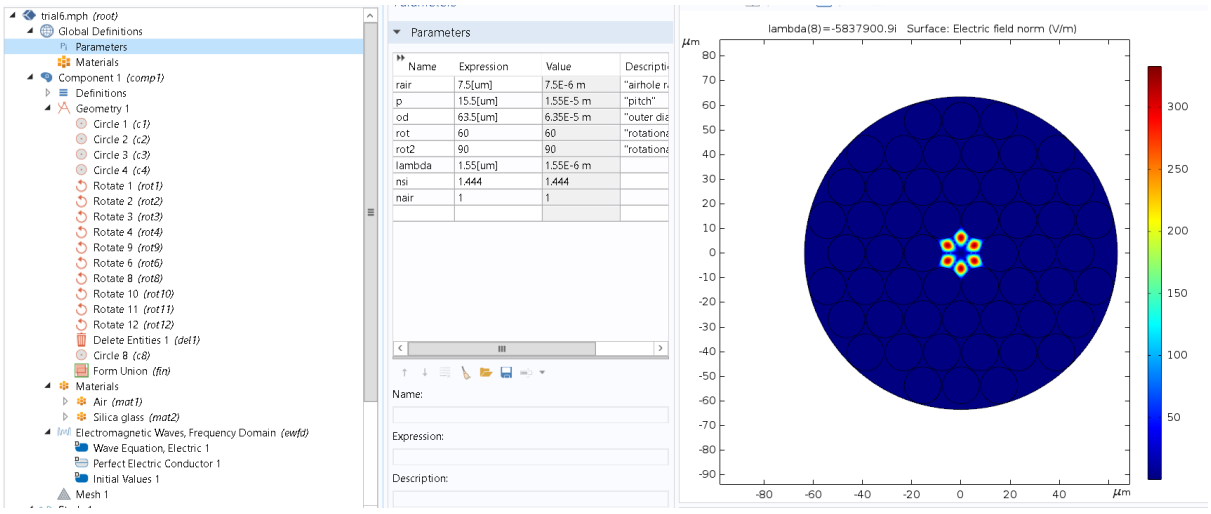
The mode numbers:

LP modes are typically denoted as LP_lm where l and m are mode numbers. In modes l=0, the power propagating in the core vanishes at the cut-off.

l the azimuthal number,

m the radial number.

- **Single-Mode Fibers**: These fibers are designed to support only the LP01 mode, ensuring minimal dispersion and high bandwidth over long distances.
- **Multi-Mode Fibers**: These fibers support multiple LP modes. They are used for shorter distances due to modal dispersion, where different modes travel at different speeds.



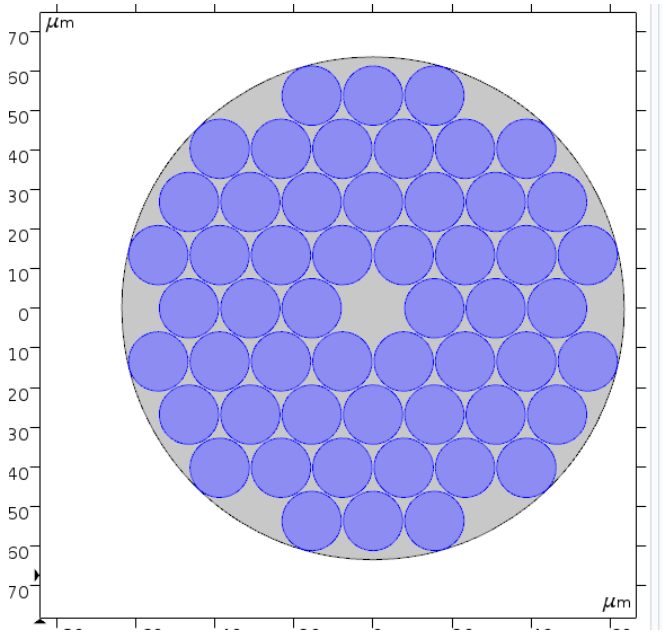
Further, altering the parameters of the geometry we get, mode LP31

Parameters:

Name	Expression	Value	Description
rair	7.5[um]	7.5E-6 m	"airhole radius"
p	15.5[um]	1.55E-5 m	"pitch"
od	63.5[um]	6.35E-5 m	"outer diameter"
rot	60	60	"rotational angle1"
rot2	90	90	"rotational angle2"
lambda	1.55[um]	1.55E-6 m	
nsi	1.444	1.444	
nair	1	1	

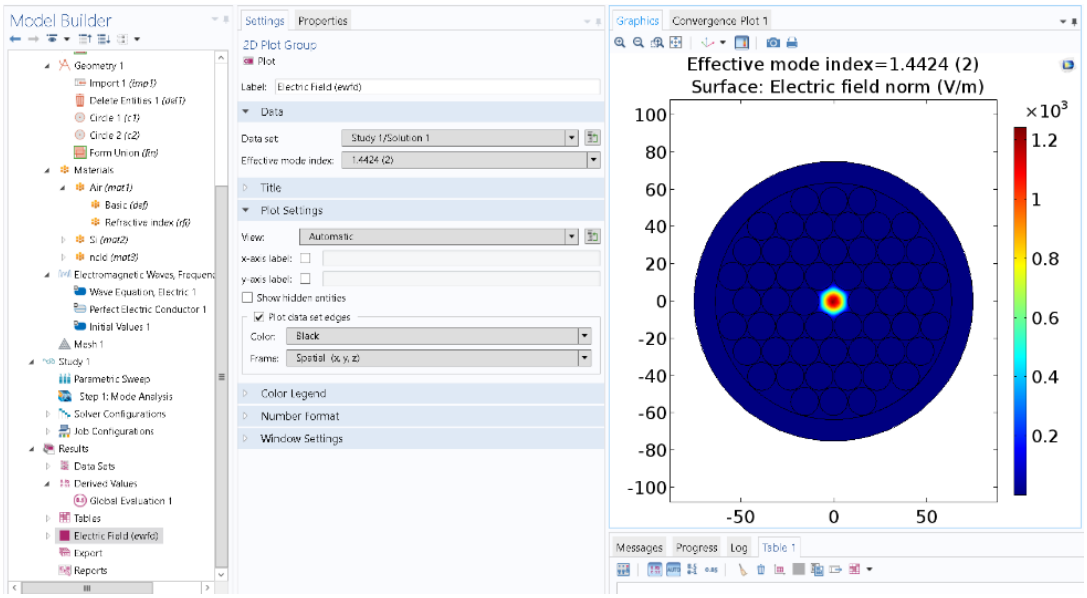
WEEK 3:

Further modifying the geometry by removing corner airholes and decreasing the outer diameter as below and increasing the number of modes to 16, we get modes without losses

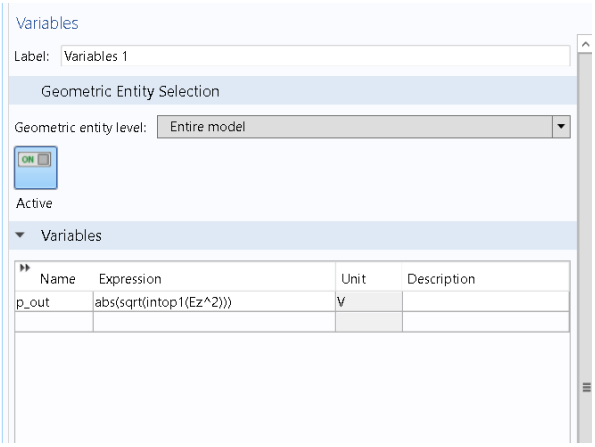


OBSERVING POWER VARIATION IN CLADDING AREA:

Adding cladding layer, of diameter as Perfectly Matched Layer (PML) and running the parametric sweep we get,

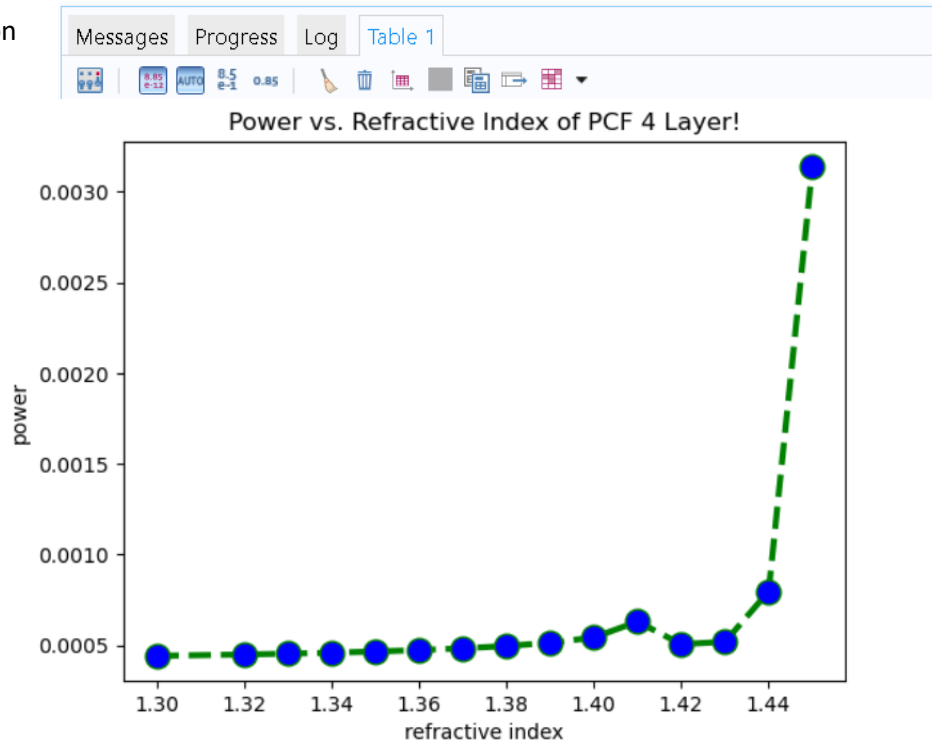


And the power was calculated using the formula under variables option:



Post running the parameter sweep and calculated power is tabulated below.

Using Python for graphical



representation of the output

Python code:

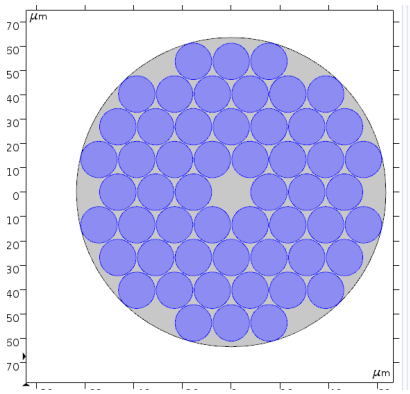
```
import matplotlib.pyplot as graph
import numpy as py

# data
ncl = [1.3,1.32,1.33,1.34,1.35,1.36,1.37,1.38,1.39,1.4,1.41,1.42,1.43,1.44,1.45]
power = [0.000441887,0.000449271,0.000453858,0.000459252,0.00046569,0.000473526,0.000483316,0.0004


# plotting the points
graph.plot(ncl, power,color='green', linestyle='dashed', linewidth = 3,marker='o', markerfacecolor
graph.xlabel('refractive index')
graph.ylabel('power')
graph.title('Power vs. Refractive Index of PCF 4 Layer!')

# function to show the plot
graph.show()
```

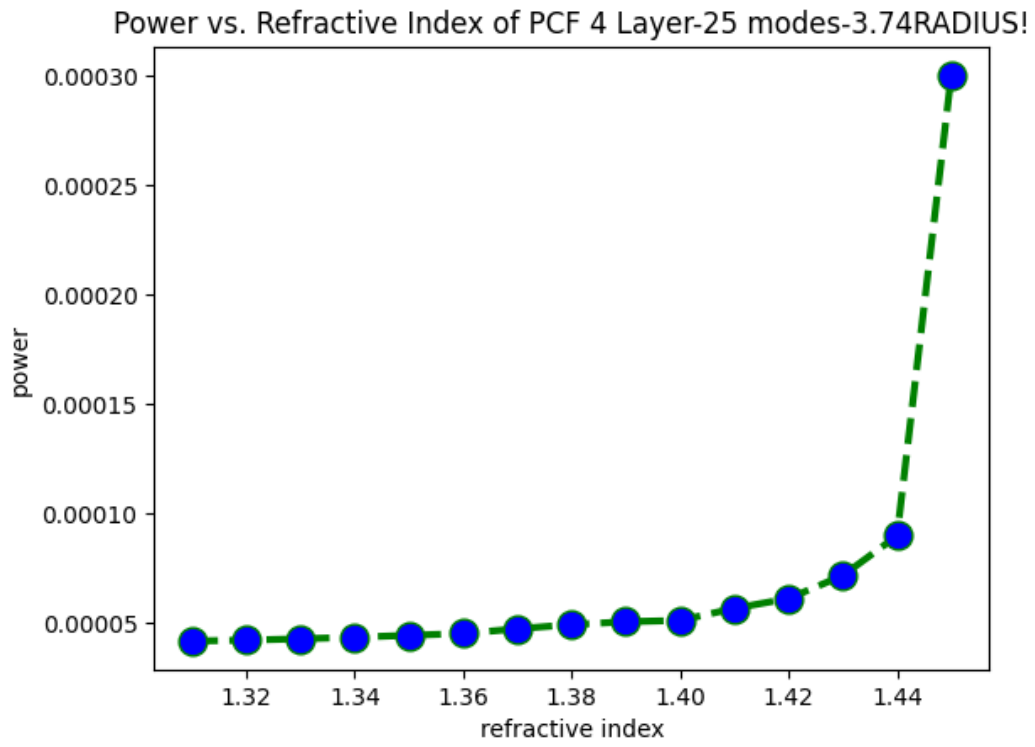
WEEK 4:

Altering the parameters and analysing the change of power of Evanescent fields

Rair:3.75 um

Geometry: PERIODIC NO AHC

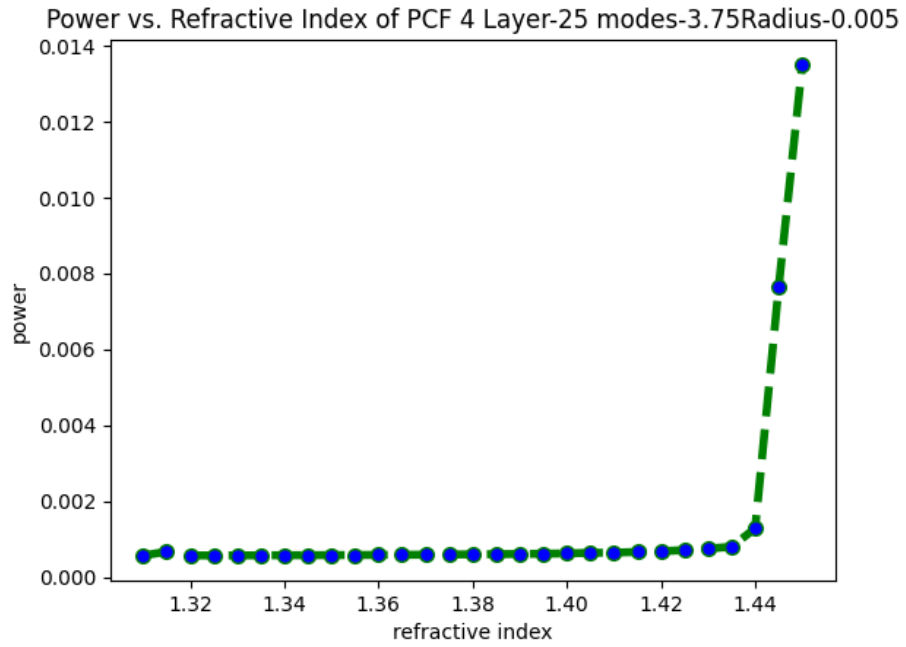




CODE:

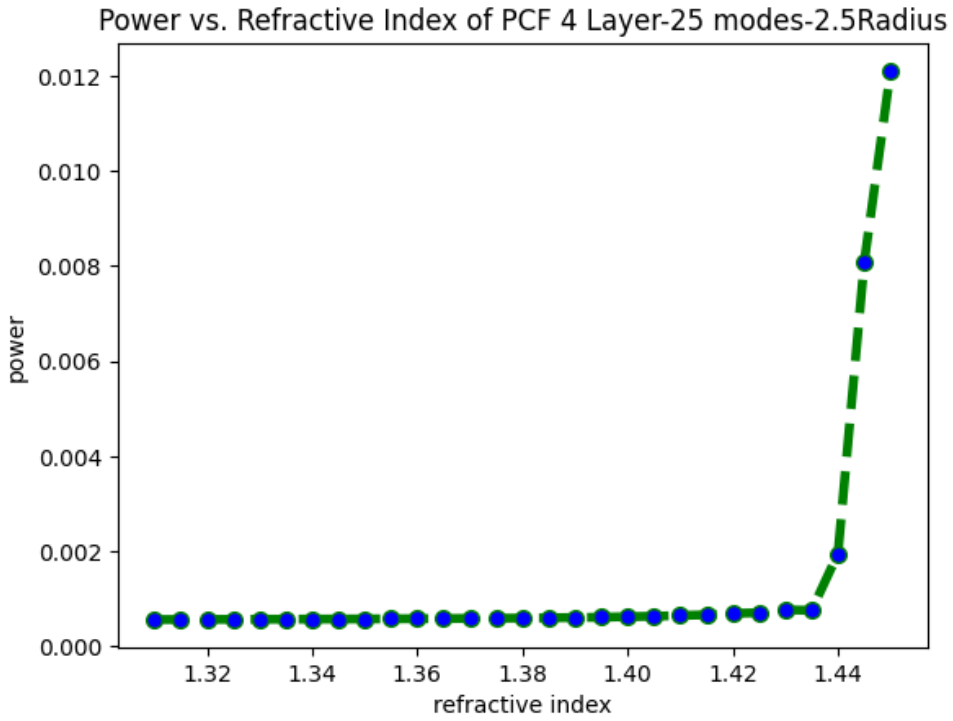
```
import matplotlib.pyplot as graph
import numpy as py

# data
ncl = [1.31,1.32,
1.33,1.34,1.35,1.36,1.37,1.38,1.39,1.4,1.41,1.42,1.43,1.44,1.45]
power = [4.18E-05,4.22E-05,4.28E-05,4.35E-05,4.44E-05,4.52E-05,4.74E-
05,4.93E-05,5.06E-05,5.12E-05,5.67E-05,6.12E-05,7.17E-05,8.98E-05,3.00E-04]

# plotting the points
graph.plot(ncl, power,color='green', linestyle='dashed', linewidth =
3,marker='o', markerfacecolor='blue', markersize=12)
graph.xlabel('refractive index')
graph.ylabel('power')
graph.title('Power vs. Refractive Index of PCF 4 Layer-25 modes-
3.74RADIUS!')

# function to show the plot
graph.show()
```

Result of 3.75 radius with 0.005 step size




```
import matplotlib.pyplot as graph


# data
ncl =
[1.31,1.315,1.32,1.325,1.33,1.335,1.34,1.345,1.35,1.355,1.36,1.365,1.37,1.3
75,1.38,1.385,1.39,1.395,1.4,1.405,1.41,1.415,1.42,1.425,1.43,1.435,1.44,1.
445,1.45]
power = [5.63E-04,6.67E-04,5.66E-04,5.67E-04,5.68E-04,5.70E-04,5.72E-
04,5.74E-04,5.76E-04,5.78E-04,5.81E-04,5.83E-04,5.86E-04,5.91E-04,5.95E-
04,6.00E-04,6.05E-04,6.12E-04,6.20E-04,6.35E-04,
6.42E-04,6.58E-04,6.78E-04,7.06E-04,7.47E-04,7.96E-04,1.28E-03,7.64E-
03,1.35E-02]

# plotting the points
graph.plot(ncl, power,color='green', linestyle='dashed', linewidth =
4,marker='o', markerfacecolor='blue', markersize=7)
graph.xlabel('refractive index')
graph.ylabel('power')
graph.title('Power vs. Refractive Index of PCF 4 Layer-25 modes-3.75Radius-
0.005')

# function to show the plot
graph.show()
```

Result of Radius 2.5:

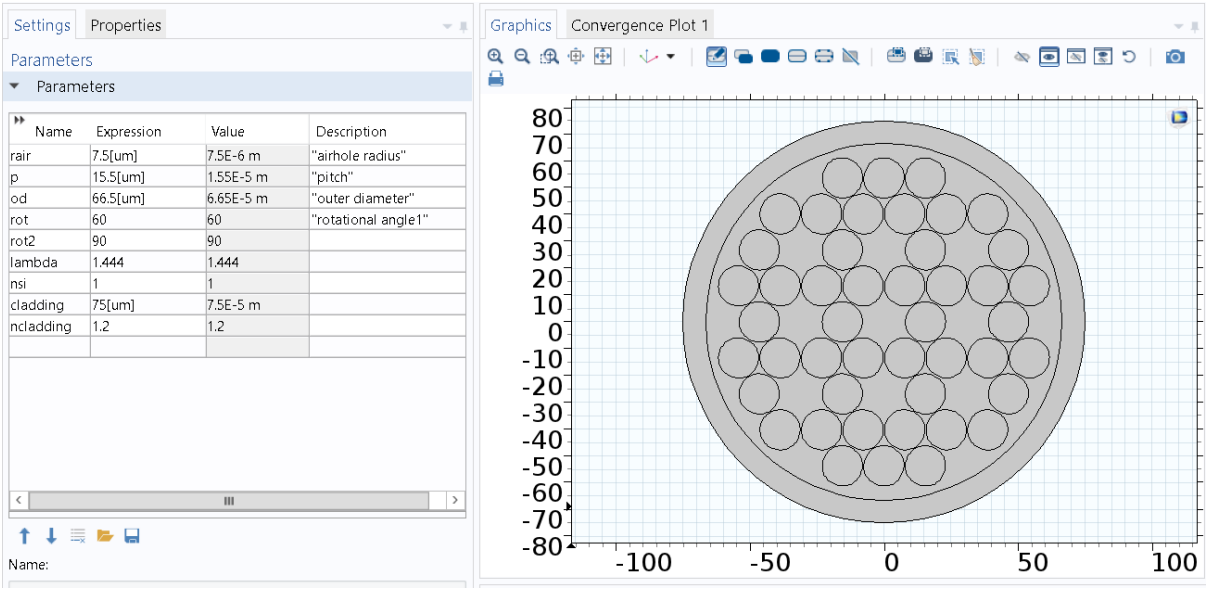



```
import matplotlib.pyplot as graph

# data
ncl25 =
[1.31,1.315,1.32,1.325,1.33,1.335,1.34,1.345,1.35,1.355,1.36,1.365,1.37,1.3
75,1.38,1.385,1.39,1.395,1.4,1.405,1.41,1.415,1.42,1.425,1.43,1.435,1.44,1.
445,1.45]
power25 = [5.63E-04,5.64E-04,5.66E-04,5.67E-04,5.69E-04,5.70E-04,5.72E-
04,5.74E-04,5.76E-04,5.79E-04,5.81E-04,5.84E-04,5.88E-04,5.91E-04,5.95E-
04,5.99E-04,6.07E-04,6.12E-04,6.23E-04,6.33E-04,6.48E-04,6.63E-04,6.94E-
04,7.06E-04,7.67E-04,7.57E-04,1.95E-03,8.08E-03,1.21E-02]

# plotting the points
graph.plot(ncl25, power25,color='green', linestyle='dashed', linewidth =
4,marker='o', markerfacecolor='blue', markersize=7)
graph.xlabel('refractive index')
graph.ylabel('power')
graph.title('Power vs. Refractive Index of PCF 4 Layer-25 modes-2.5Radius')

# function to show the plot
graph.show()
#%%
```

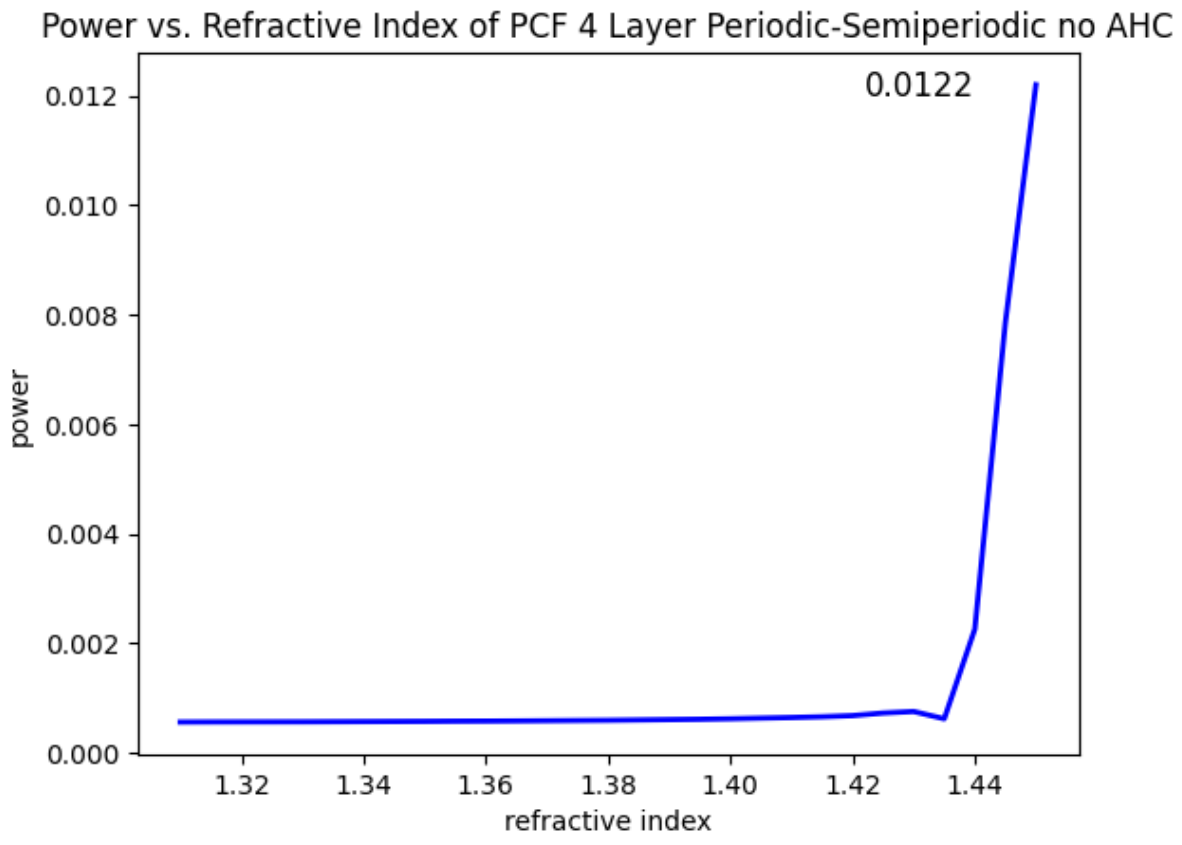
3rd July:

Airhole Radius: 7.5 um

Geometry: Semi Periodic with No Centre Airhole



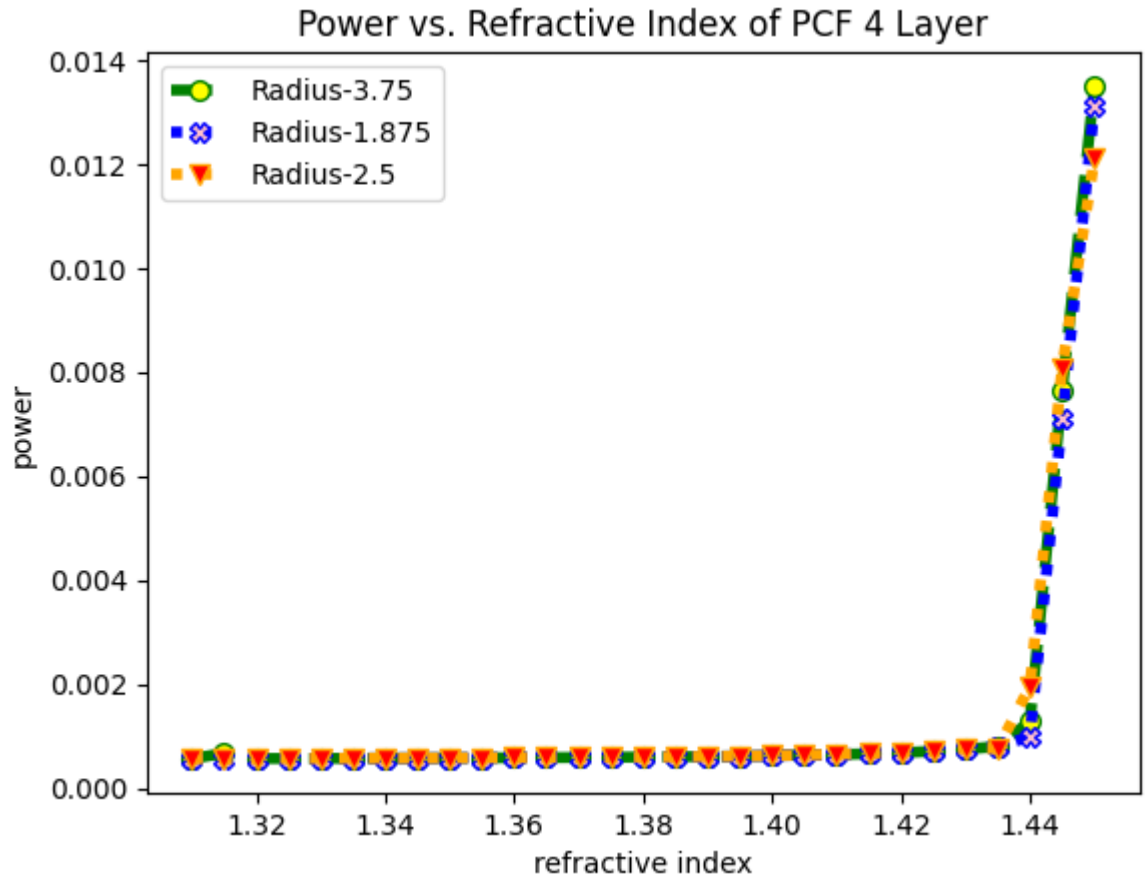
RESULT:



PARAMETER:

Airhole Radius: 3.25, 2.5, 1.875 um

Geometry: Semi Periodic with no Centre Airhole



In a well-designed hexagonal PCF, most of the power is confined within the core region.

4th JULY

PARAMETER:

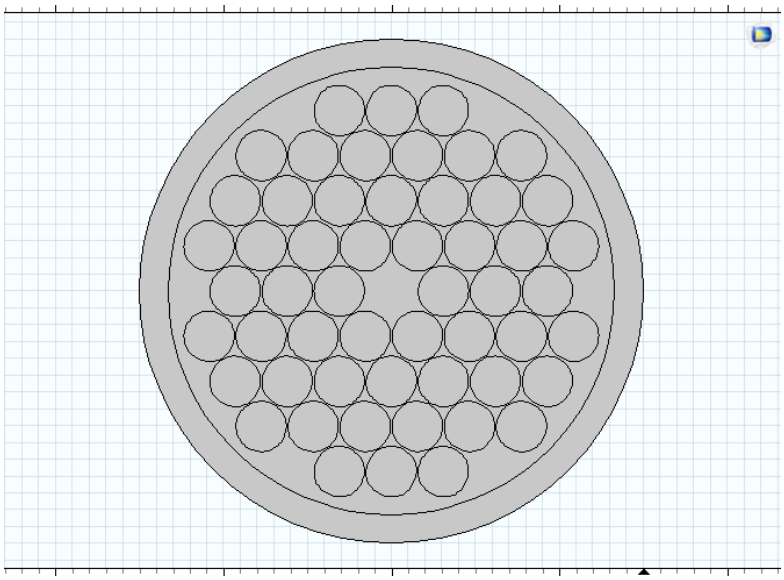
AIRHOLE RADIUS: 7.5 um

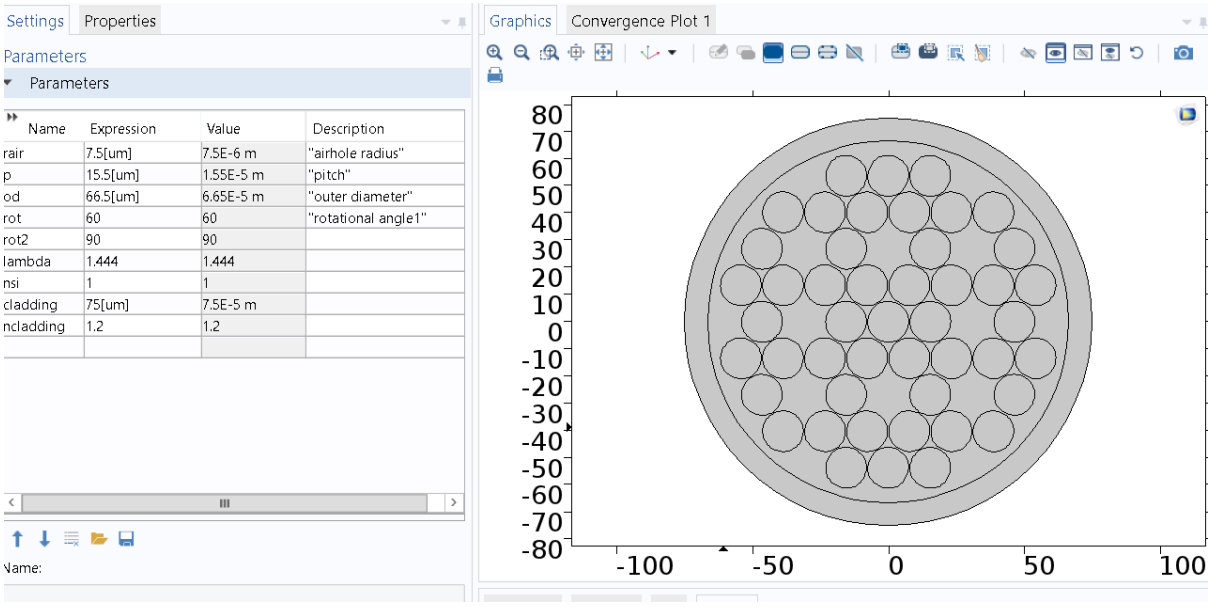
GEOMETRY: PERIODIC NO AHC

PARAMETER:

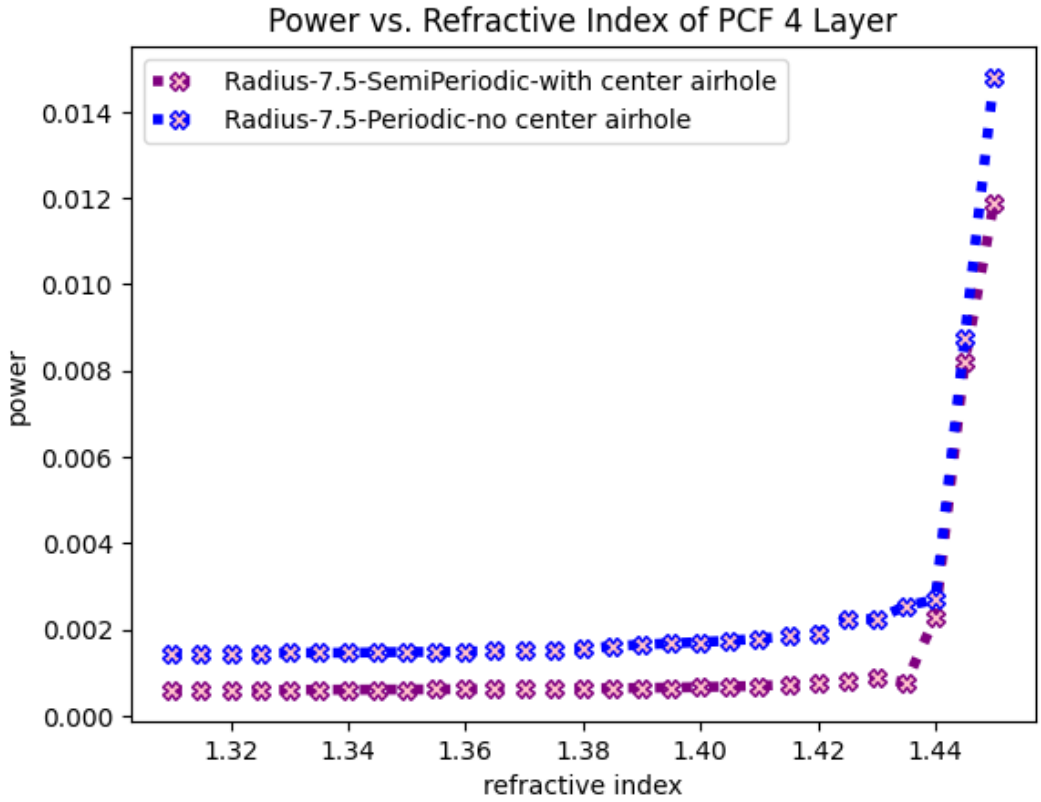
AIRHOLE RADIUS: 7.5 um

GEOMETRY: SEMI PERIODIC with AHC





RESULT:

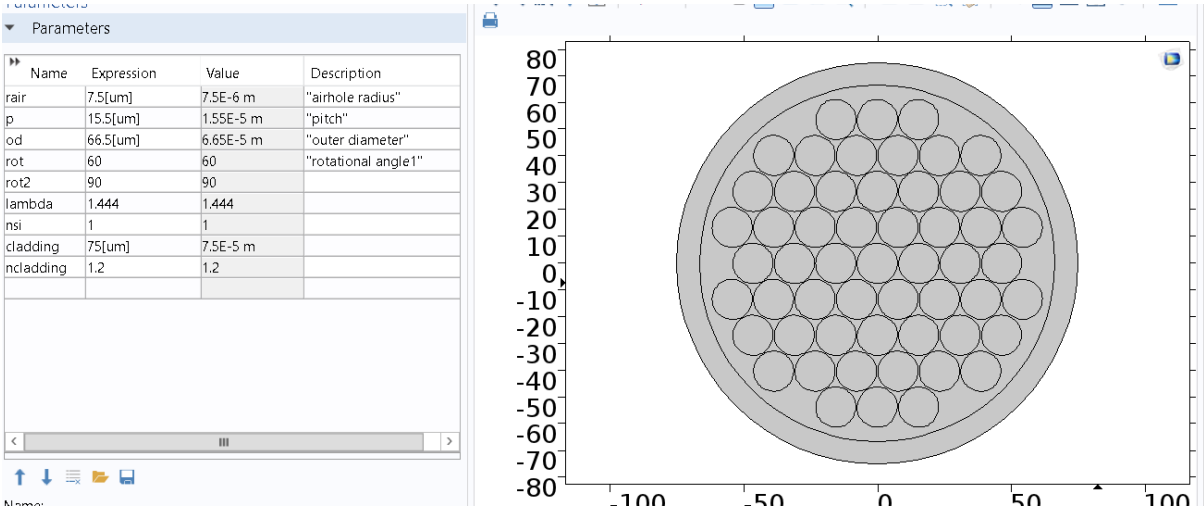


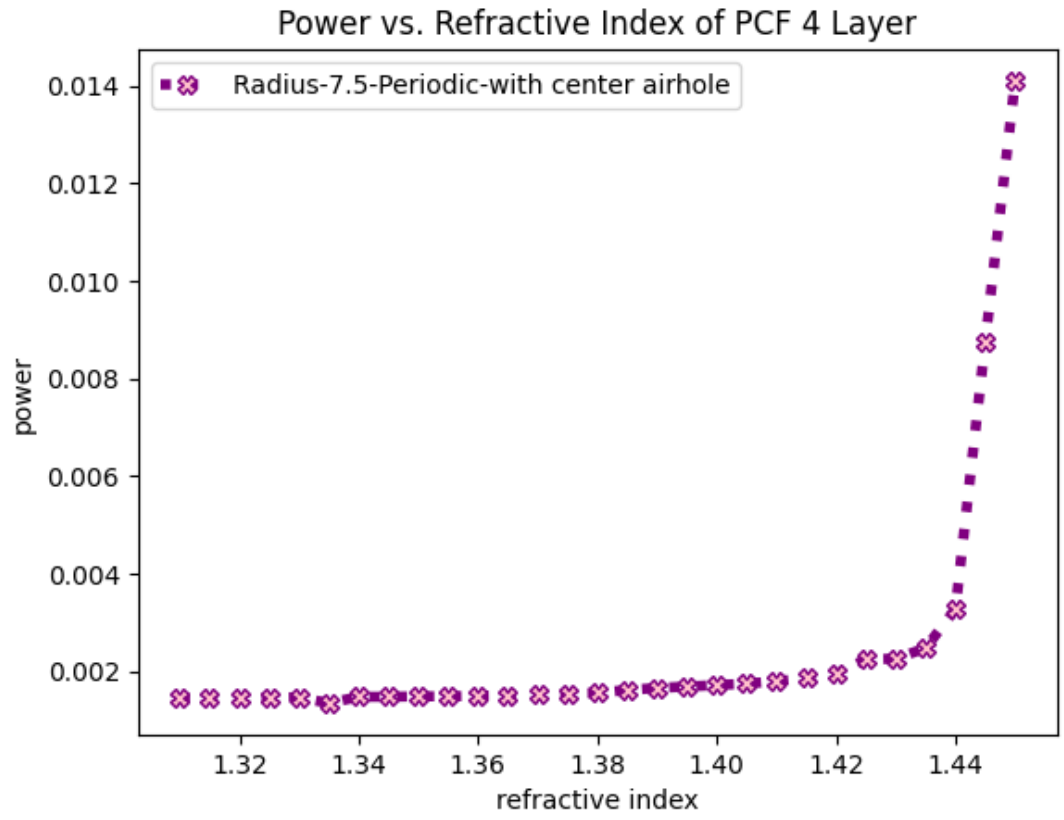
5TH JULY

PARAMETER:

AIRHOLE RADIUS: 7.5 um

GEOMETRY: PERIODIC with AHC



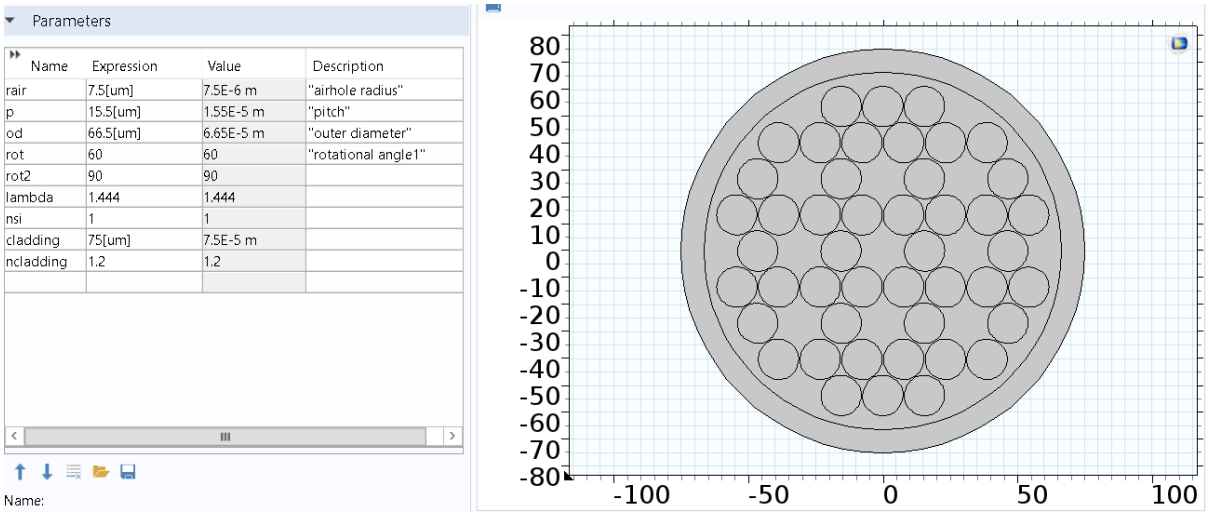


WEEK 5:

PARAMETER:

AIRHOLE RADIUS: 7.5 um

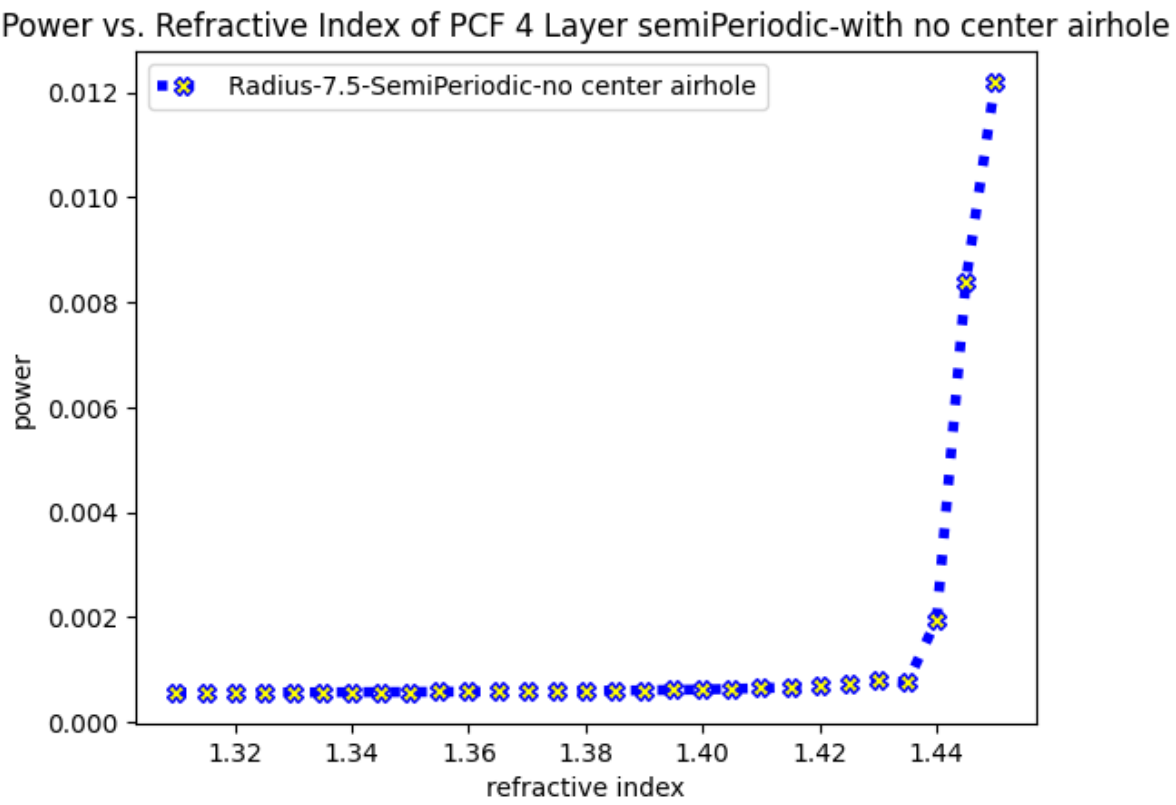
GEOMETRY: SEMI PERIODIC with no AHC



Parameters

Name	Expression	Value	Description
rair	7.5[um]	7.5E-6 m	"airhole radius"
p	15.5[um]	1.55E-5 m	"pitch"
od	66.5[um]	6.65E-5 m	"outer diameter"
rot	60	60	"rotational angle1"
rot2	90	90	
lambda	1.444	1.444	
nsi	1	1	
cladding	75[um]	7.5E-5 m	
ncladding	1.2	1.2	

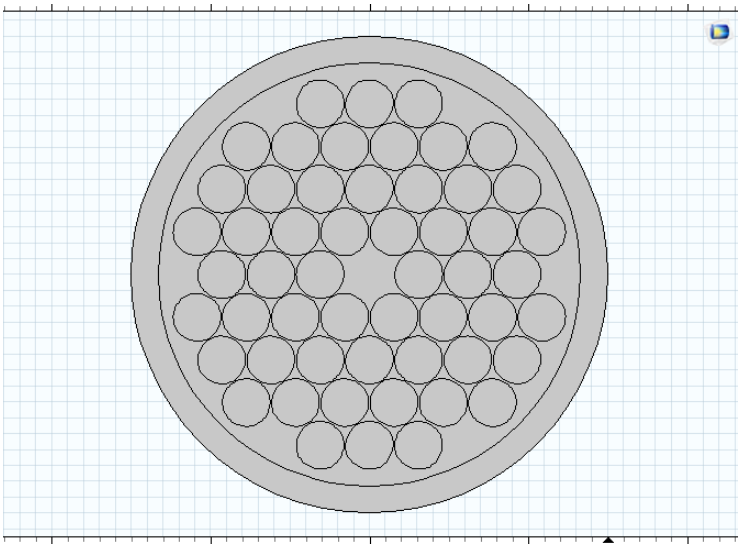
Name:

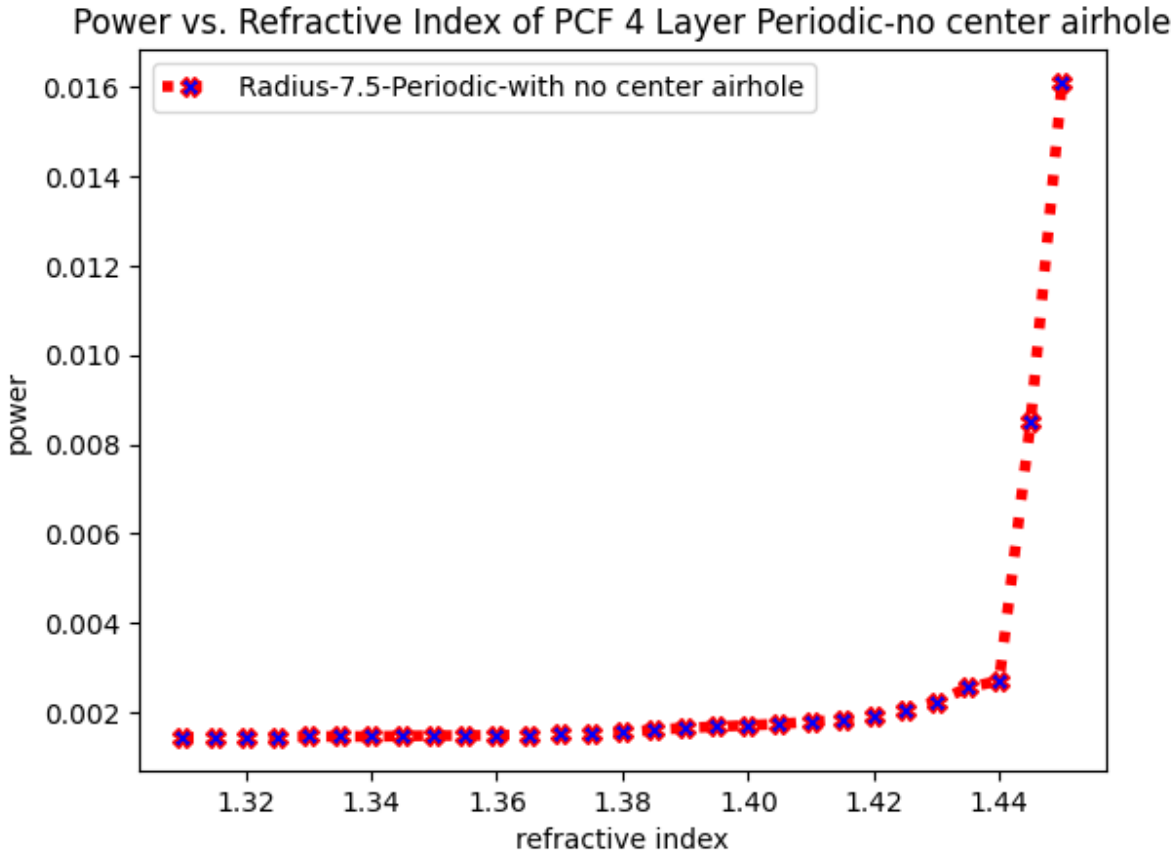


PARAMETER:

AIRHOLE RADIUS: 7.5 um

GEOMETRY: PERIODIC with no AHC





PARAMETER:

AIRHOLE RADIUS: 7.5 um
GEOMETRY:
PERIODIC—With AHC + without AHC

SEMIPERIODIC—with AHC + without AHC

WORKING PRINCIPLE:

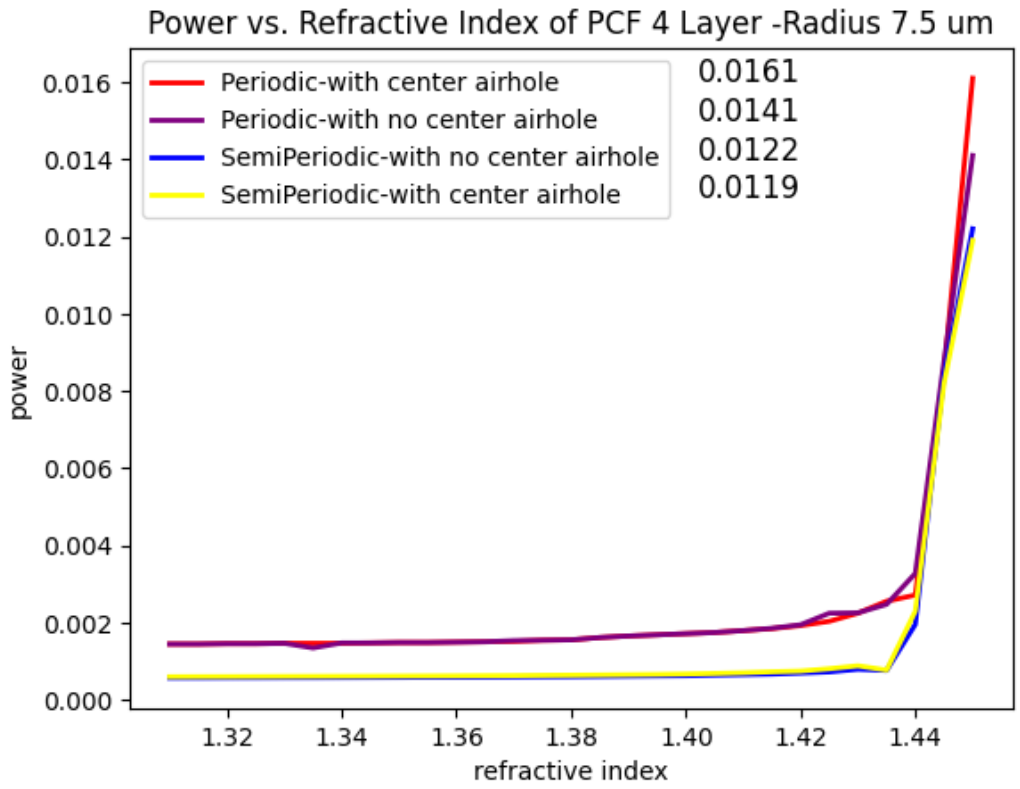
In a photonic crystal Fiber, Total Internal reflection is required to guide the light into the core and this can be achieved is n_{Cl} (Refractive Index of cladding) is less than n_{cO} (Refractive Index of core)

CASE 1: $n_{cO} > n_{Cl}$ Total Internal reflection of light at core-cladding boundary.

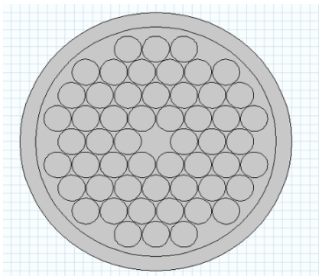
If the Refractive Index of Cladding is higher than the Refractive Index of the Core, then light will not be confined to the core. Instead, it will refract out of the core and into the cladding. This causes significant signal loss.

CASE 2: $n_{cO} < n_{Cl}$ No Total Internal reflection or Leakage of light into cladding

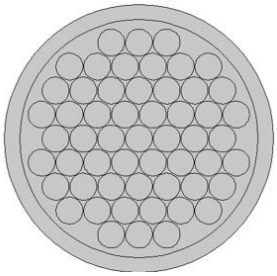
Below is the plot of COMSOL Multiphysics simulation of a PCF of Total thickness 66.5 um and Airhole radius of 7.5 um and analyzing the dispersion of light injected in Periodic and Semi periodic arrangement of Airhole



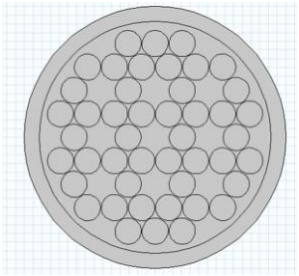
PERIODIC with no AHC



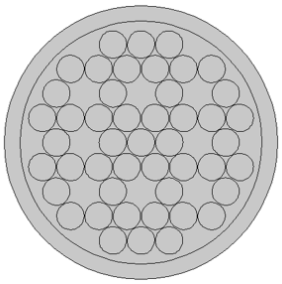
PERIODIC with AHC



SEMI PERIODIC with no AHC



SEMI PERIODIC with AHC

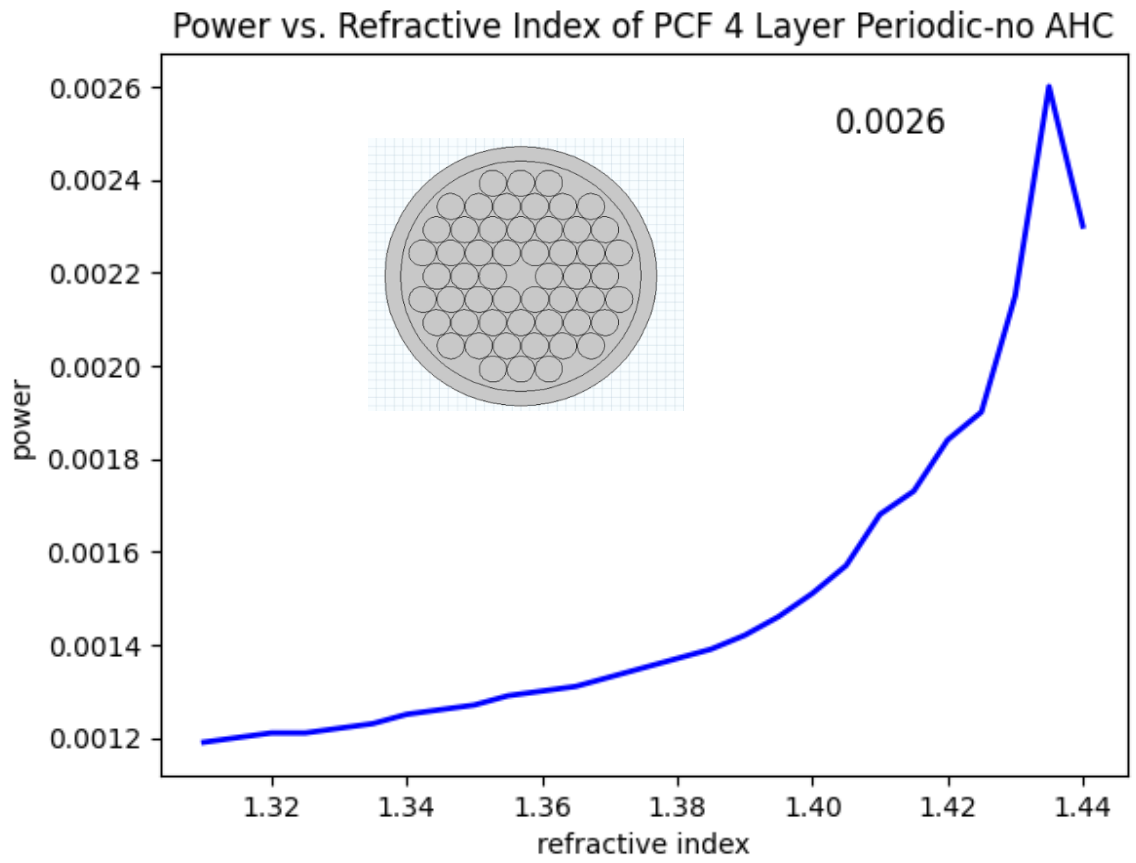


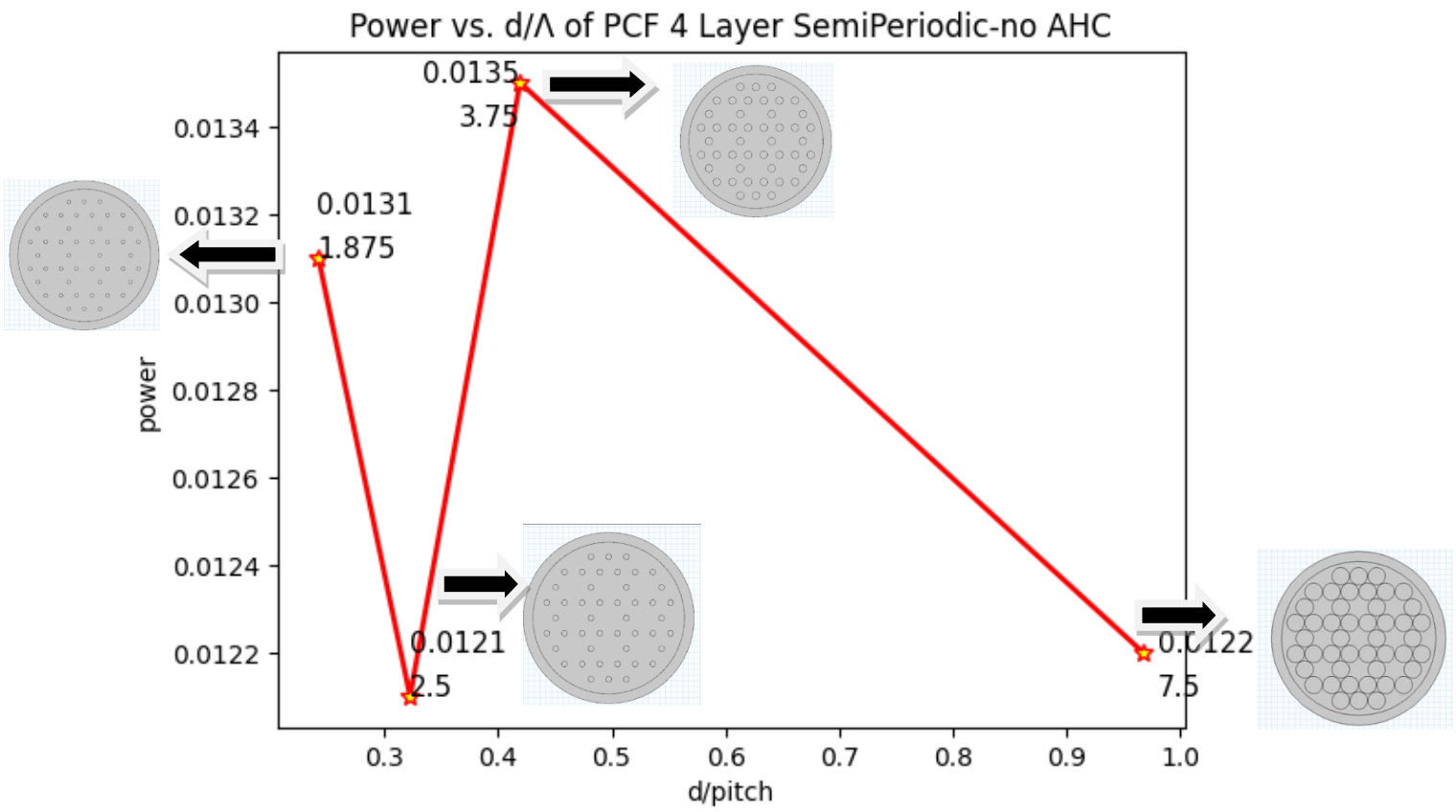
8th Jul

PARAMETER:

AIRHOLE RADIUS: 7.5 um
GEOMETRY:

PERIODIC—without AHC





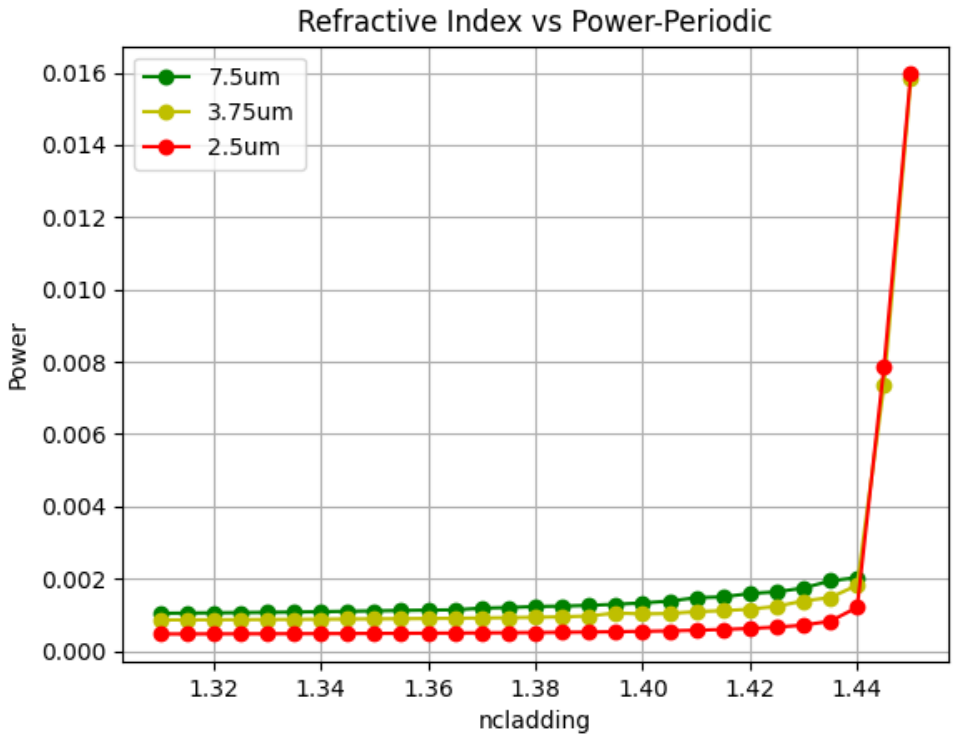
PLOT IN DIAMETER/ PITCH FOR SEMIPERIODIC GEOMETRY

CODE:

```
import matplotlib.pyplot as graph

#SemiperiodicnoAHC
xaxis=[0.967741935,0.419354839,0.322580645,0.241935484]

power75semiperiodic=[5.63E-04,5.65E-04,5.66E-04,5.67E-04,5.68E-04,5.70E-
04,5.72E-04,5.74E-04,5.76E-04,5.79E-04,5.81E-04,5.84E-04,5.88E-04,5.92E-
04,5.96E-04,6.02E-04,6.08E-04,6.14E-04,6.23E-04,6.35E-04,6.46E-04,6.60E-
04,6.81E-04,7.28E-04,7.56E-04,6.23E-04,2.26E-03,7.86E-03,1.22E-02]
r1=7.5
pmax75SP=max(power75semiperiodic)
graph.text(0.98,0.0122,pmax75SP, fontsize=11, ha='left')
graph.text(0.98,0.0121,r1, fontsize=11, ha='left')

power375SP = [5.63E-04,6.67E-04,5.66E-04,5.67E-04,5.68E-04,5.70E-04,5.72E-
04,5.74E-04,5.76E-04,5.78E-04,5.81E-04,5.83E-04,5.86E-04,5.91E-04,5.95E-
04,6.00E-04,6.05E-04,6.12E-04,6.20E-04,6.35E-04,
6.42E-04,6.58E-04,6.78E-04,7.06E-04,7.47E-04,7.96E-04,1.28E-03,7.64E-
03,1.35E-02]
pmax375=max(power375SP)
r2=3.75
graph.text(0.419,0.0135,pmax375, fontsize=11, ha='right')
```

```
graph.text(0.419,0.0134,r2, fontsize=11, ha='right')

power25SP = [5.63E-04,5.64E-04,5.66E-04,5.67E-04,5.69E-04,5.70E-04,5.72E-
04,5.74E-04,5.76E-04,5.79E-04,5.81E-04,5.84E-04,5.88E-04,5.91E-04,5.95E-
04,5.99E-04,6.07E-04,6.12E-04,6.23E-04,6.33E-04,6.48E-04,6.63E-04,6.94E-
04,7.06E-04,7.67E-04,7.57E-04,1.95E-03,8.08E-03,1.21E-02]
pmax25SP=max(power25SP)
r3=2.5
graph.text(0.322,0.0122,pmax25SP, fontsize=11, ha='left')
graph.text(0.322,0.0121,r3, fontsize=11, ha='left')

power18SP= [5.63E-04,5.64E-04,5.66E-04,5.67E-04,5.68E-04,5.70E-04,5.72E-
04,5.74E-04,5.76E-04,5.79E-04,5.82E-04,5.84E-04,5.88E-04,5.91E-04,5.94E-
04,6.00E-04,6.06E-04,6.12E-04,6.21E-04,6.30E-04,6.43E-04,6.60E-04,6.89E-
04,7.06E-04,7.47E-04,7.96E-04,9.85E-04,7.10E-03,1.31E-02]
pmax18SP= max(power18SP)
r4=1.875
graph.text(0.24,0.0132,pmax18SP, fontsize=11, ha='left')
graph.text(0.24,0.0131,r4, fontsize=11, ha='left')

pmax=[pmax75SP,pmax375,pmax25SP,pmax18SP]
#plot
graph.plot(xaxis, pmax, color='red', linestyle='solid', marker='*',
linewidth=2, markerfacecolor='yellow',markersize=7)


graph.xlabel('d/pitch')
graph.ylabel('power')
graph.title('Power vs. d/Λ of PCF 4 Layer SemiPeriodic-no AHC')
# function to show the plot
graph.show()
```

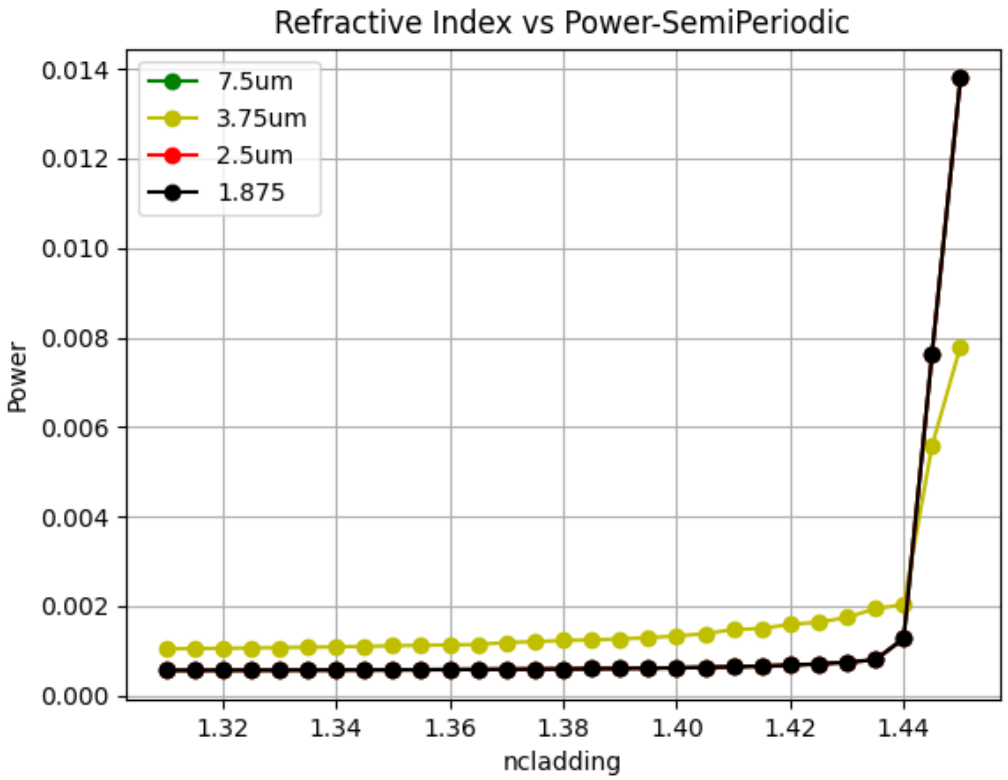
9th JUL

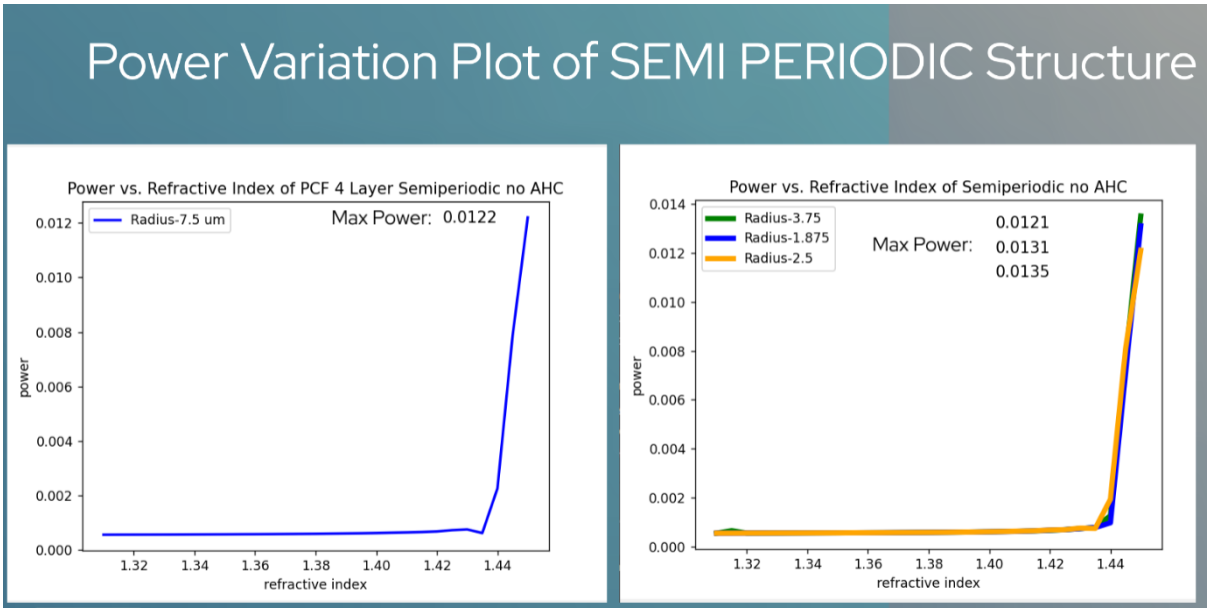


PERIODIC RESULTS:

The data for the plot is in Excel sheet “MOF”

SEMIPERIODIC RESULTS:



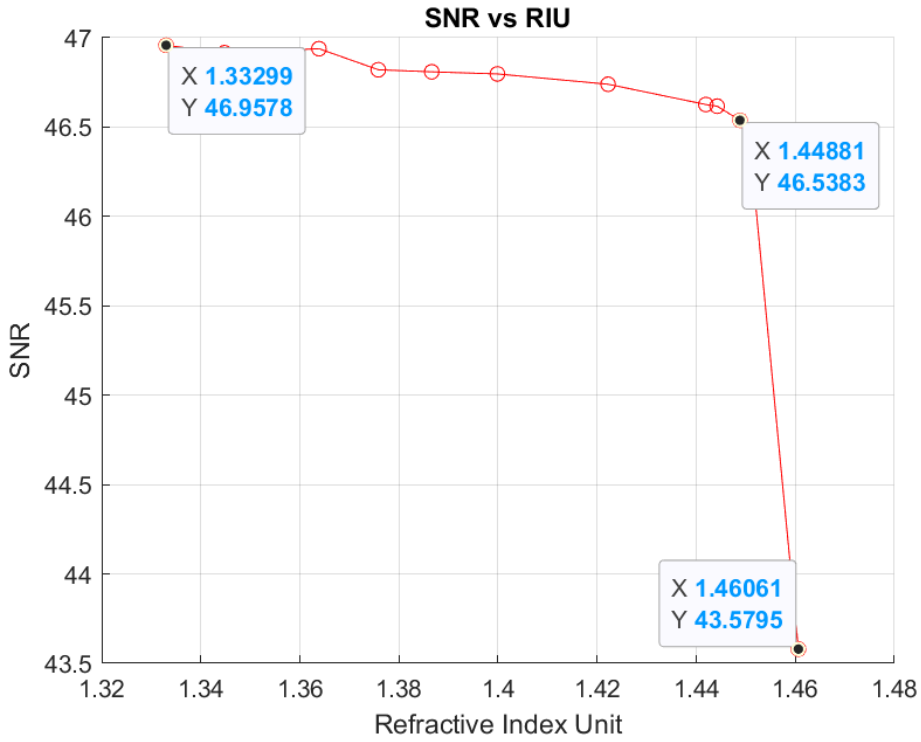


CODE:

```
import matplotlib.pyplot as graph

#periodicnoairhole
ncl75periodic=[1.31, 1.315, 1.32, 1.325, 1.33, 1.335, 1.34, 1.345, 1.35,
1.355, 1.36, 1.365, 1.37, 1.375, 1.38, 1.385, 1.39,1.395, 1.4, 1.405, 1.41,
1.415, 1.42, 1.425, 1.43, 1.435, 1.44, 1.445, 1.45]
power75periodic=[1.44E-03,1.44E-03,1.45E-03,1.45E-03,1.46E-03,1.34E-
03,1.47E-03,1.47E-03,1.48E-03,1.48E-03,1.49E-03,1.50E-03,1.53E-03,1.54E-
03,1.55E-03,1.61E-03,1.65E-03,1.68E-03,1.71E-03,1.74E-03,1.79E-03,1.85E-
03,1.94E-03,2.24E-03,2.25E-03,2.47E-03,3.27E-03,8.76E-03,1.41E-02]
pmax75noAHC=max(power75periodic)
graph.text(1.44,0.014,pmax75noAHC, fontsize=12, ha='right')
#plot
graph.plot(ncl75periodic, power75periodic, color='blue', linestyle='solid',
linewidth=2,markersize=7)


ncl375periodic=[1.31, 1.315, 1.32, 1.325, 1.33, 1.335, 1.34, 1.345, 1.35,
1.355, 1.36, 1.365, 1.37, 1.375, 1.38, 1.385, 1.39,1.395, 1.4, 1.405, 1.41,
1.415, 1.42, 1.425, 1.43, 1.435, 1.44]
power375periodic=[1.42E-02,1.37E-02,1.33E-02,1.29E-02,1.24E-02,1.20E-
02,1.15E-02,1.11E-02,1.06E-02,1.02E-02,9.71E-03,9.24E-03,8.78E-03,8.31E-
03,7.85E-03,7.36E-03,6.88E-03,6.38E-03,5.90E-03,5.39E-03,4.86E-03,4.32E-
03,3.77E-03,3.20E-03,2.58E-03,1.90E-03,1.06E-03]
pmax375noAHC=max(power375periodic)


#plot
graph.plot(ncl375periodic, power375periodic, color='red',
linestyle='solid', linewidth=2,markersize=7)
graph.text(1.44,0.001,pmax75noAHC, fontsize=12, ha='left')



ncl25periodic=[1.31, 1.315, 1.32, 1.325, 1.33, 1.335, 1.34, 1.345, 1.35,
1.355, 1.36, 1.365, 1.37, 1.375, 1.38, 1.385, 1.39,1.395, 1.4, 1.405, 1.41,
1.415, 1.42, 1.425, 1.43, 1.435, 1.44]
power25periodic=[2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-
03,2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-
03,2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-
03,2.88E-03,2.88E-03,2.88E-03,2.88E-03,2.88E-03]
pmax25noAHC=max(power25periodic)
graph.text(1.42,0.005,pmax25noAHC, fontsize=12, ha='right')


#plot
graph.plot(ncl25periodic, power25periodic, color='green',
linestyle='solid', linewidth=2,markersize=7)


graph.xlabel('refractive index')
graph.ylabel('power')
graph.title('Power vs. Refractive Index of PCF 4 Layer Periodic-Periodic no
AHC')
graph.legend(['Radius-7.5 um','Radius-3.75 um','Radius-2.5 um'])
# function to show the plot
graph.show()
#%%
```

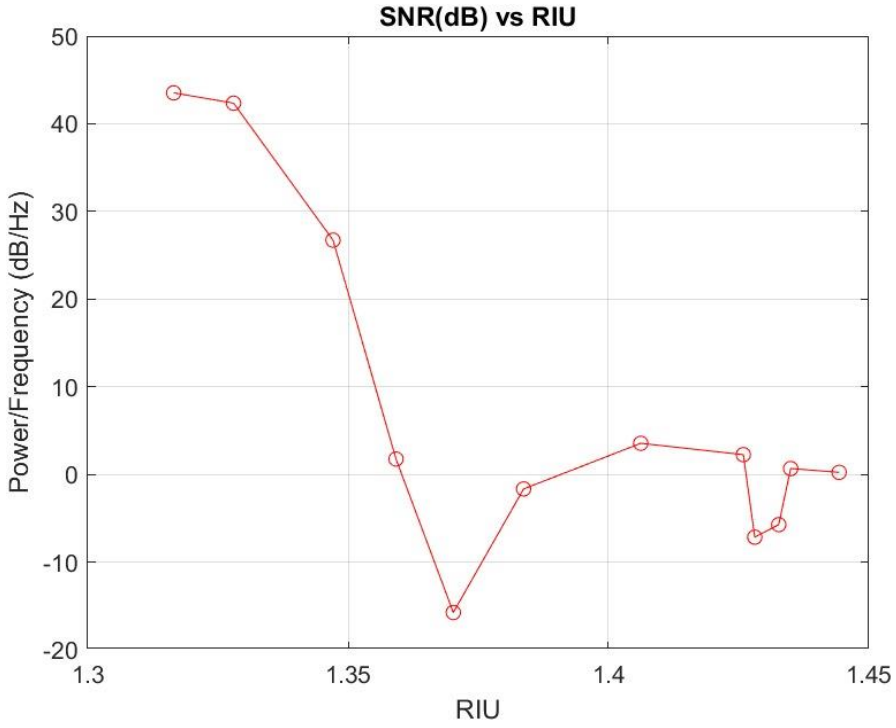
SNR vs RIU PLOT

As per ICUMSA(International Committee of Uniform Method of Sugar Analysis

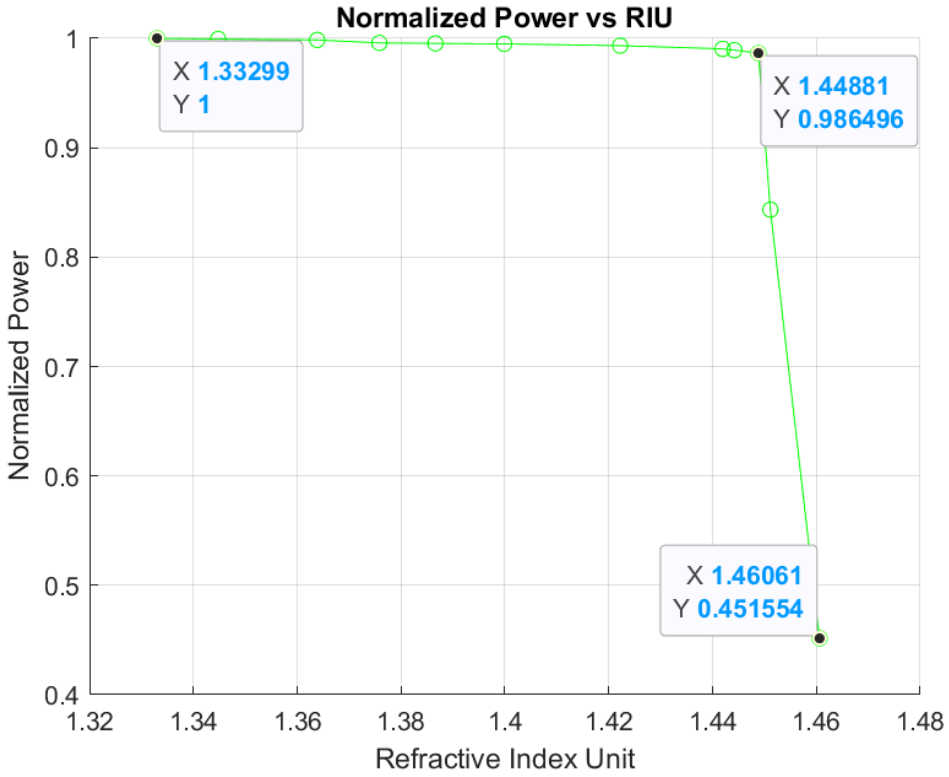


As my previous plot was not correct-The noise part was calculated from reference element while signal was calculated from sensing element Hence does not match

With the dataset i have, I tried to calculate the SNR but the plot does not look proper.
The program is in file ‘psdtrial2.m’ and ‘psdtrial.m’



Normalised Power Plot

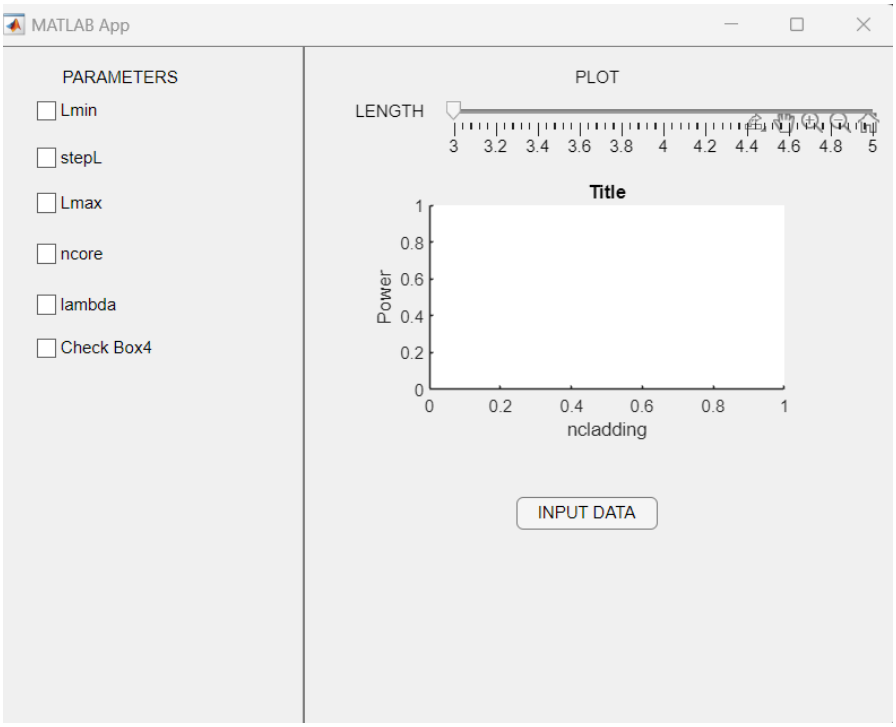


GUI

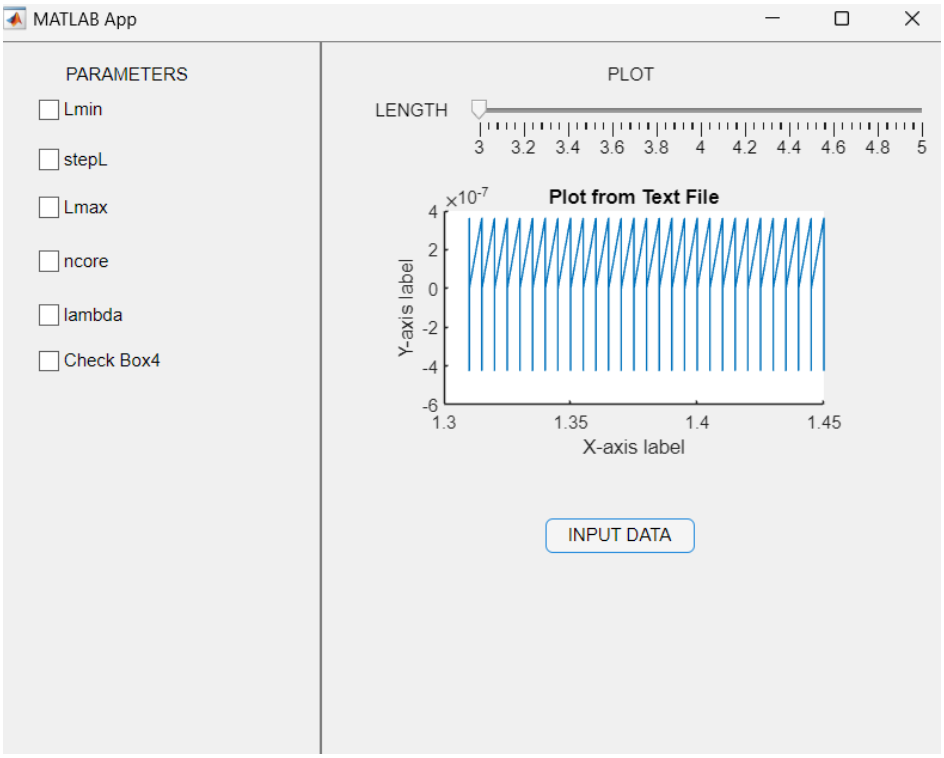
An attempt of creating a GUI was done. However, improvisations has to be done.

Clicking on the program PCF, opens the GUI box

select INPUT DATA button, to insert the .txt file for the plot



Result appears as below



CONCLUSIONS

REFERENCES:

REFERENCES

Chiang, Jung-Sheng. (2018). Analysis of Leaky Modes in Photonic Crystal Fibers Using the Surface Integral Equation Method. Crystals. 8. 177. 10.3390/cryst8040177.

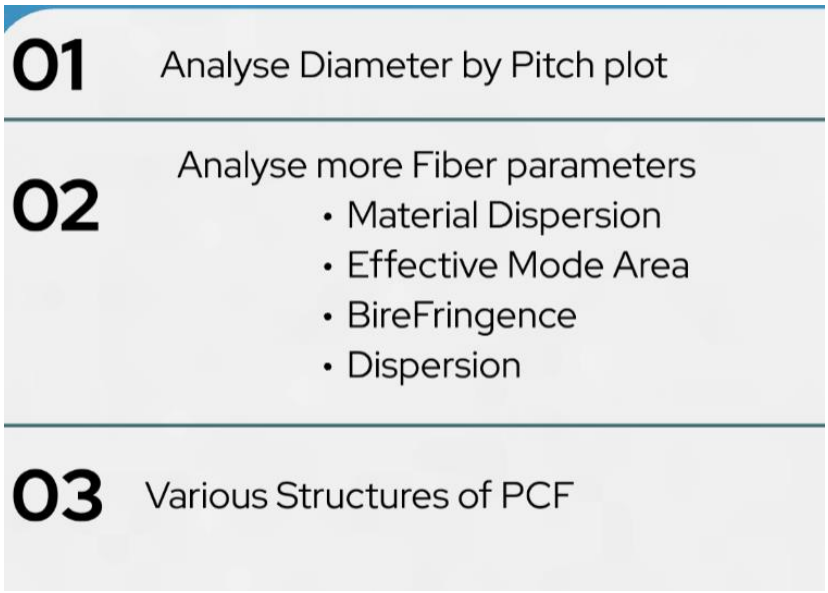
" The confinement losses are monotonically **decreased with the air-hole size and the number of air-hole rings**. It can be seen that both a **small air-hole size** and a smaller number of air-holes induce **a larger loss**, but reduce rapidly if the air-hole size is enlarged "

Chen, Ming-Yang & Zhou, Jun. (2014). Design of add-drop multiplexer based on multi-core optical fibers for mode-division multiplexing. Optics Express. 22. 1440-51. 10.1364/OE.22.001440.

Z. Liu and H.-Y. Tam, 'Fabrication and Sensing Applications of Special Microstructured Optical Fibers', Selected Topics on Optical Fiber Technologies and Applications. InTech, Feb. 14, 2018. doi: 10.5772/intechopen.70755.

M. Uthman, B. M. A. Rahman, N. Kejalakshmy, A. Agrawal and K. T. V. Grattan, "Design and Characterization of Low-Loss Porous-Core Photonic Crystal Fiber," in IEEE Photonics Journal, vol. 4, no. 6, pp. 2315-2325, Dec. 2012, doi: 10.1109/JPHOT.2012.2231939.

FURTHER PROGRESS:



LINK to the presentation: https://prezi.com/p/edit/qp_j4x80ceyy/