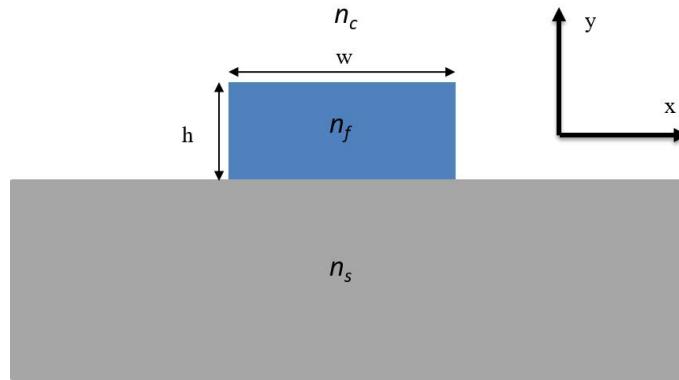


**Problem 1 Score:** \_\_\_\_\_. Consider a strip waveguide shown in below:  $n_f = 3.5$ ,  $n_c = 1$  and  $n_s = 1.5$ ,  $w = 3\mu\text{m}$ ,  $h = 1\mu\text{m}$ . The working wavelength in vacuum is  $1.55\mu\text{m}$ . Calculate and plot the propagation constants, effective indices, and all the guiding mode profiles of  $y$ -polarization and  $x$ -polarization. You can use the software you learned in class or any software you like.



**Solution:** 使用Lumerical软件中的Mode来模拟，设置和结果如下：

- (1) **Materials & Structure:** 设置 $x$ 坐标在 $[-1.5\mu\text{m}, 1.5\mu\text{m}]$ 范围内、 $y$ 坐标在 $[-0.5\mu\text{m}, 0.5\mu\text{m}]$ 范围内、折射率为3.5的长方体作为芯层；设置 $x$ 坐标在 $[-5\mu\text{m}, 5\mu\text{m}]$ 范围内、 $y$ 坐标在 $[-5.5\mu\text{m}, -0.5\mu\text{m}]$ 、 $z$ 坐标在 $[-0.5\mu\text{m}, 0.5\mu\text{m}]$ 范围内、折射率为1.5的长方体作为衬底。其余设置默认。
- (2) **FDE:** 设置模拟温度为300K，求解器类型为“2D Z normal”，背景材料折射率为1；设置模拟区域的 $x$ 坐标在 $[-3\mu\text{m}, 3\mu\text{m}]$ 范围内， $y$ 坐标在 $[-2\mu\text{m}, 2\mu\text{m}]$ 范围内， $z$ 坐标为0；设置 $x$ 方向划分网格数300， $y$ 方向划分网格数200；设置 $x_{\min}, x_{\max}, y_{\min}$ 和 $y_{\max}$ 处的边界条件均为PML。其余设置默认。
- (3) **Run:** 设置波长为 $1.55\mu\text{m}$ ，在 $n = 3.5$ 附近搜寻模式，共得到74个模式，其各参数即模场分布如表1所示。

表 1:

模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
1	3.4250	13.8839		
2	3.4078	13.8143		

Table 1 continued from previous page

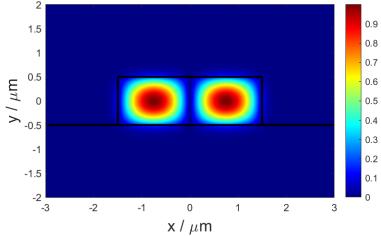
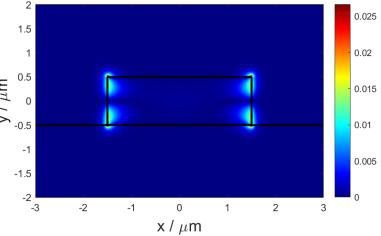
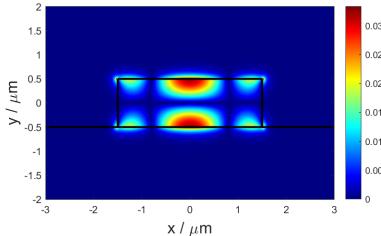
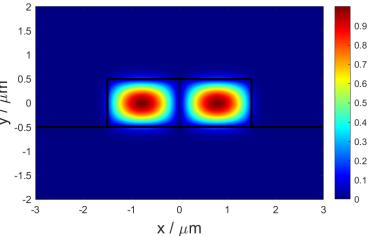
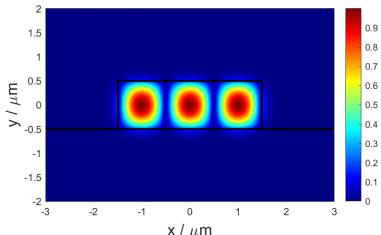
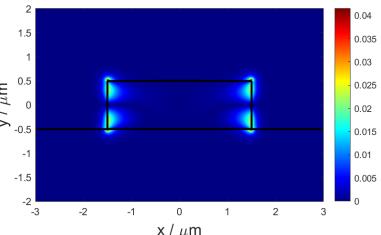
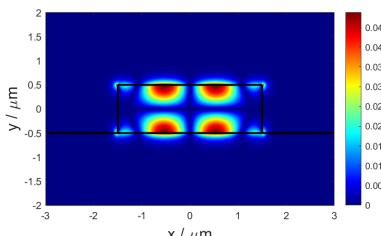
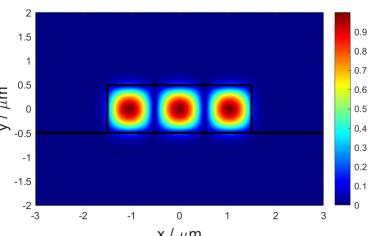
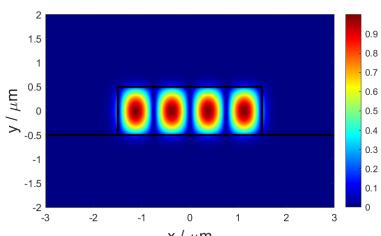
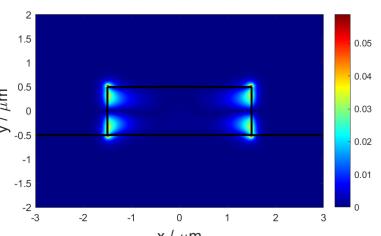
模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
3	3.3959	13.7659		
4	3.3810	13.7055		
5	3.3468	13.5669		
6	3.3359	13.5226		
7	3.2770	13.2837		

Table 1 continued from previous page

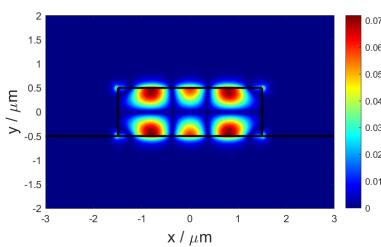
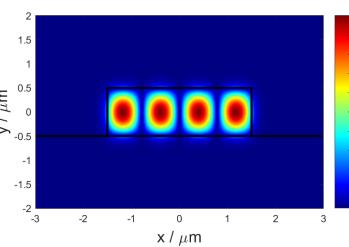
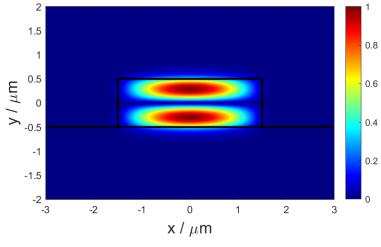
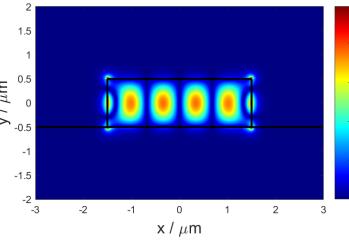
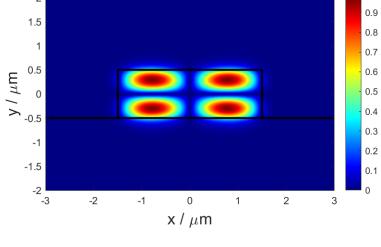
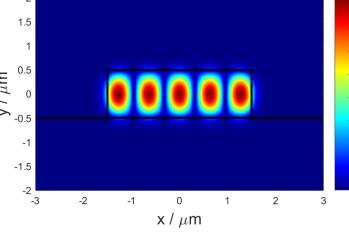
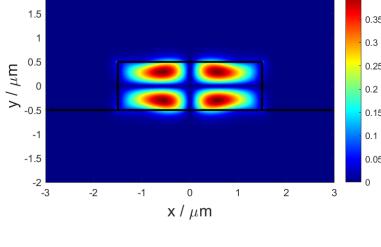
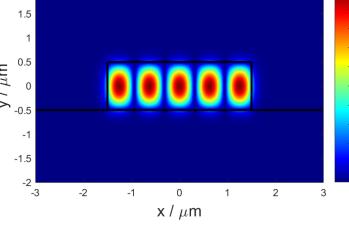
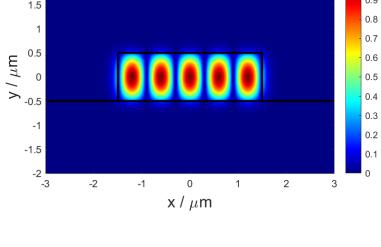
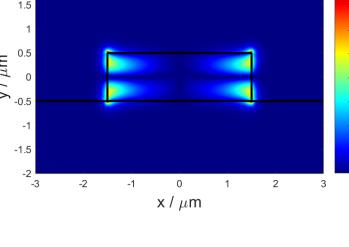
模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
8	3.2718	13.2628		
9	3.2225	13.0628		
10	3.1922	12.9400		
11	3.1870	12.9191		
12	3.1850	12.9110		

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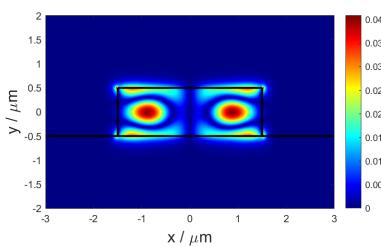
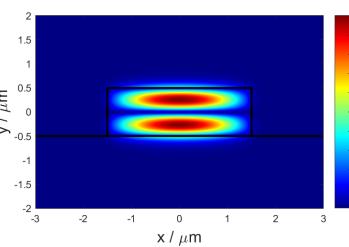
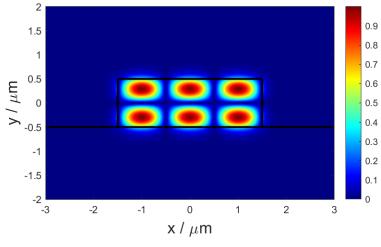
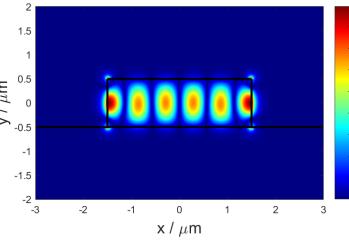
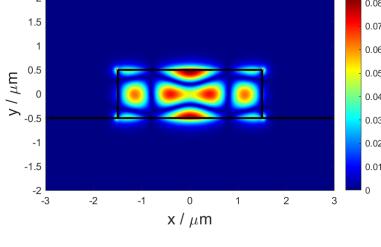
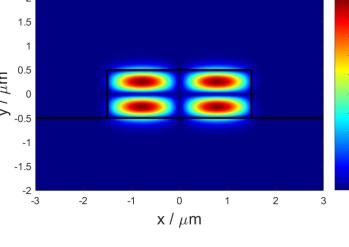
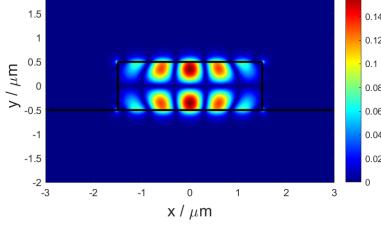
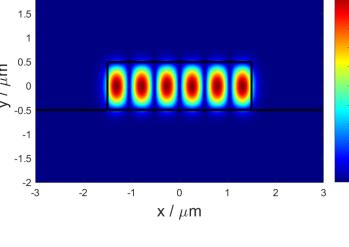
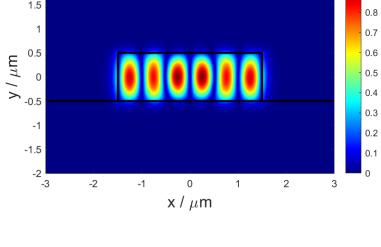
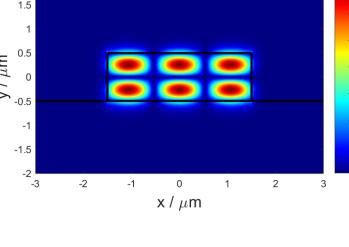
模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
13	3.1460	12.7527		
14	3.1392	12.7251		
15	3.1167	12.6342		
16	3.0822	12.4943		
17	3.0712	12.4494		

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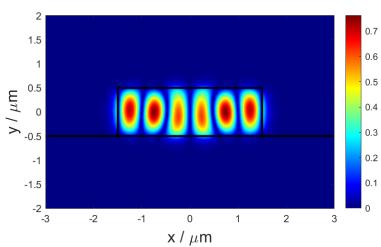
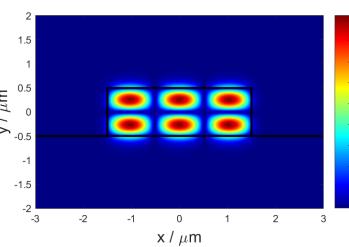
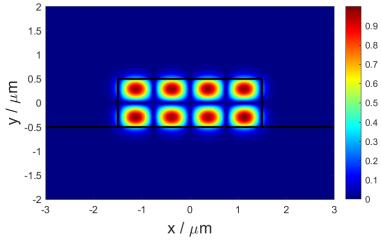
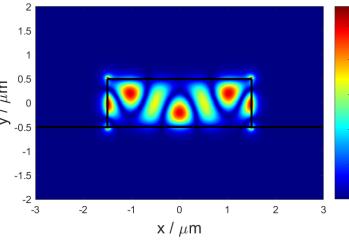
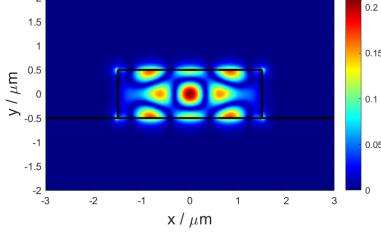
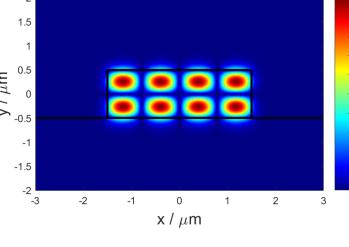
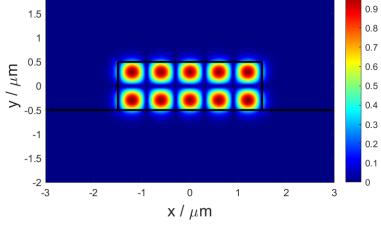
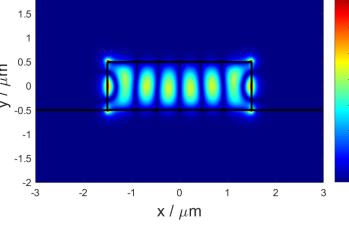
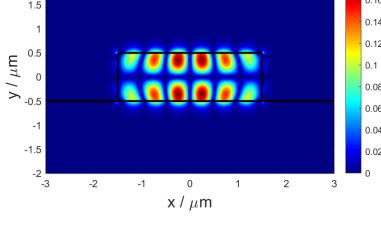
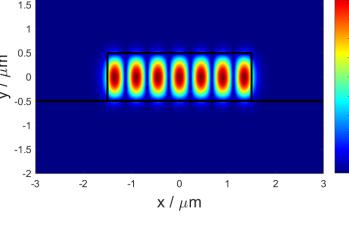
模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
18	3.0655	12.4263		
19	3.0643	12.4215		
20	2.9980	12.1527		
21	2.9653	12.0202		
22	2.9535	11.9724		

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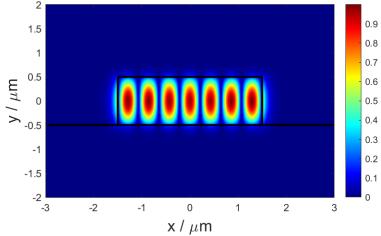
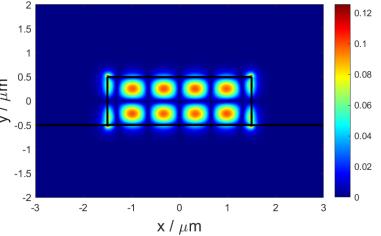
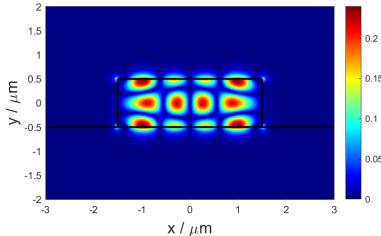
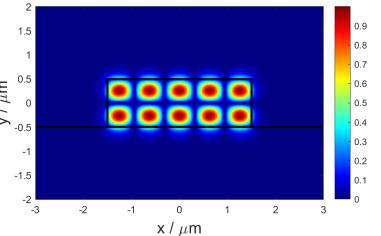
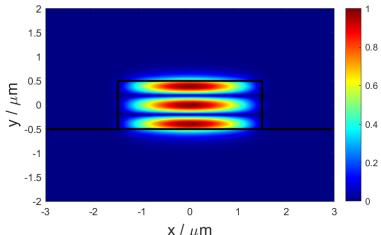
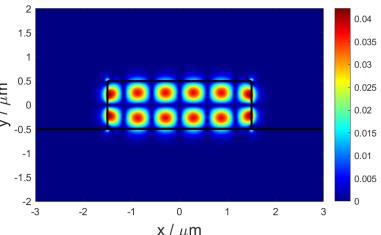
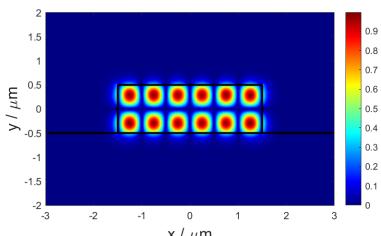
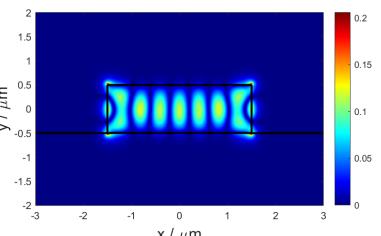
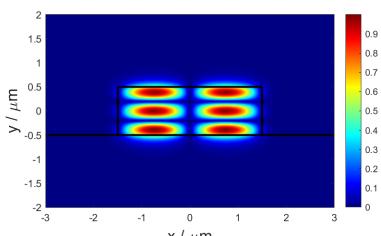
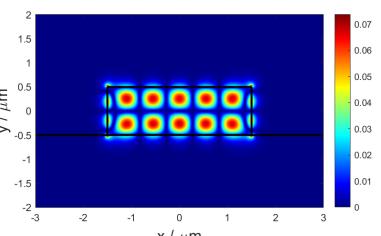
模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
23	2.9261	11.8616		
24	2.9063	11.7810		
25	2.8617	11.6002		
26	2.8397	11.5110		
27	2.8263	11.4567		

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模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
28	2.7986	11.3446		
29	2.7927	11.3208		
30	2.7643	11.2057		
31	2.7531	11.1602		
32	2.6849	10.8835		

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模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
33	2.6843	10.8811		
34	2.6633	10.7960		
35	2.6439	10.7177		
36	2.6280	10.6531		
37	2.6136	10.5945		

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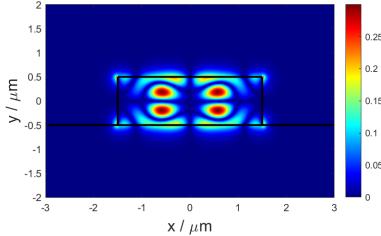
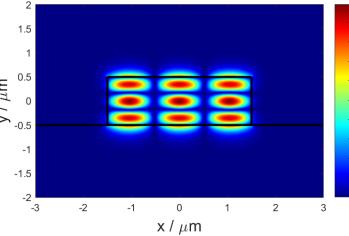
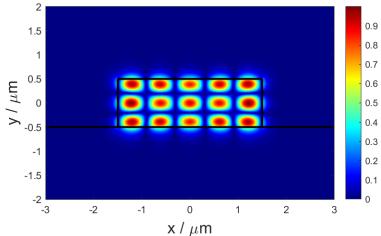
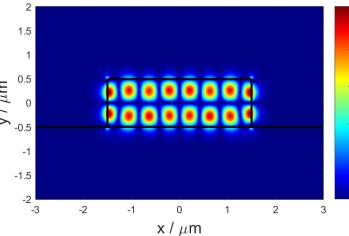
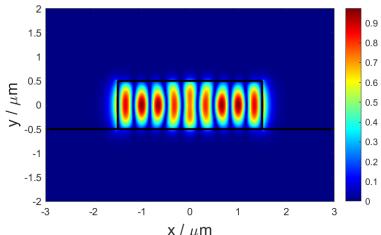
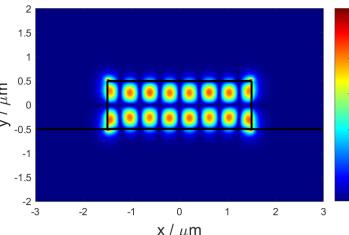
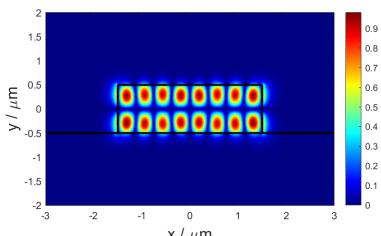
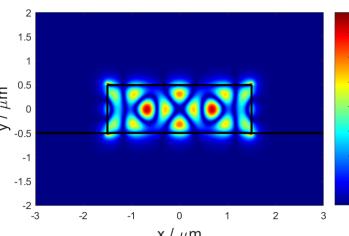
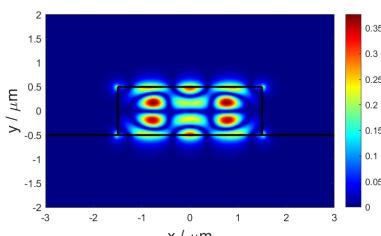
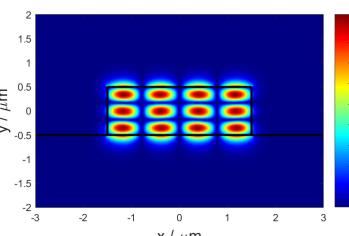
模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
38	2.5703	10.4190		
39	2.5691	10.4142		
40	2.5444	10.3140		
41	2.4922	10.1027		
42	2.4859	10.0769		

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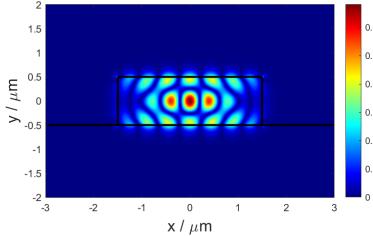
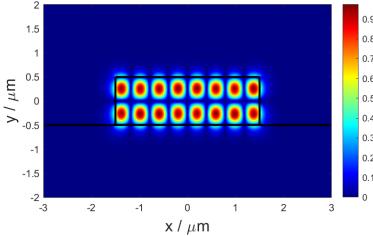
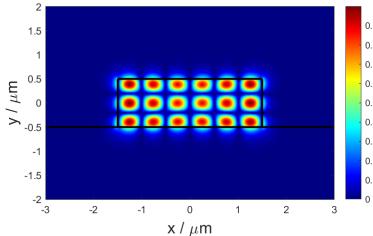
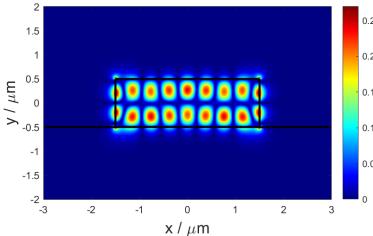
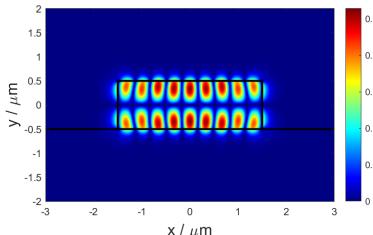
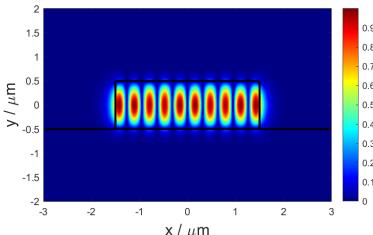
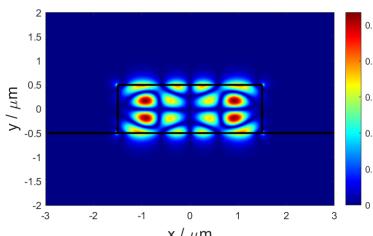
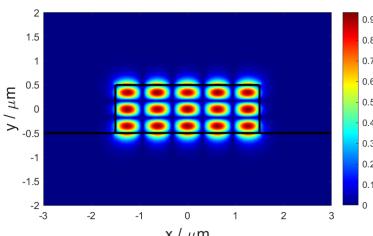
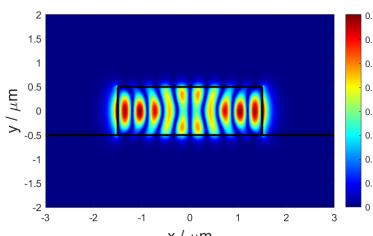
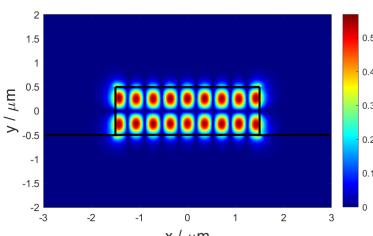
模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
43	2.4714	10.0183		
44	2.4210	9.8138		
45	2.3922	9.6971		
46	2.3742	9.6243		
47	2.2968	9.3106		

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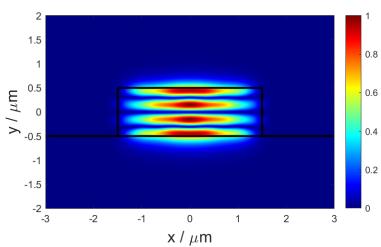
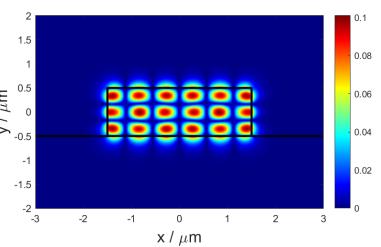
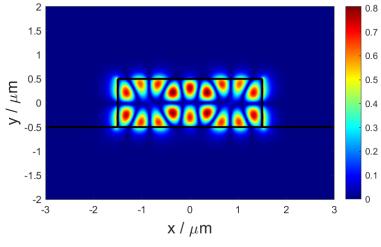
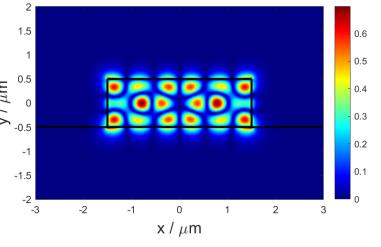
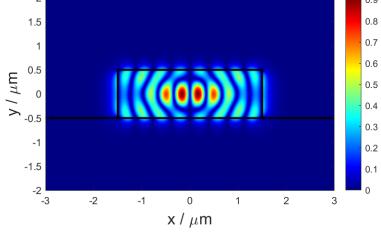
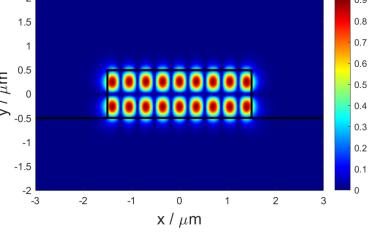
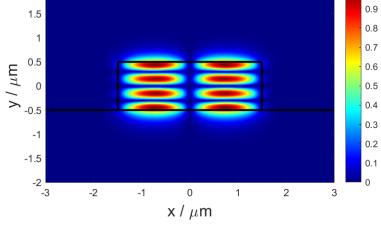
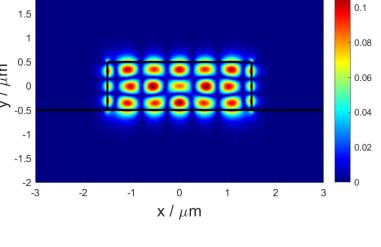
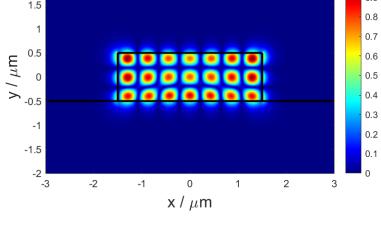
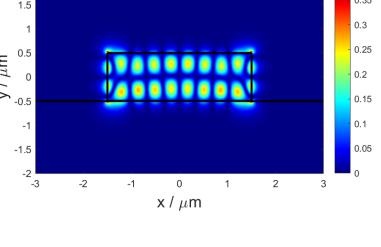
模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
48	2.2931	9.2953		
49	2.2687	9.1966		
50	2.2549	9.1406		
51	2.2477	9.1115		
52	2.2333	9.0529		

Table 1 continued from previous page

模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
53	2.2242	9.0161		
54	2.1663	8.7814		
55	2.1251	8.6144		
56	2.0910	8.4763		
57	2.0369	8.2567		

Table 1 continued from previous page

模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
58	2.0253	8.2100		
59	1.9955	8.0891		
60	1.9553	7.9260		
61	1.9456	7.8867		
62	1.9241	7.7997		

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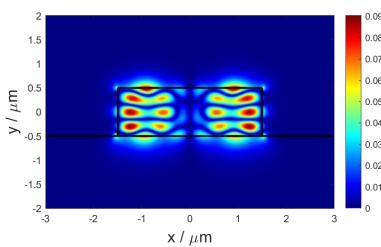
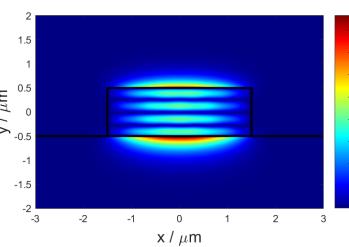
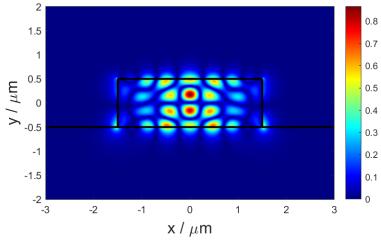
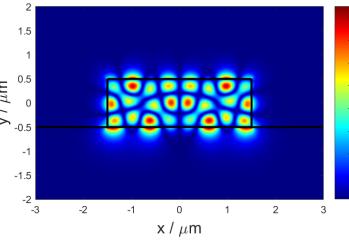
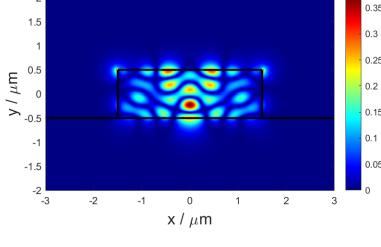
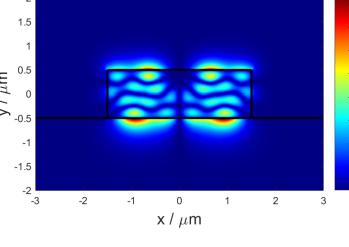
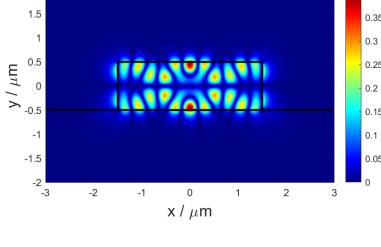
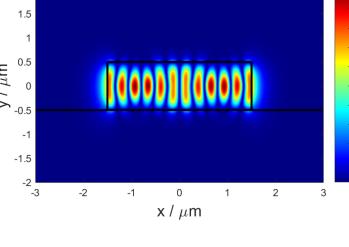
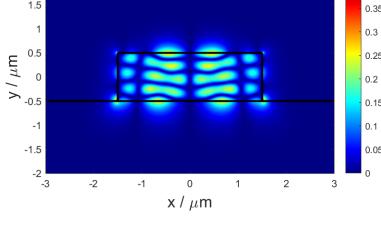
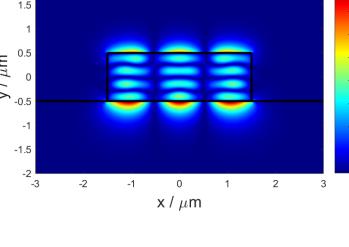
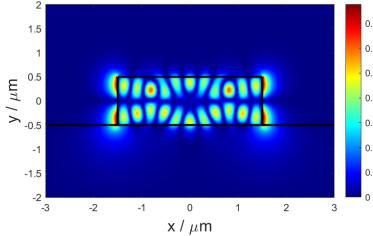
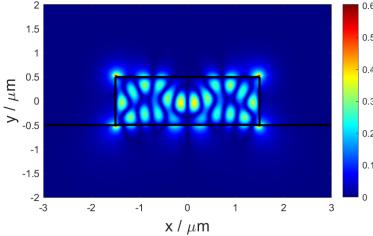
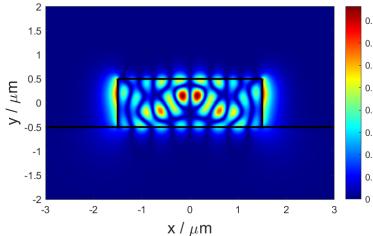
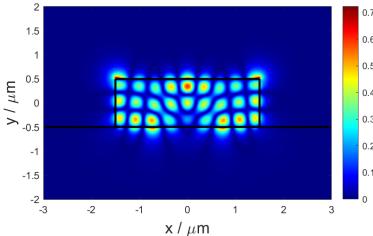
模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
63	1.8725	7.5903		
64	1.8326	7.4289		
65	1.8229	7.3896		
66	1.7911	7.2606		
67	1.7402	7.0543		

Table 1 continued from previous page

模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
68	1.7116	6.9381		
69	1.7085	6.9257		
70	1.6977	6.8820		
71	1.6020	6.4939		
72	1.5619	6.3314		

Table 1 continued from previous page

模式序号 #	有效折射率 $N$	传播常数 $\beta / \mu\text{m}^{-1}$	$E_x(x, y)$	$E_y(x, y)$
73	1.5617	6.3305		
74	1.5498	6.2823		

□