Projeto de Circuitos Fotônicos Integrados

Circuitos fotônicos básicos

Atividade 2 – Anel de ressonância

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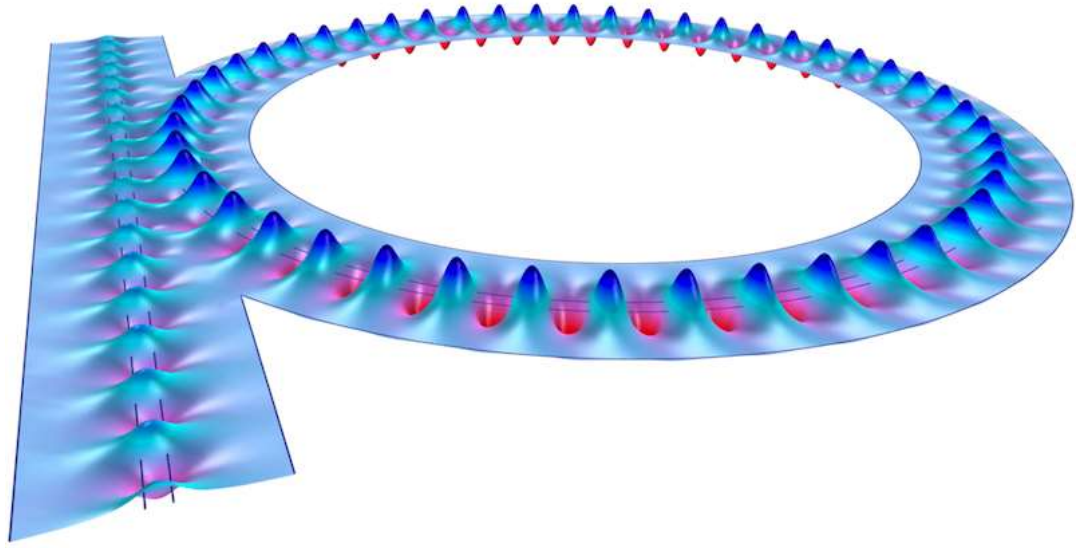
CURSOS, CAPACITAÇÃO E TREINAMENTOS

EMBRAPII

Empresa Brasileira de Pesquisa e Inovação Industrial

Sumário

- Introdução;
- Determinação do escopo;
- Fluxograma de determinação dos parâmetros;
- Determinação do índice efetivo e do índice de grupo;
- Determinação dos parâmetros do circuito (g, Q, Lc, etc.);
- Análise dos resultados (caso ideal);
- Análise dos resultados (utilizando dispositivos do PDK);
- GDS.

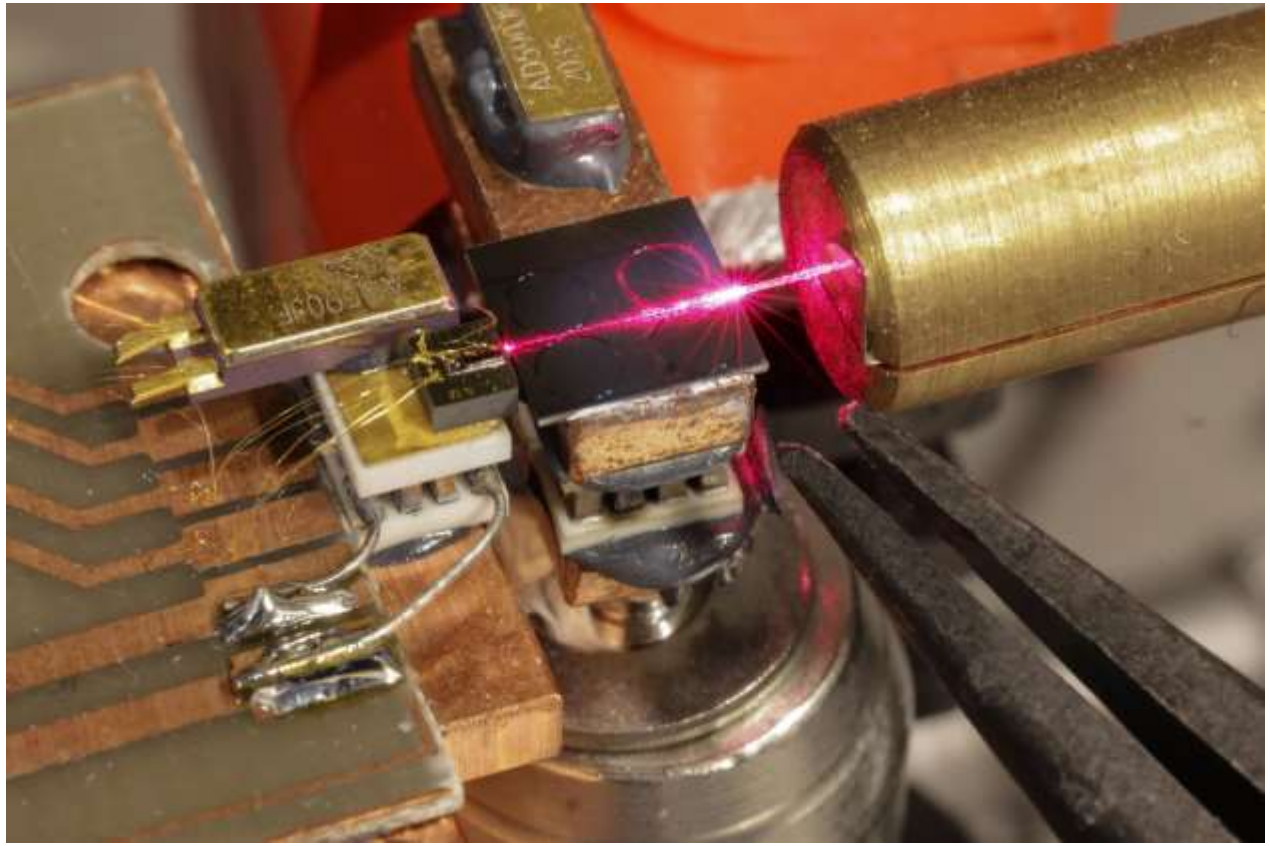


Introdução

Utilizado para medição de diferençao de fase relativa entre dois percuros ópticos.

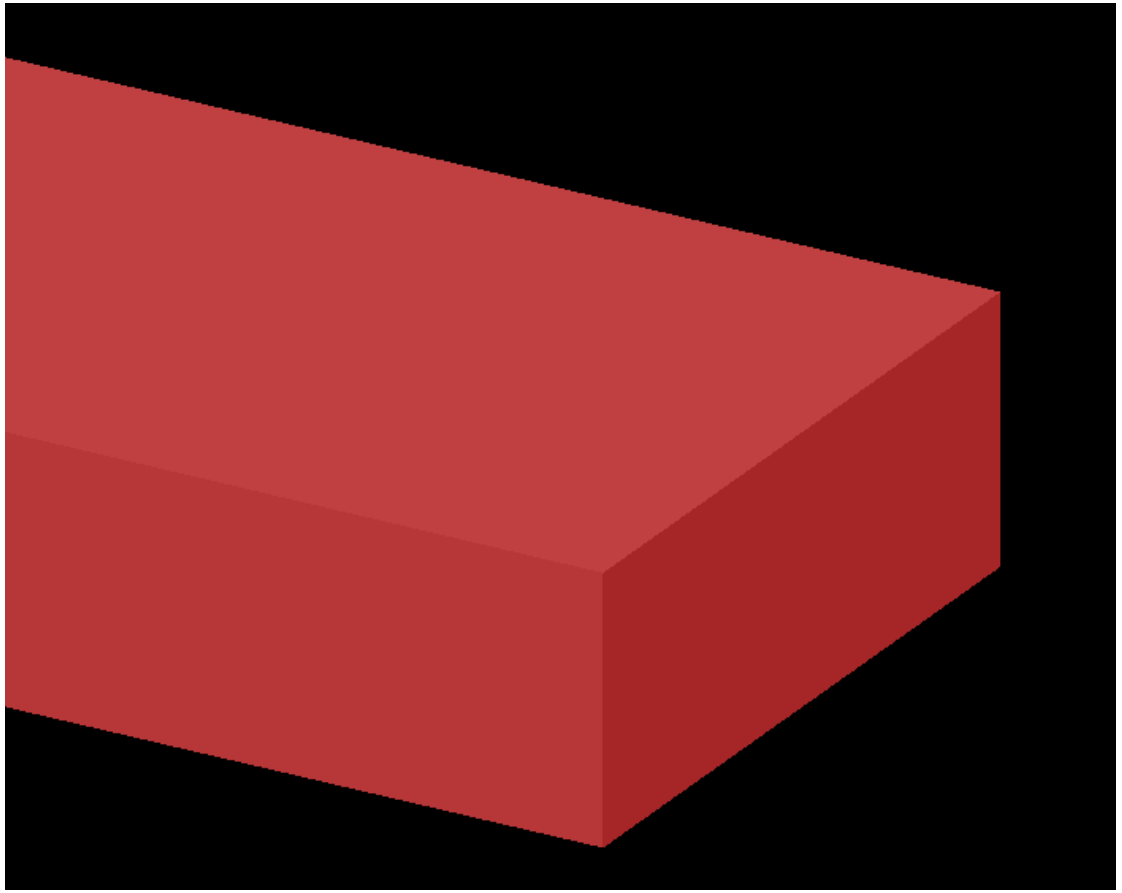
Aplicações:

- Filtragem;
- Biossensores;
- Modulação;
- Óptica não linear;
- Etc.

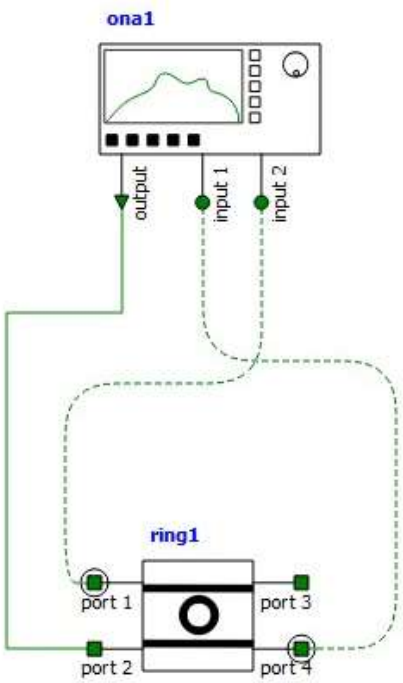


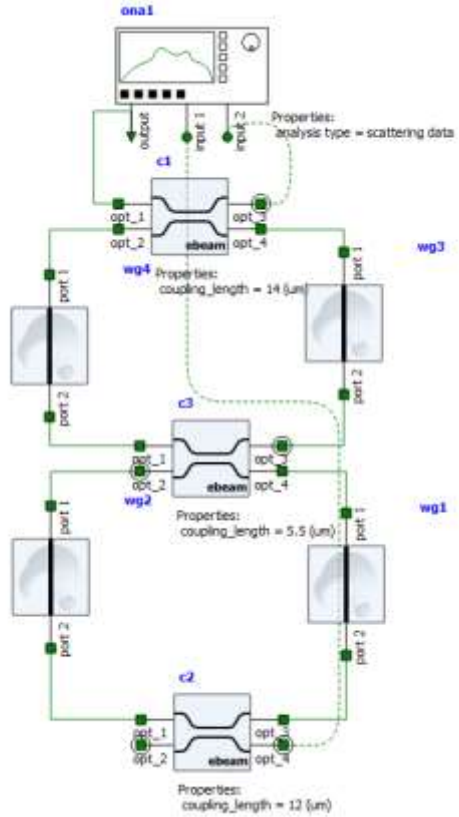
Tecnologia, geometria e circuitos

SOI - 450 x 220 nm

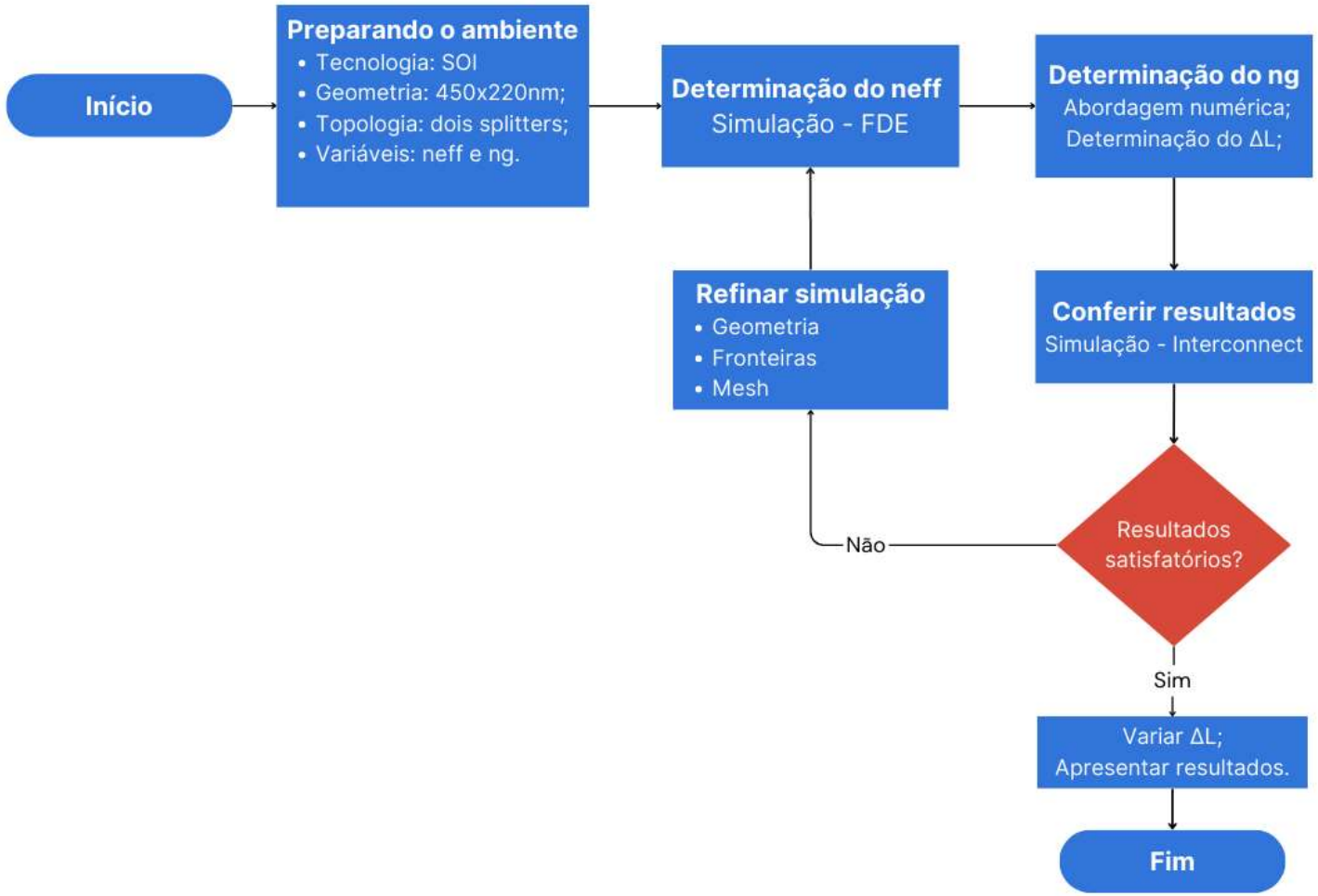


Circuitos: anel unitário e associação em série



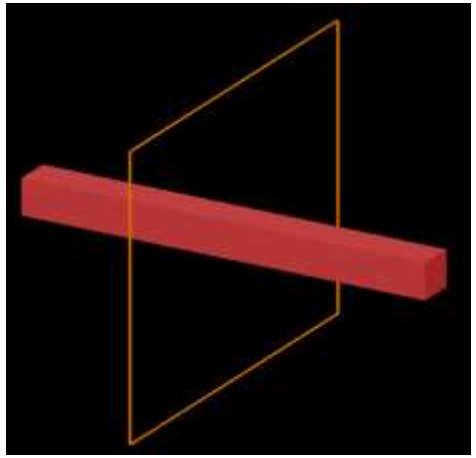


Fluxograma de determinação dos parâmetros iniciais



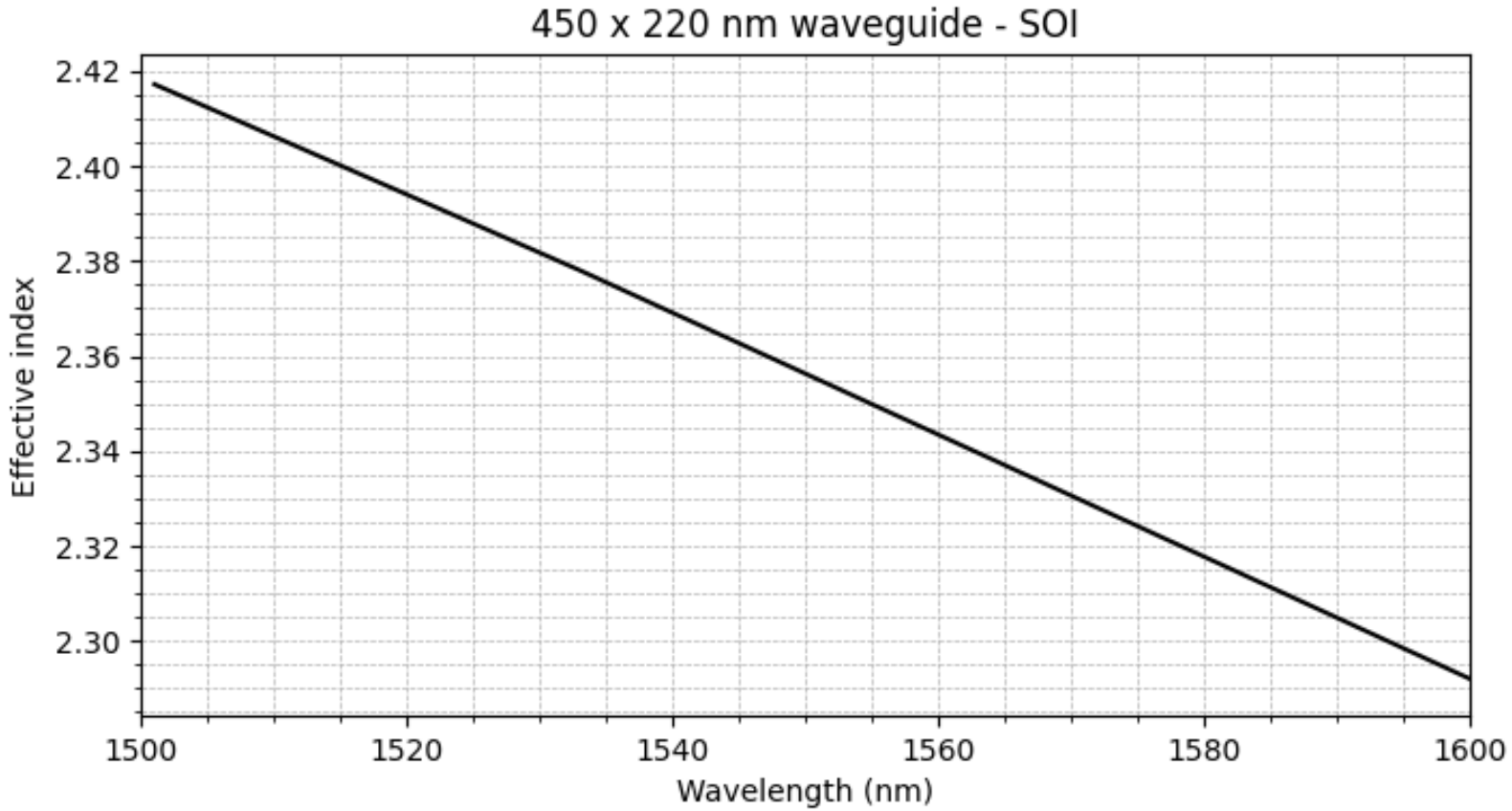
Extração do índice efetivo - FDE

Solver: 2D x normal



Condições de fronteira

x min bc	Metal
x max bc	Metal
y min bc	Metal
y max bc	Metal
z min bc	Metal
z max bc	Metal

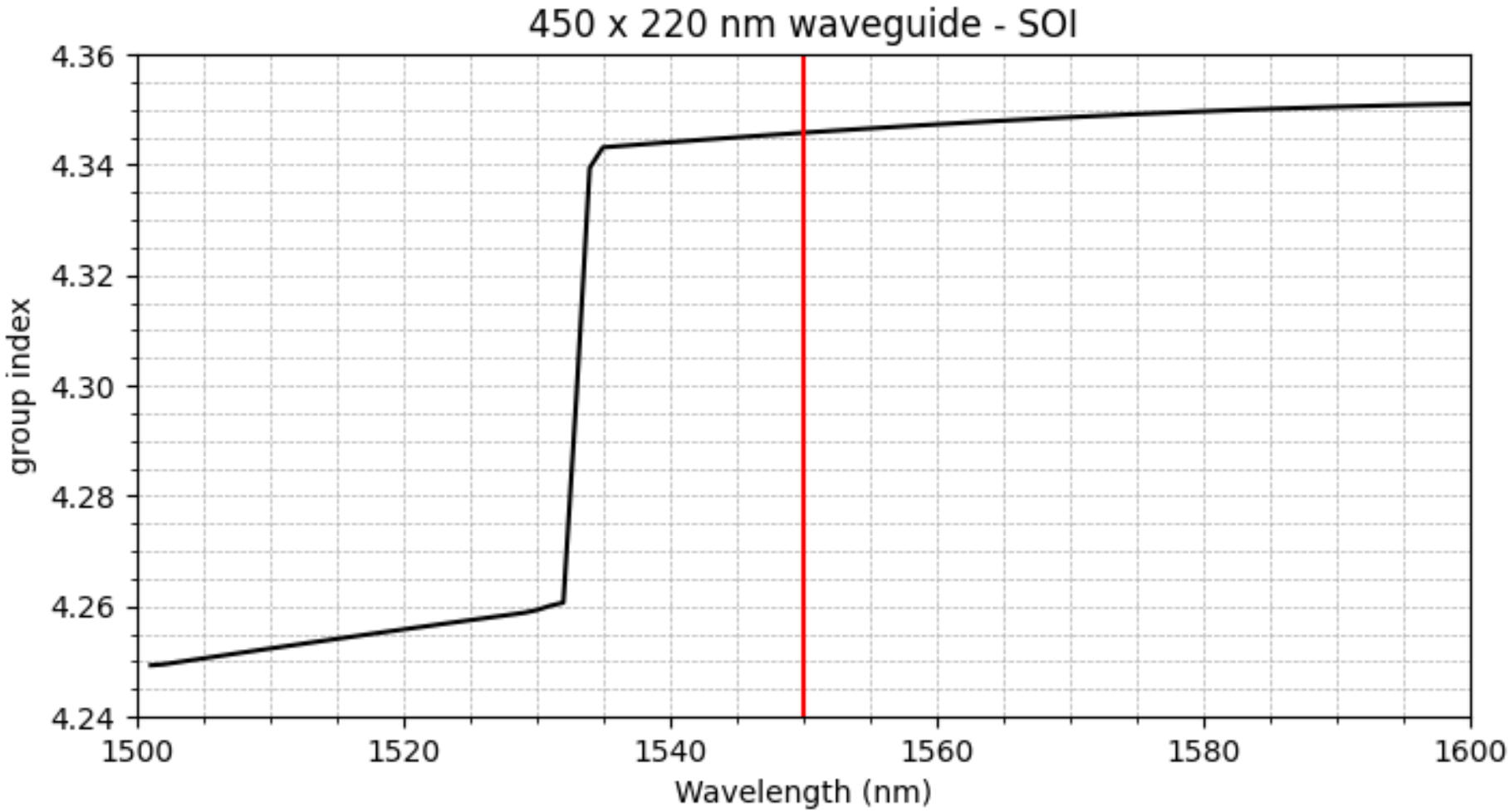


Determinação numérica do índice de grupo

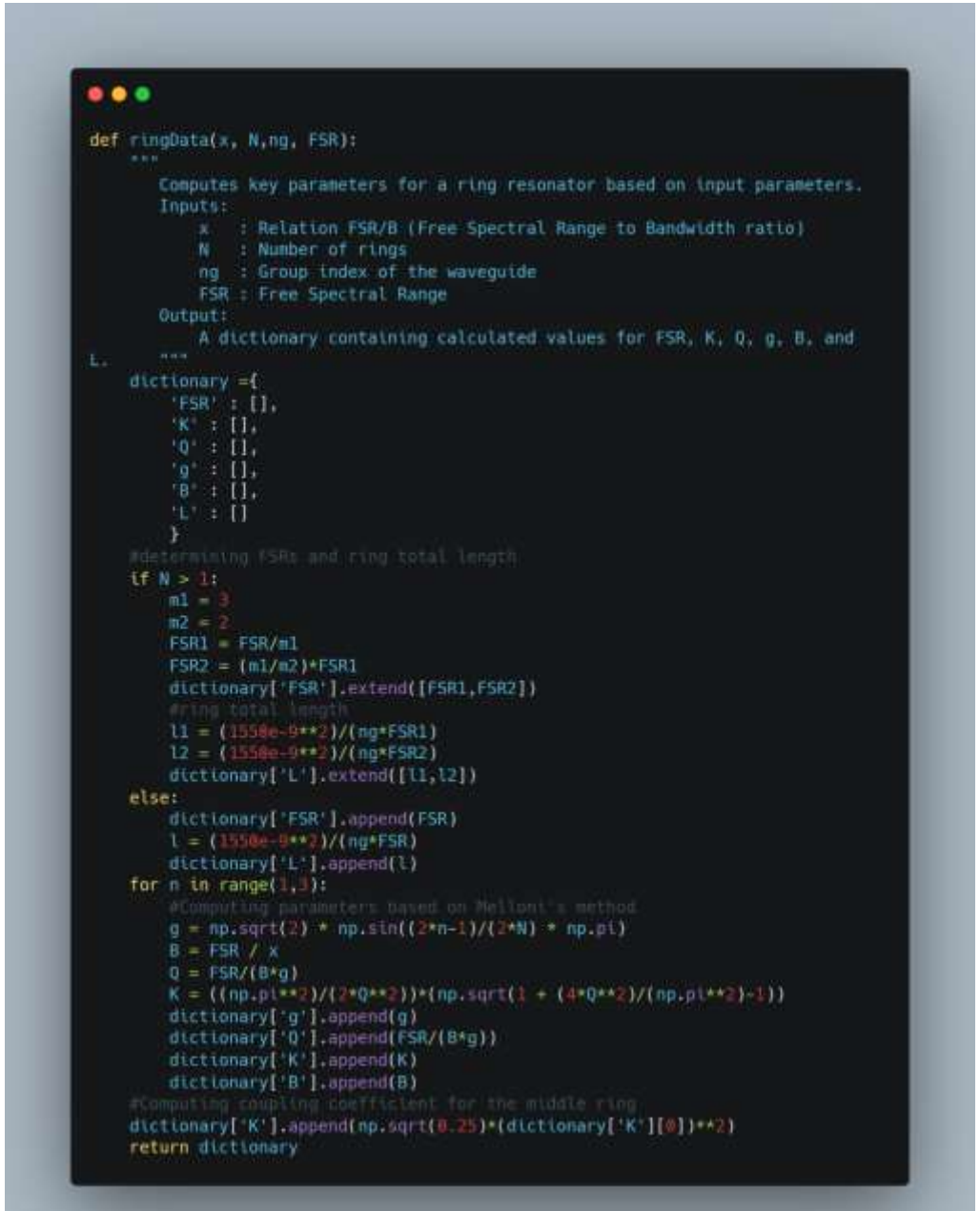
$$n_g(\lambda) = n_{\text{eff}}(\lambda) - \lambda \frac{dn_{\text{eff}}}{d\lambda}$$

```
def derivative(data):
    derive = np.zeros(len(data[:, 1]))
    derive[1:-1] = (data[2:, 1] - data[:-2, 1]) / (data[2:, 0] - data[:-2, 0])  # central
    derive[0] = (data[1, 1] - data[0, 1]) / (data[1, 0] - data[0, 0])  # foward
    derive[-1] = (data[-1, 1] - data[-2, 1]) / (data[-1, 0] - data[-2, 0])  # backward
    return np.transpose([data[:, 0], derive])
////////////
neff_lambda = np.column_stack((wavelength_sweep, neff_sweep))
derivative_neff = derivative.derivative(neff_lambda)
ng =  neff_sweep.flatten()- (derivative_neff[:,1]*wavelength_sweep.flatten())
```

Gráfico obtido – índice de grupo



Determinação dos parâmetros do circuito

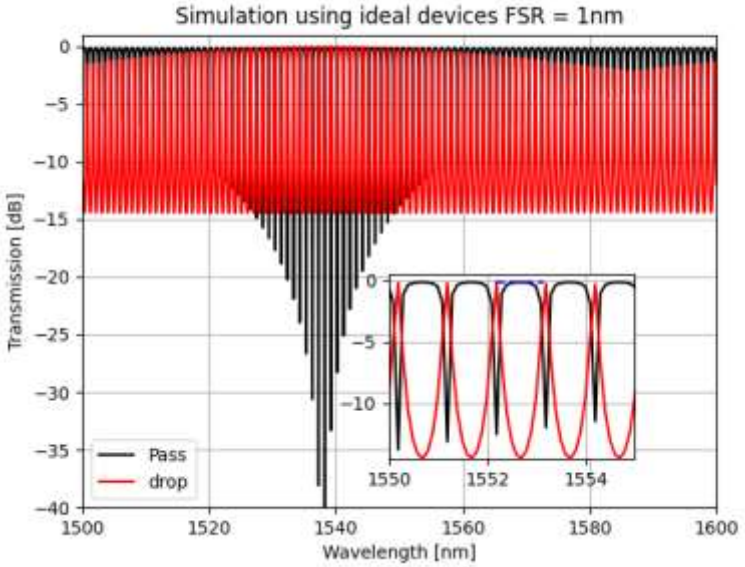


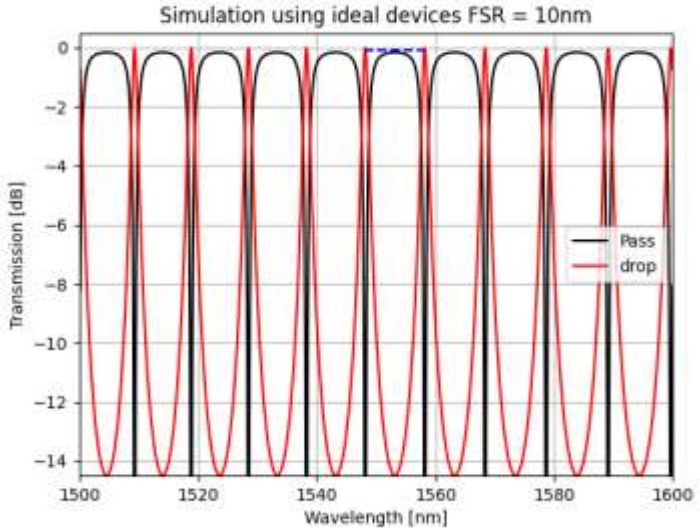
```python
def ringData(x, N,ng, FSR):
    """
       Computes key parameters for a ring resonator based on input parameters.
       Inputs:
           x   : Relation FSR/B (Free Spectral Range to Bandwidth ratio)
           N   : Number of rings
           ng  : Group index of the waveguide
           FSR : Free Spectral Range
       Output:
           A dictionary containing calculated values for FSR, K, Q, g, B, and
L.     """
    dictionary ={
        'FSR' : [],
        'K' : [],
        'Q' : [],
        'g' : [],
        'B' : [],
        'L' : []
        }
    #determining FSRs and ring total length
    if N > 1:
        m1 = 3
        m2 = 2
        FSR1 = FSR/m1
        FSR2 = (m1/m2)*FSR1
        dictionary['FSR'].extend([FSR1,FSR2])
        #ring total length
        l1 = (1550e-9**2)/(ng*FSR1)
        l2 = (1550e-9**2)/(ng*FSR2)
        dictionary['L'].extend([l1,l2])
    else:
        dictionary['FSR'].append(FSR)
        l = (1550e-9**2)/(ng*FSR)
        dictionary['L'].append(l)
    for n in range(1,3):
        #Computing parameters based on Melloni's method
        g = np.sqrt(2) * np.sin((2*n-1)/(2*N) * np.pi)
        B = FSR / x
        Q = FSR/(B*g)
        K = ((np.pi**2)/(2*Q**2))*(np.sqrt(1 + (4*Q**2)/(np.pi**2)-1))
        dictionary['g'].append(g)
        dictionary['Q'].append(FSR/(B*g))
        dictionary['K'].append(K)
        dictionary['B'].append(B)
    #Computing coupling coefficient for the middle ring
    dictionary['K'].append(np.sqrt(0.25)*(dictionary['K'][0])**2)
    return dictionary
```

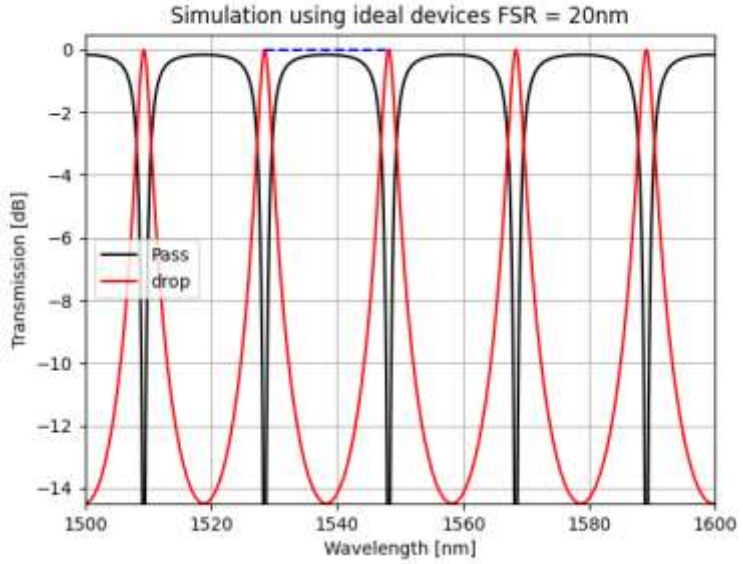
Circuitos com dispositivos ideias

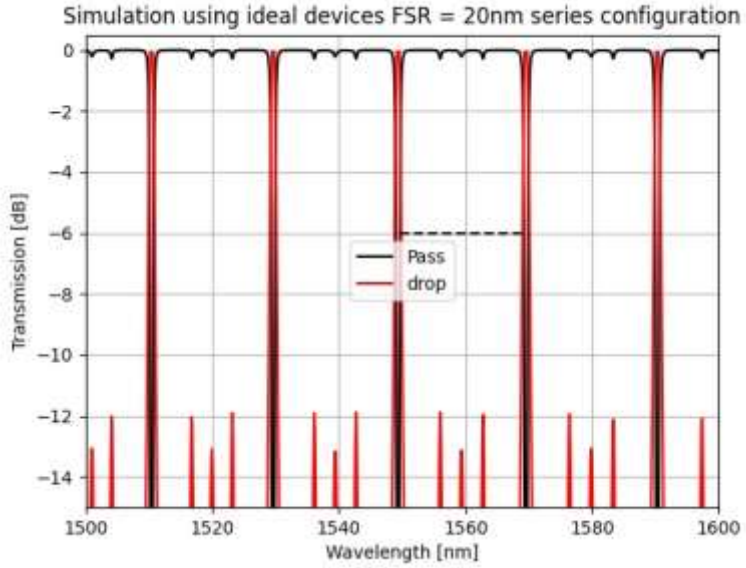
FSR/B	N	Ng	FSR (nm)	K1, K2	K3	L (μm)
10	1	4.355	1	0.4442	-	551.66
15	1	4.355	10	0.2961	-	55.164
15	1	4.355	20	0.2961	-	27.583
10	2	4.355	20	0.3141	0.0493	27.583

Transmissão do anel ressonante – dispositivos ideais

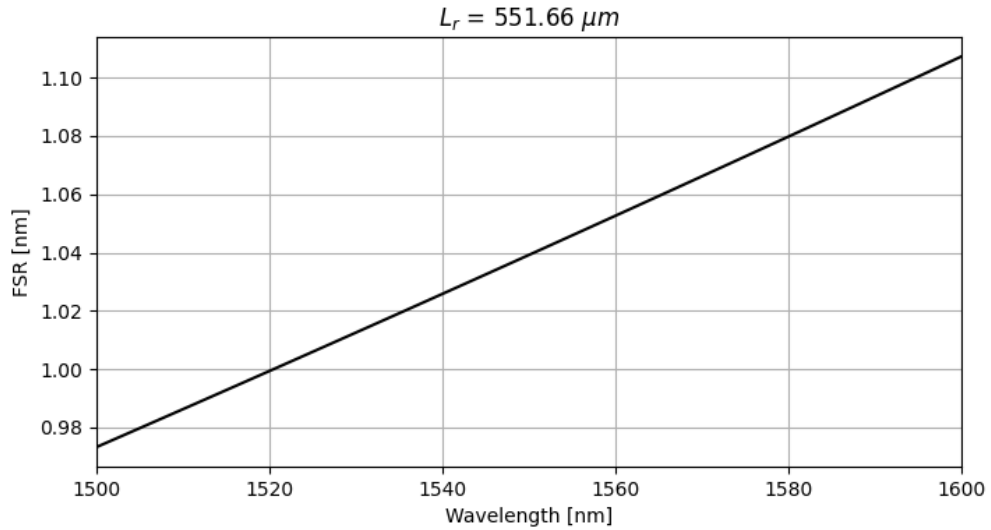


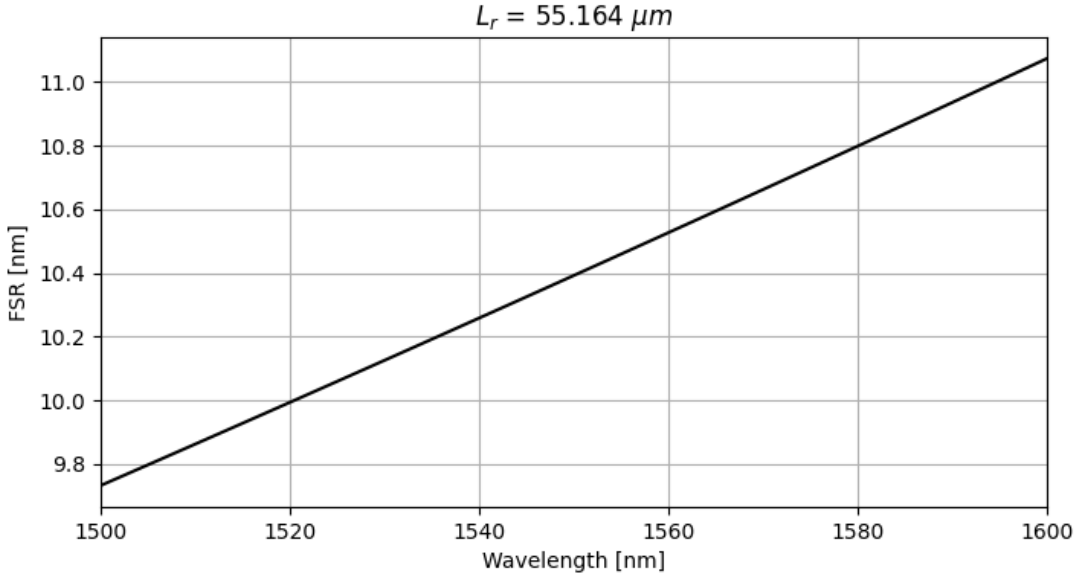


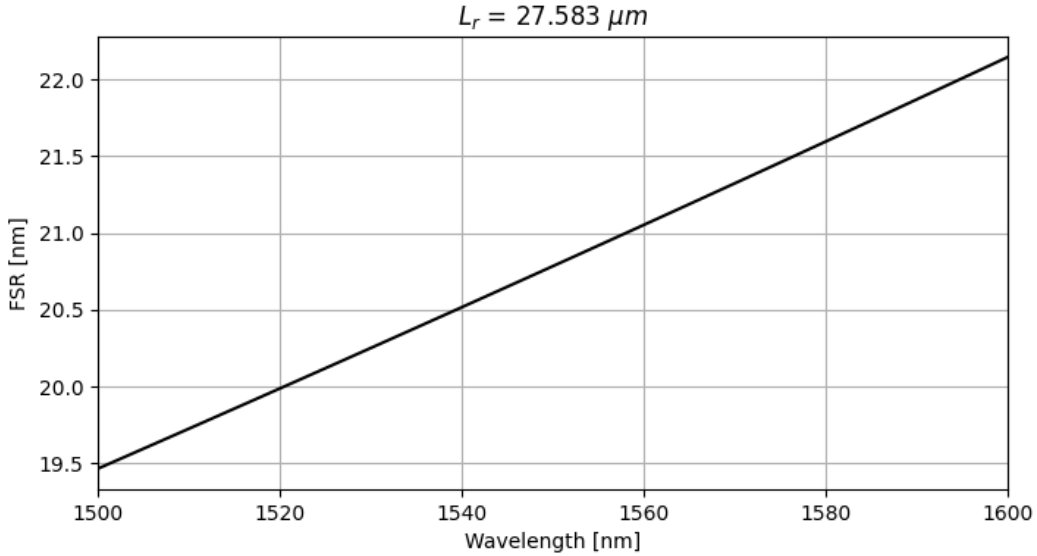




FSR – dispositivos ideais



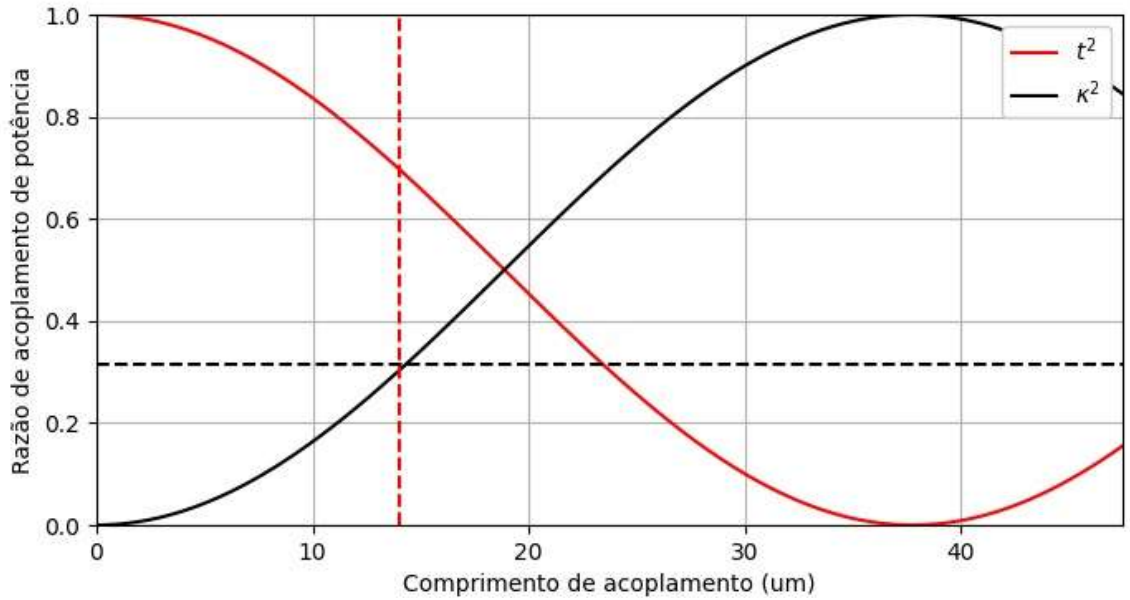


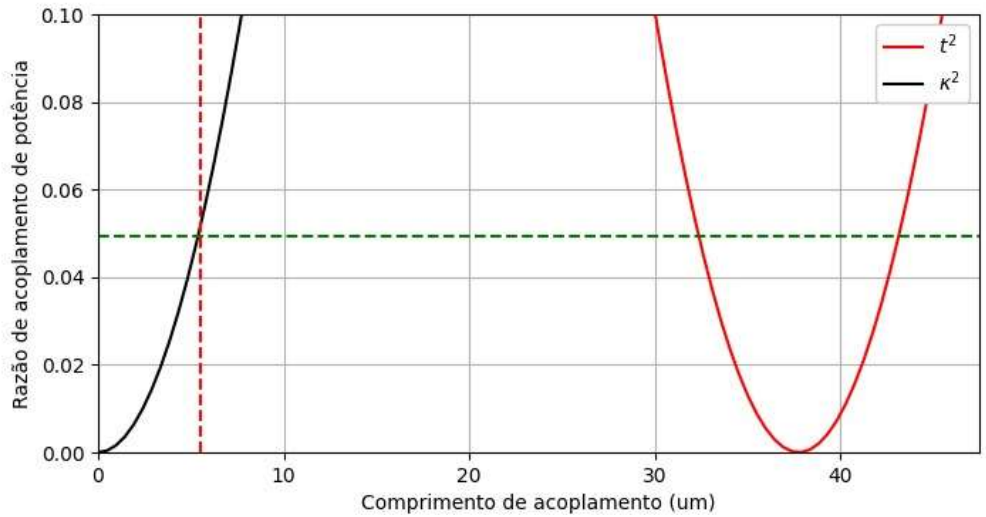


Determinando o comprimento de acoplamento (Lc) a partir de K

Determinando o comprimento de acoplamento (Lc) a partir do fator de acoplamento (k) utilizando o MODE:

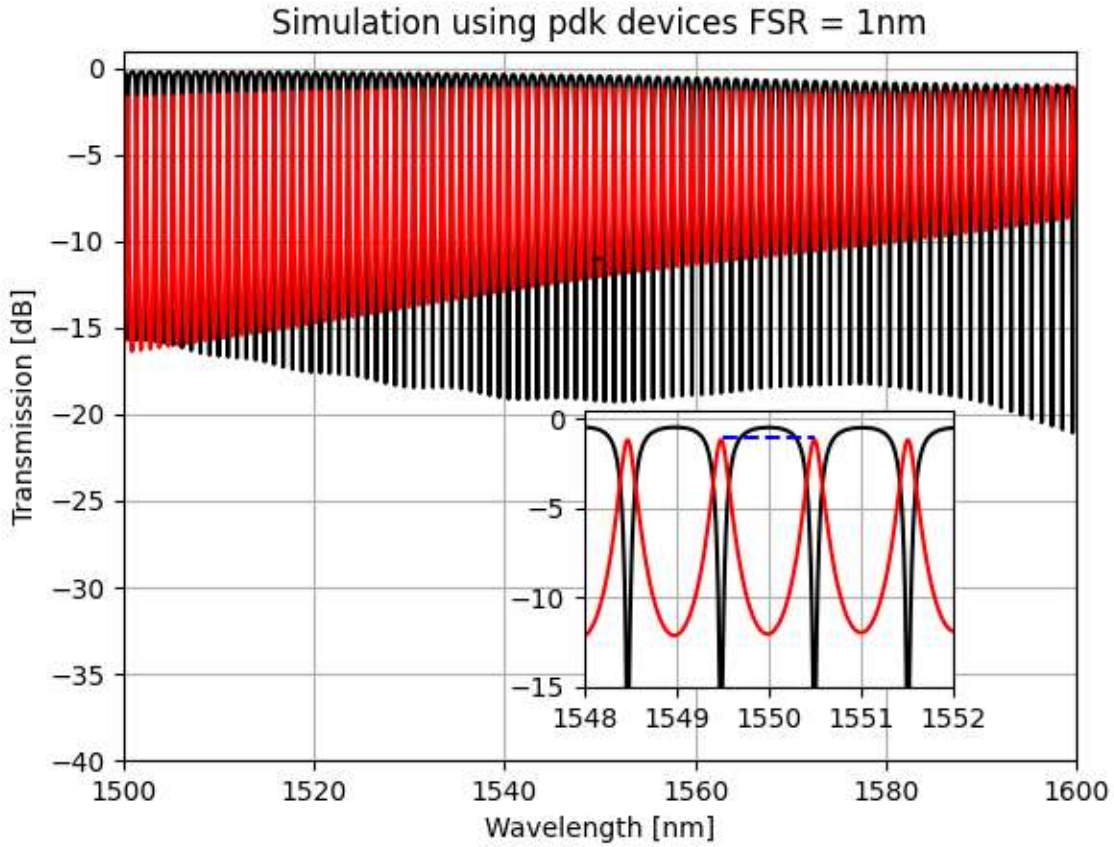
FSR/B	N	Ng	FSR (nm)	K1, K2	K3	Lc1, Lc2 (μm)	Lc3 (μm)
10	2	4.19088	1	0.3141	0.0493	14	5.5

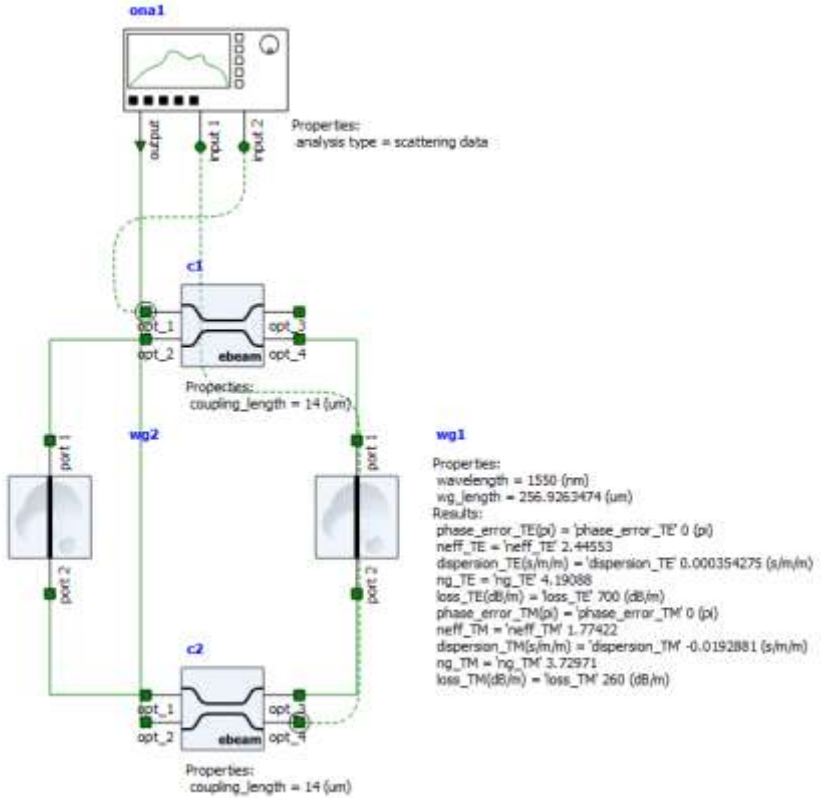




Transmissão do anel ressonante – dispositivos do PDK SiEPIC

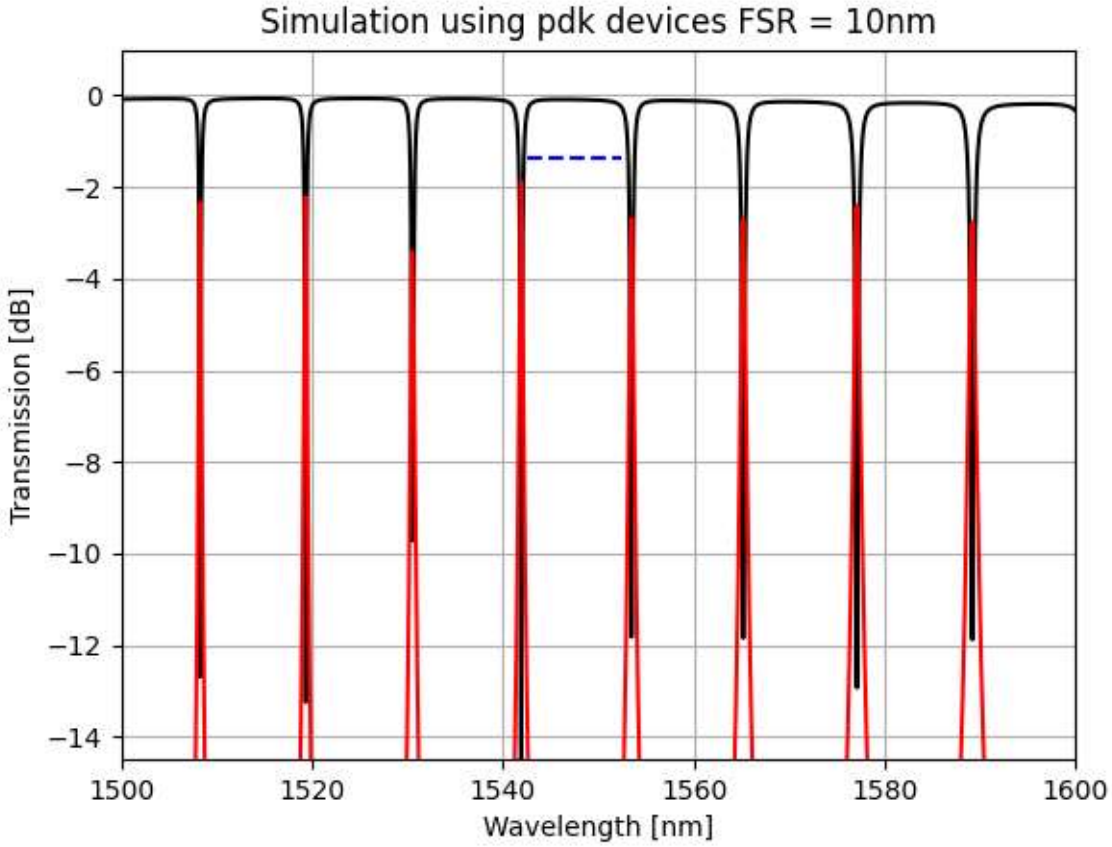
FSR/B	N	Ng	FSR (nm)	K1, K2	K3	Lc1, Lc2 (μm)	Lc3 (μm)
10	1	4.19088	1	0.3141	-	14	-

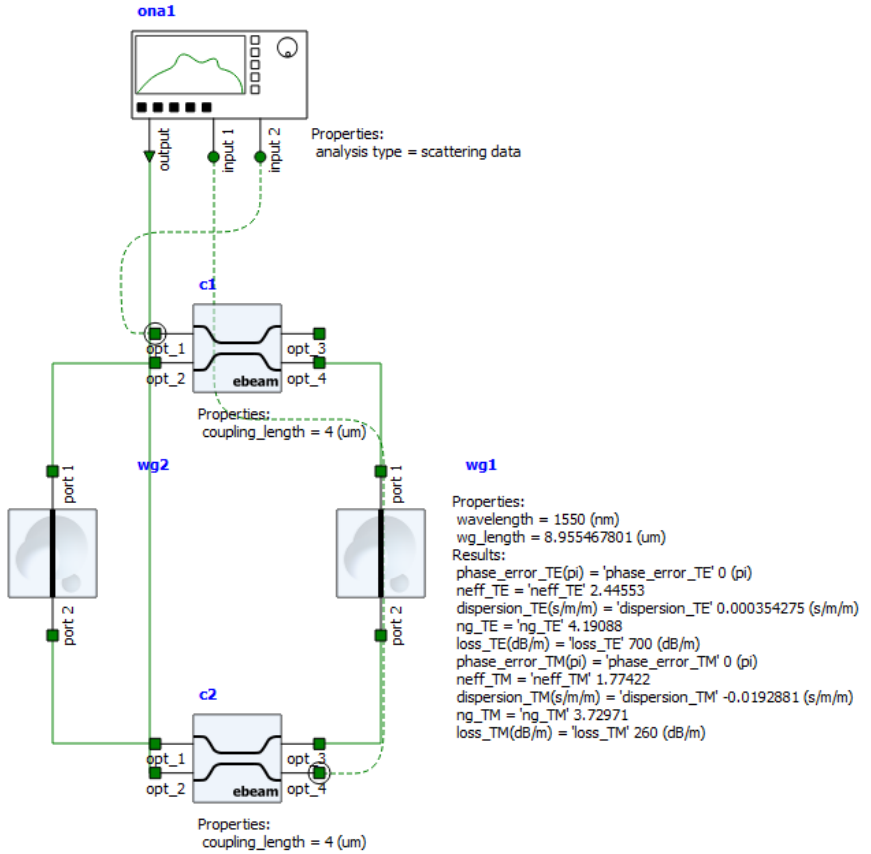




Transmissão do anel ressonante – dispositivos do PDK SiEPIC

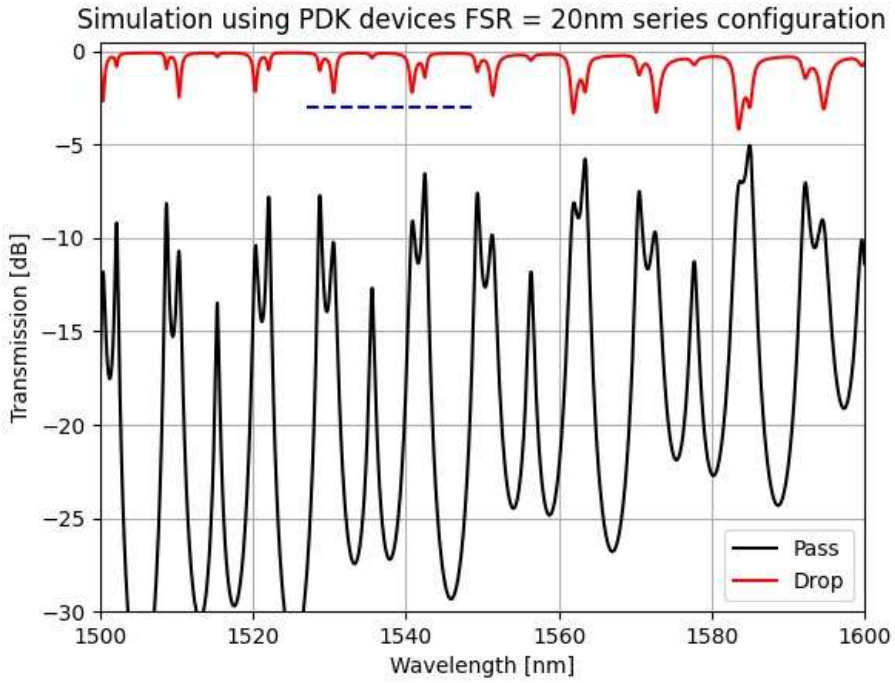
FSR/B	N	Ng	FSR (nm)	K1, K2	K3	Lc1, Lc2 (μm)	Lc3 (μm)
20	1	4.19088	10	0.3141	0.49	~~14~~ 4	-

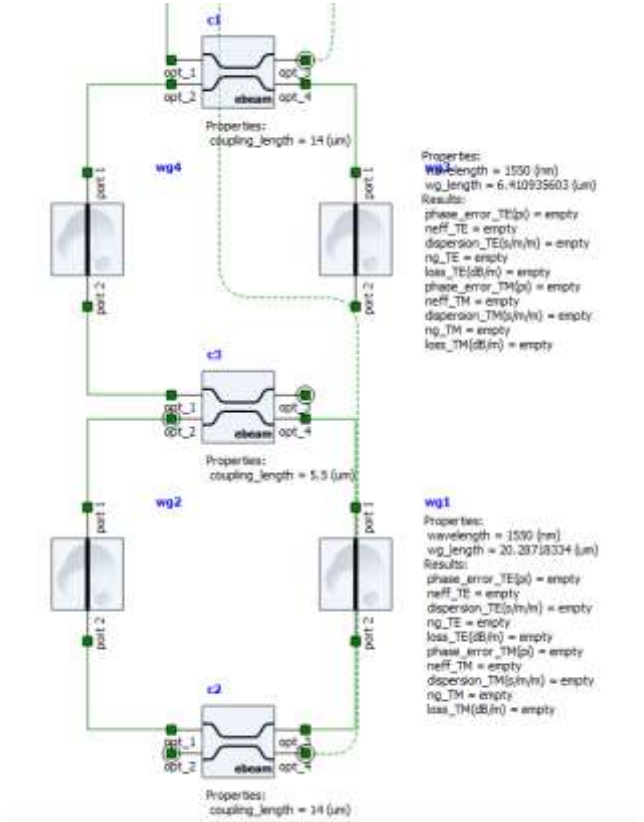




Transmissão do anel ressonante – dispositivos do PDK SiEPIC

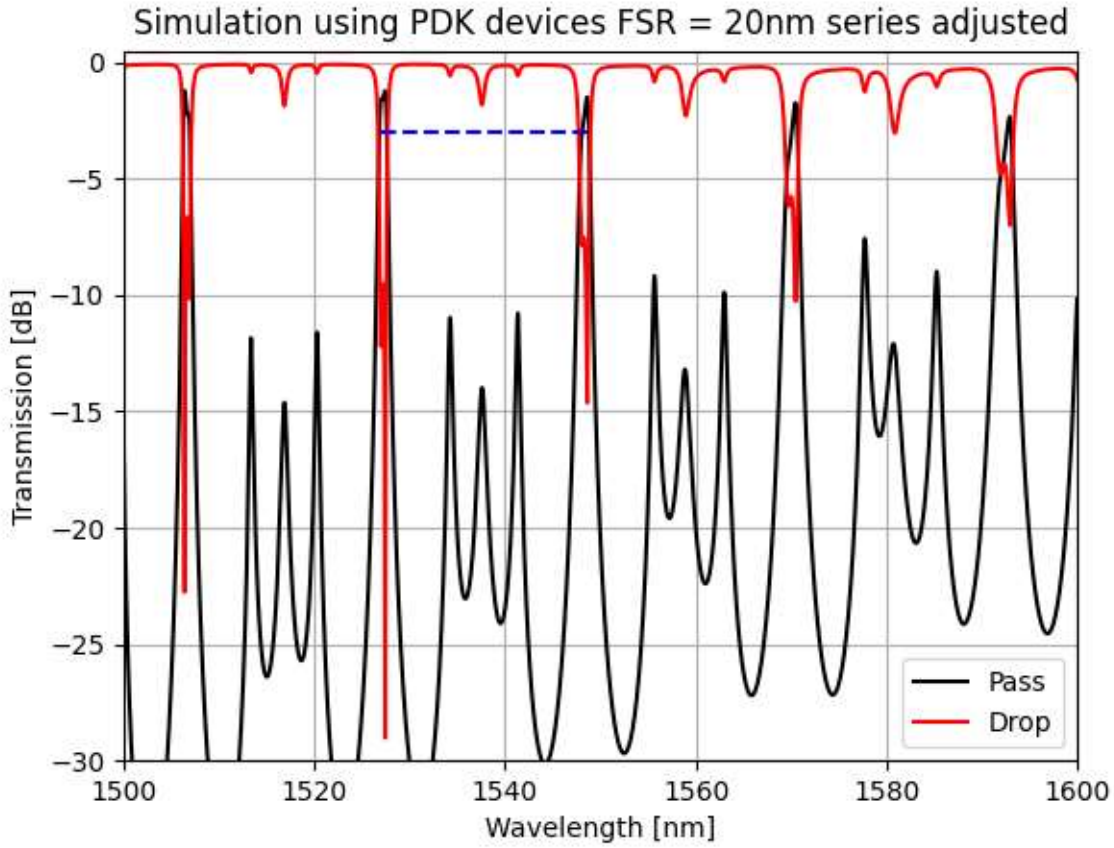
FSR/B	N	Ng	FSR (nm)	K1, K2	K3	Lc1 (μm)	Lc2 (μm)	Lc3 (μm)
10	2	4.19088	20	0.3141	0.0493	14	14	5.5

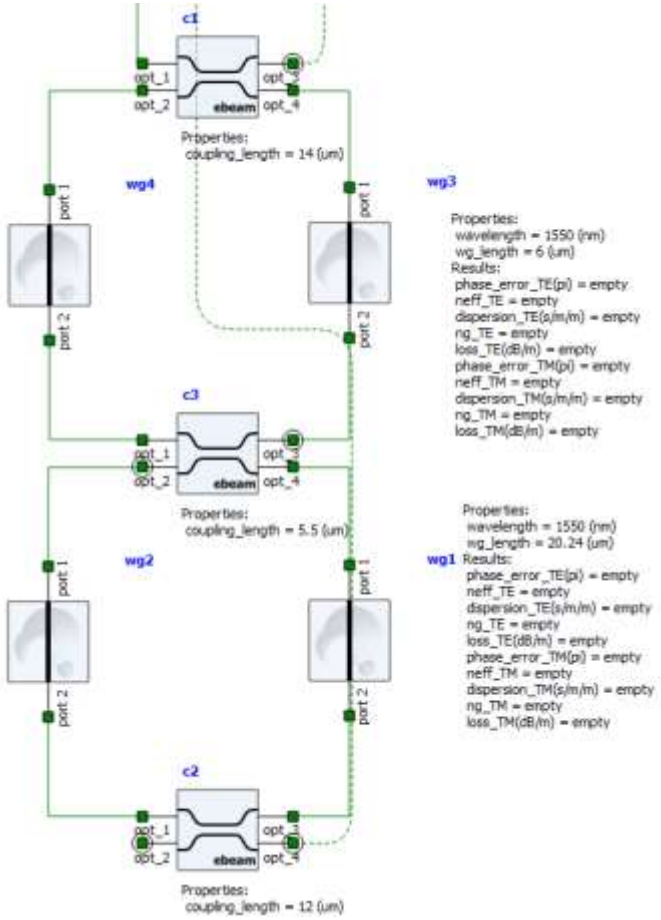




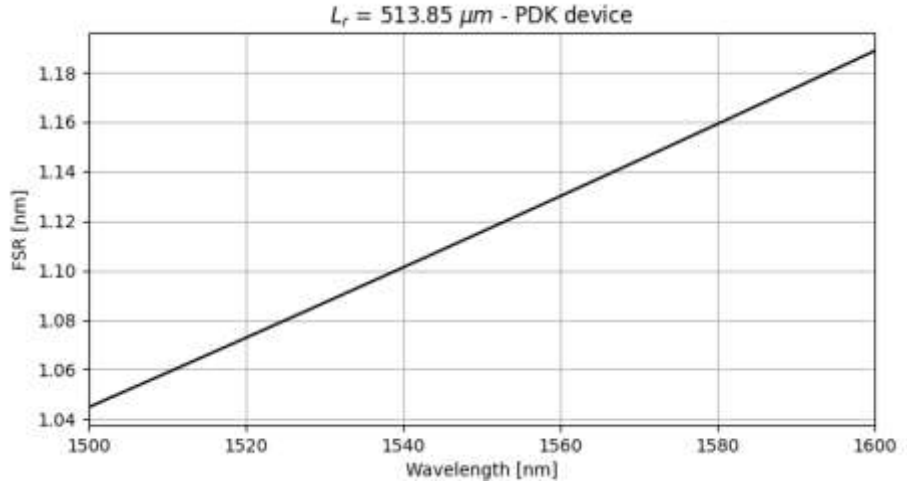
Transmissão do anel ressonante – dispositivos do PDK SiEPIC

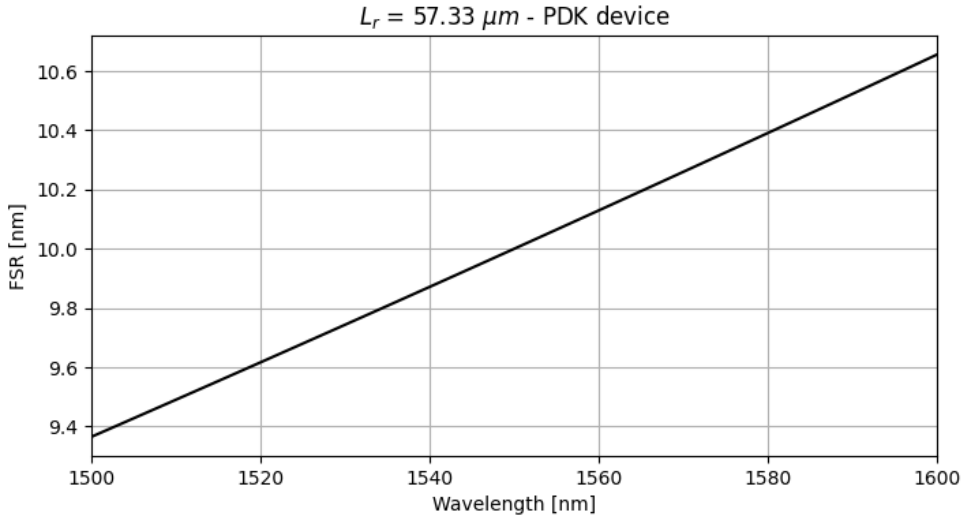
FSR/B	N	Ng	FSR (nm)	K1, K2	K3	Lc1 (μm)	Lc2 (μm)	Lc3 (μm)
10	2	4.19088	20	0.3141	0.0493	14	12	5.5

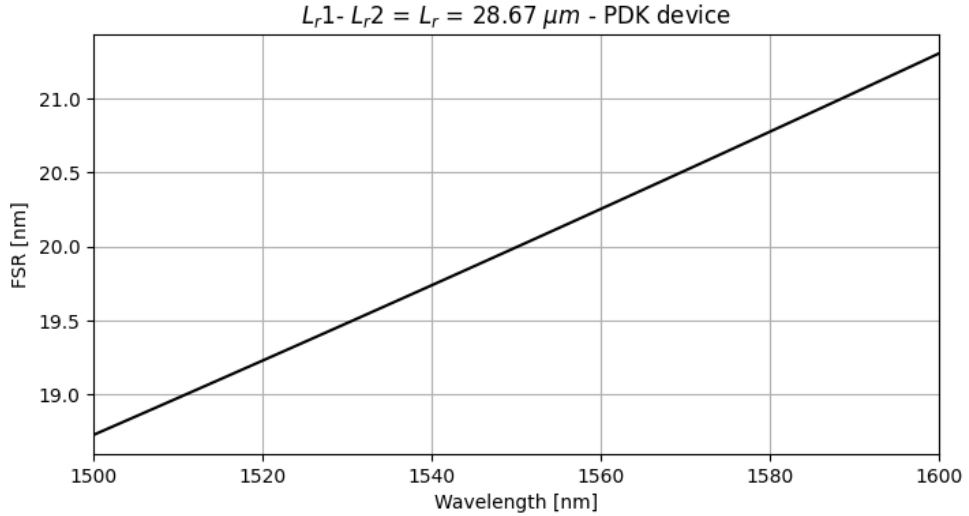




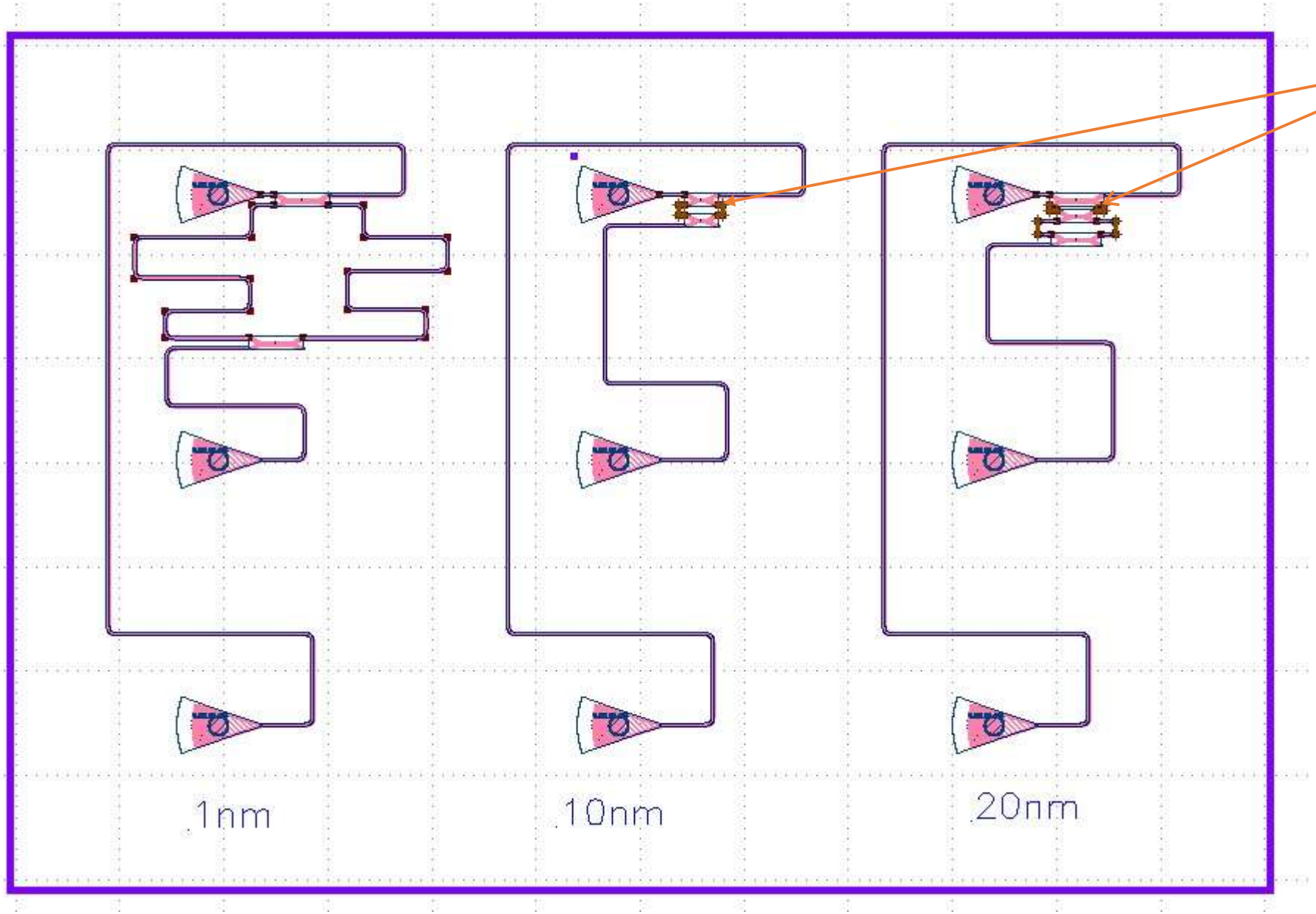
FSR – dispositivos do PDK SiEPIC







GDS– dispositivos do PDK SiEPIC



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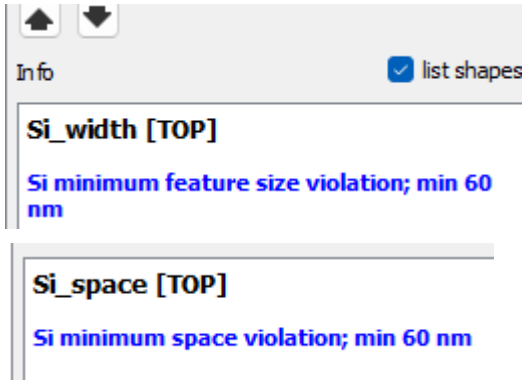

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Atividade 2 – Ring Resonator

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