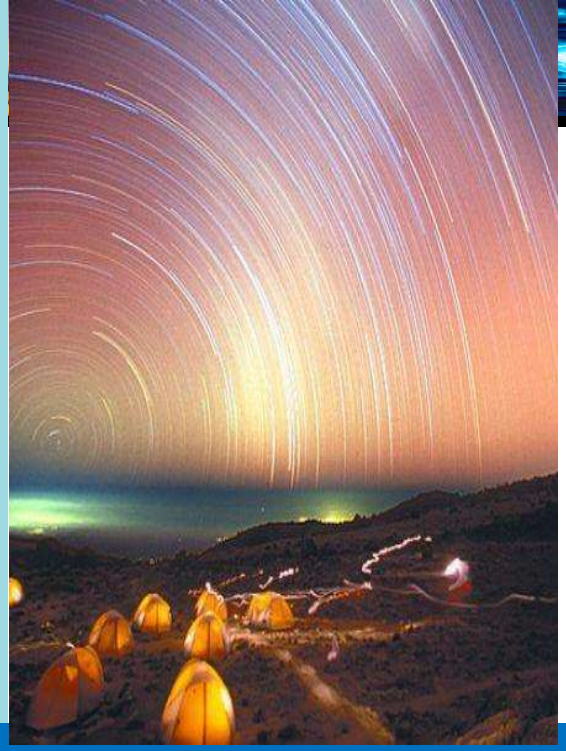
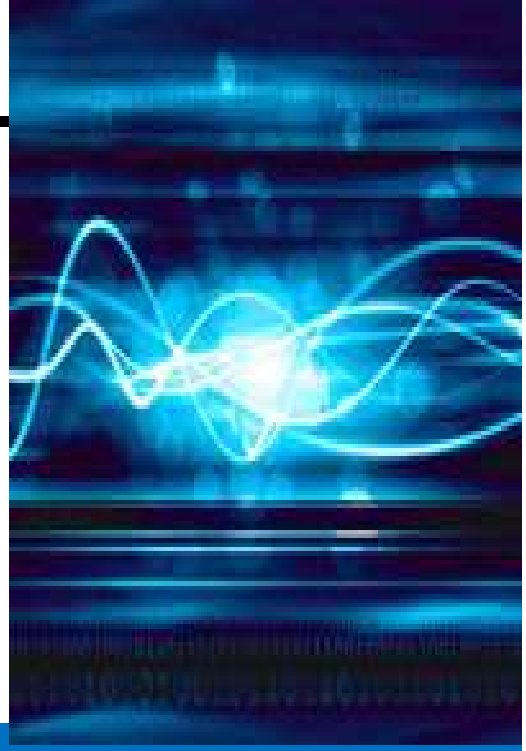
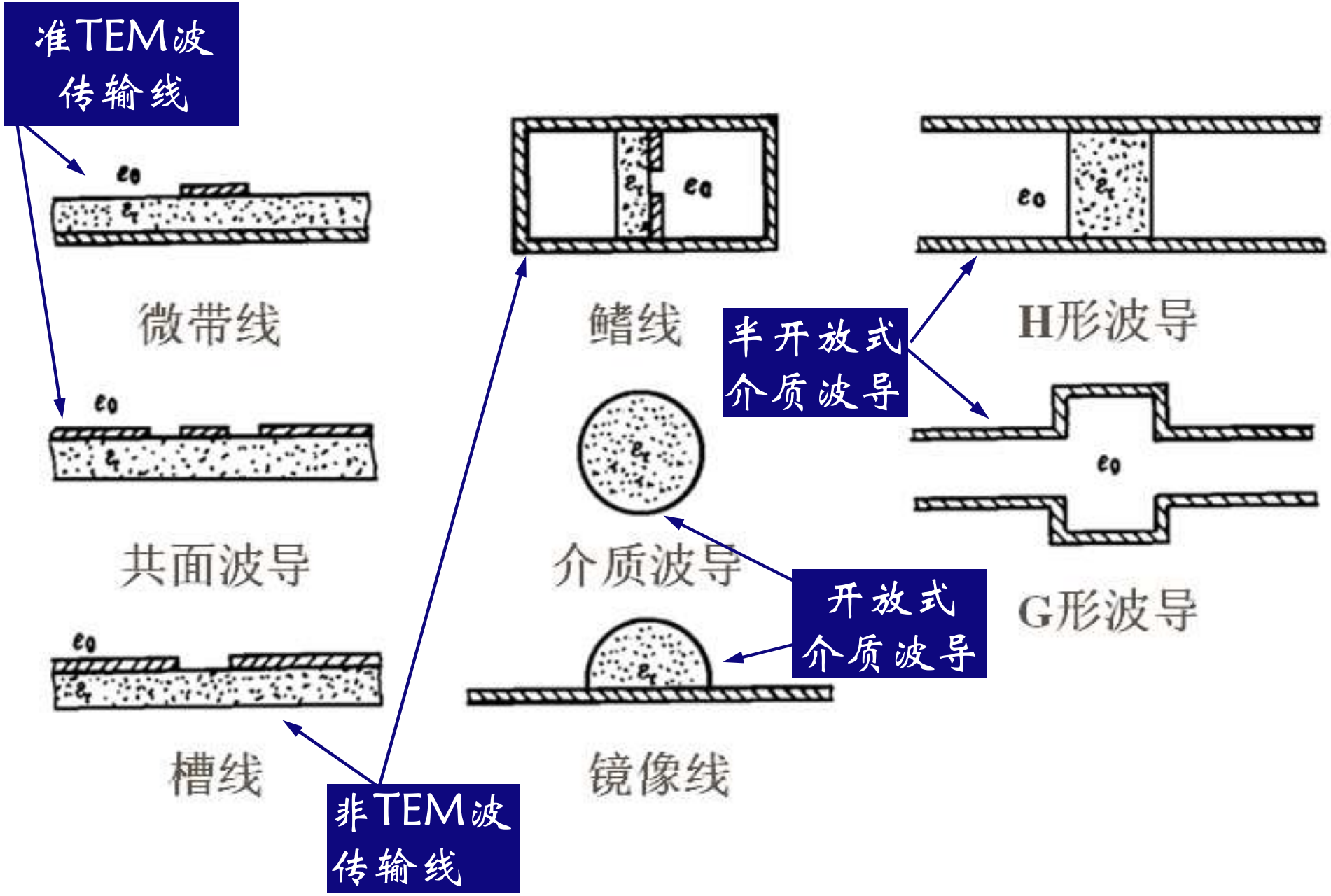
NJTECT

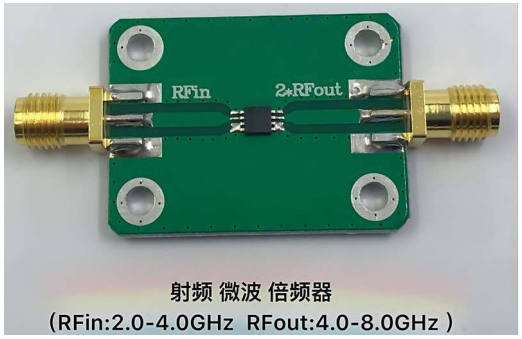




第三章　微波集成传输线


准TEM波传输线
微带线
共面波导
槽线
非TEM波传输线
鳍线
半开放式介质波导
H形波导
G形波导
介质波导
开放式介质波导
镜像线

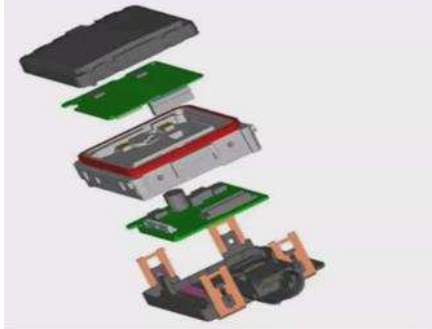
§3-1微带传输线



混合微波集成电路

单片微波集成电路

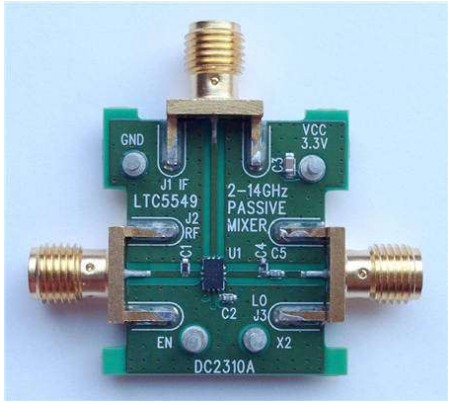
图 28. 毫米波雷达结构图



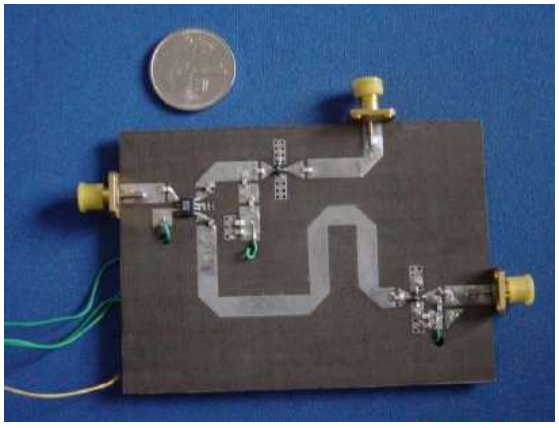
资料来源：汽车电子设计，中国银河证券研究院

图 29. MMIC PCB 评估板（型号：SG24TR14）

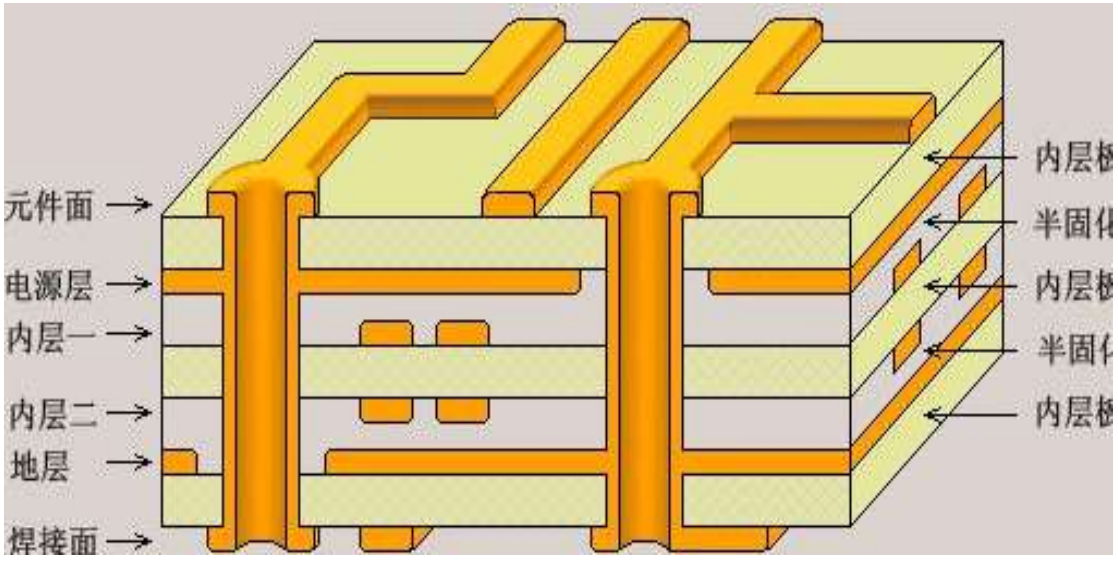
资料来源：意行半导体官网，中国银河证券研究院

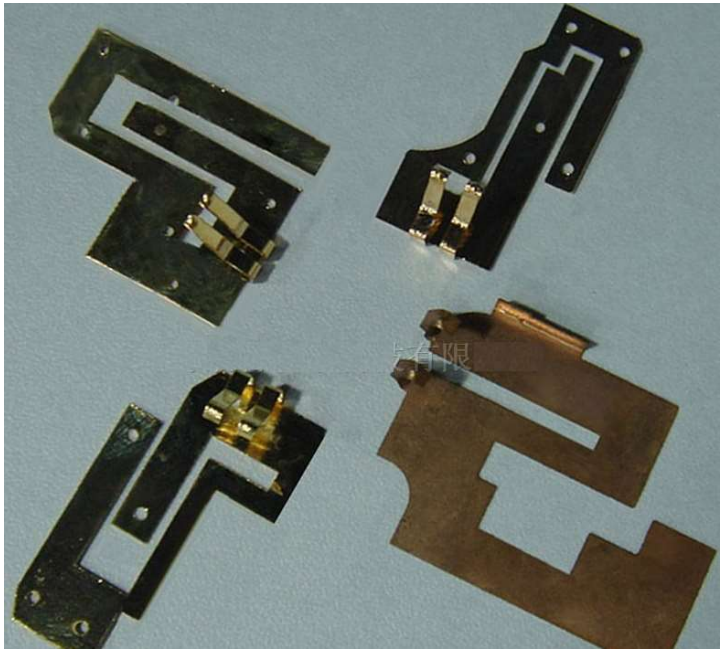


要求微波传输线



- 损耗小
- 结构合理
- 频带宽
- 性能可靠

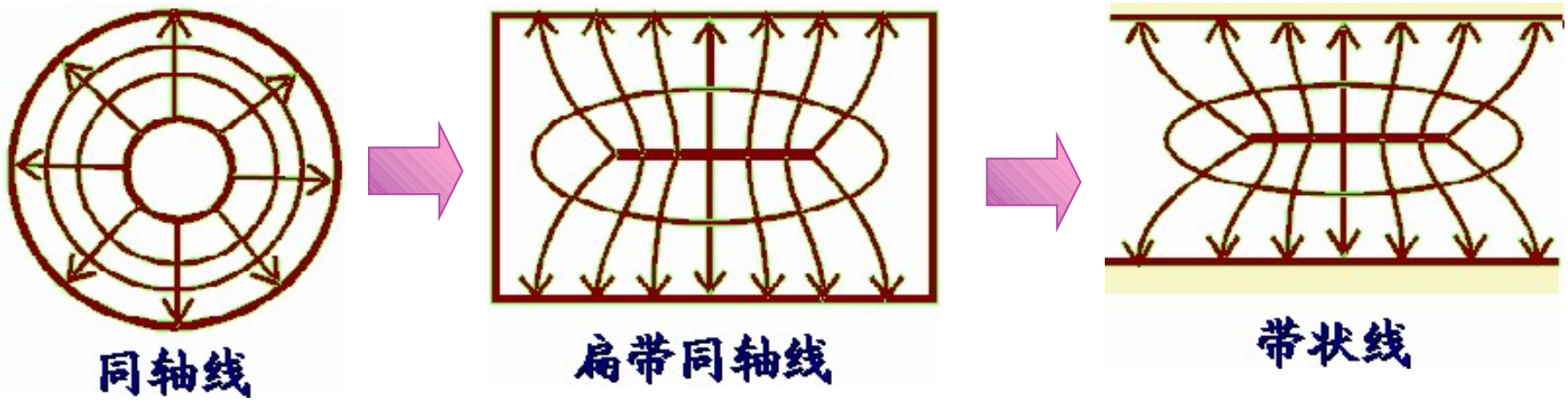




边界条件特殊，求解过程繁琐。

本章重点：初步掌握微带传输线的结构、工作原理、相关概念和特性，利用已有计算公式、曲线图和数据表计算基本参数。

一、 带状线



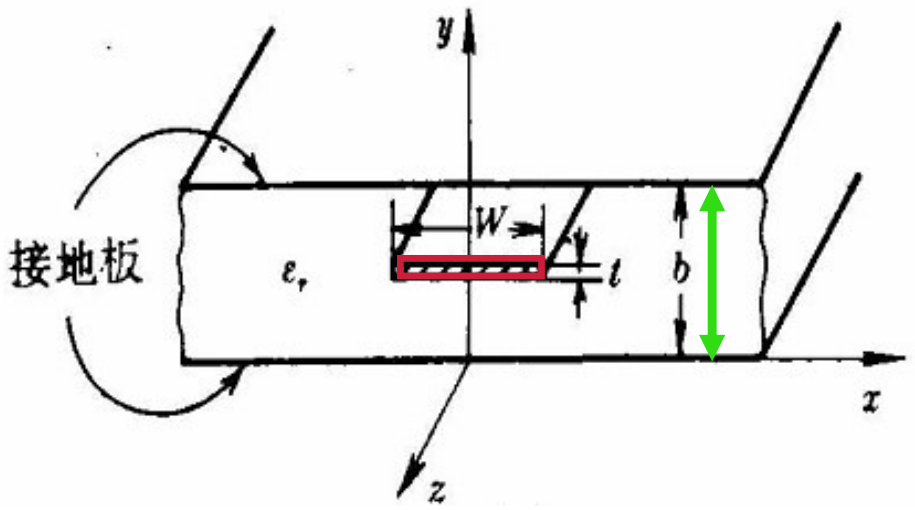
用途： 替代同轴线制作高性能的无源元件；

特点： 宽频带、高Q值、高隔离度；

缺点： 不便外接固体微波器件，---不宜做有源微波电路。

传输波型： 工作模式为TEM波，可存在高次模。

带状线的TEM特性



1、相速和波导波长

TEM模， $k_c = 0, \lambda_c = \infty \quad v_p = \dfrac{c}{\sqrt{\varepsilon_r}}$

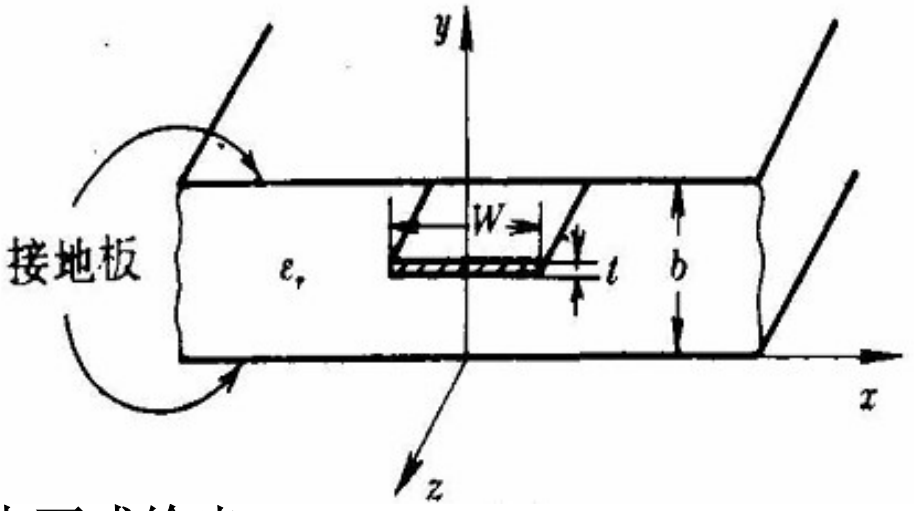
传播常数为： $\beta = \dfrac{\omega}{v_p} = k_0\sqrt{\varepsilon_r}$

带内波长为 $\lambda = \dfrac{\lambda_0}{\sqrt{\varepsilon_r}}$ λ_0 **为自由空间波长。**

2、特性阻抗

(a)导带厚度为零时

$$Z_0 = \frac{30\pi}{\sqrt{\varepsilon_r}} \frac{b}{w_e + 0.441b} \qquad (\Omega)$$



式中，w_e是中心导带的有效宽度，由下式给出：

$$\frac{w_e}{b} = \frac{w}{b} - \begin{cases} 0 & w/b > 0.35 \\ (0.35 - w/b)^2 & w/b < 0.35 \end{cases}$$

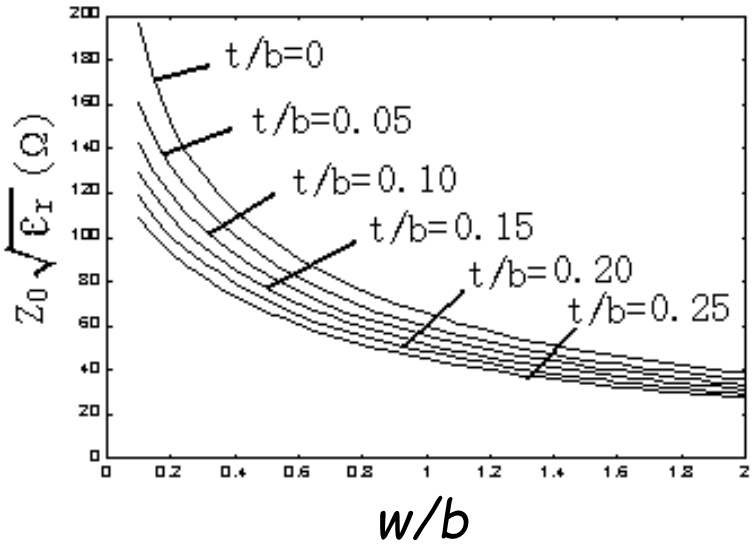
（b）导带厚度不为零时

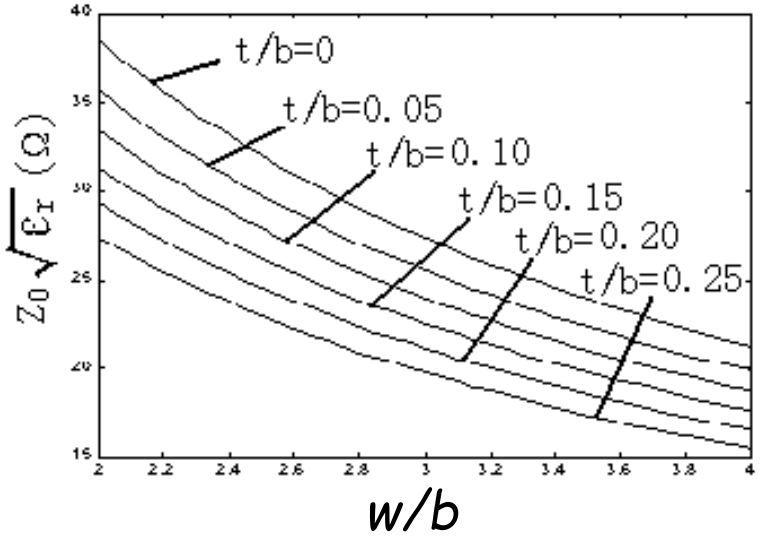
$$Z_0 = \frac{30}{\sqrt{\varepsilon_r}} \ln\left\{1 + \frac{4}{\pi}\cdot\frac{1}{m}\left[\frac{8}{\pi}\cdot\frac{1}{m} + \sqrt{\left(\frac{8}{\pi}\cdot\frac{1}{m}\right)^2 + 6.27}\right]\right\}$$

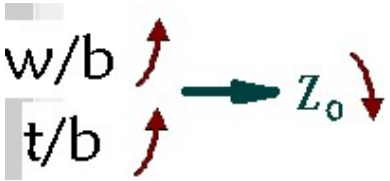
式中，$m = \dfrac{w}{b-t} + \dfrac{\Delta w}{b-t}$

$$\frac{\Delta w}{b-t} = \frac{x}{\pi(1-x)}\left\{1 - 0.5\ln\left[\left(\frac{x}{2-x}\right)^2 + \left(\frac{0.0796x}{w/b + 1.1x}\right)^n\right]\right\} \qquad n = \frac{2}{1 + \frac{2}{3}\cdot\frac{x}{1-x}} \qquad x = \frac{t}{b}$$

带状线特性阻抗与*w/b*及*t/b*的关系曲线

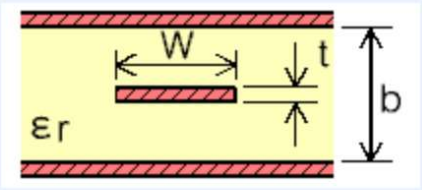






Strip Line Calculator

带状线计算工具



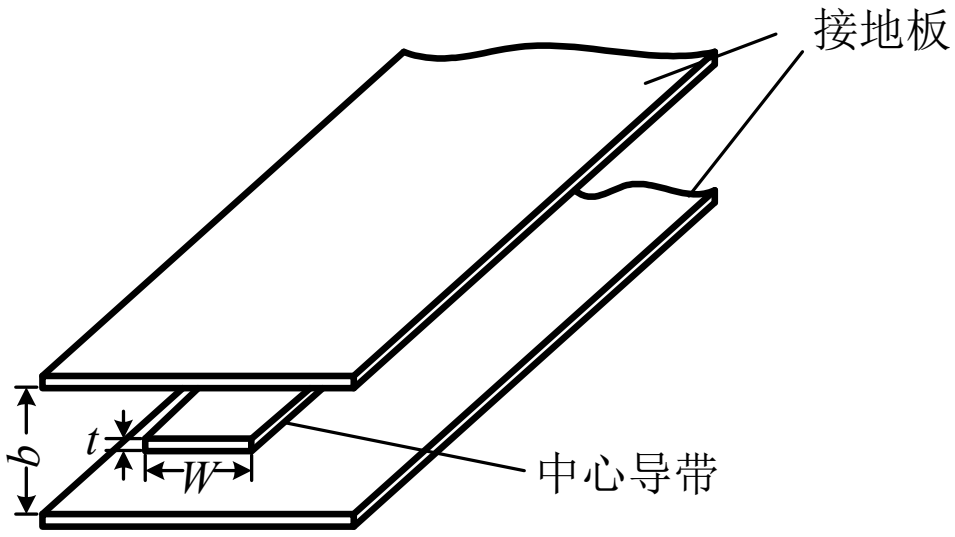
er [ ]
b [ ] [mm]
t [ ] [um]
f [ ] [MHz]

W [ ] [mm] Analyze >>> Zo [ ] [ohm]

Zo [ ] [ohm] Synthesis >>> W [ ] [mm]

k [ ] lambda/4 [ ] [mm]

3、 带状线的衰减常数 α



导体损耗 α_c

介质损耗 α_d

辐射损耗

$$\alpha = \alpha_c + \alpha_d$$

4、带状线的尺寸选择

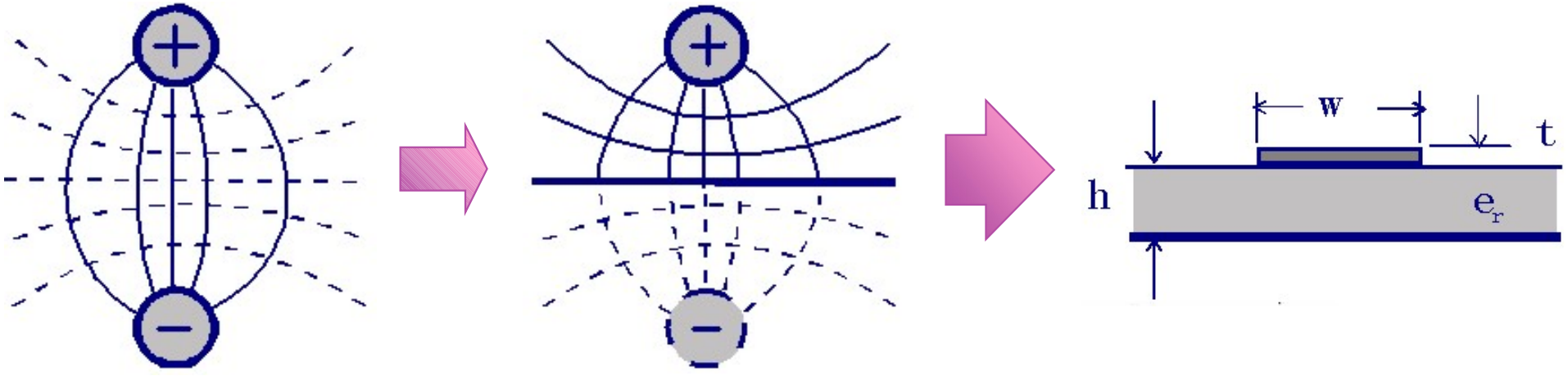
$$\begin{cases} \lambda_{\min} > 2W\sqrt{\varepsilon_r} \\ \lambda_{\min} > 2b\sqrt{\varepsilon_r} \\ W_g = (3\sim 6)W \\ b << \lambda_0/2 \end{cases}$$

$\lambda_{\min}$——微带线的最短工作波长

λ_0 ——中心工作波长

W_g ——接地板的宽度

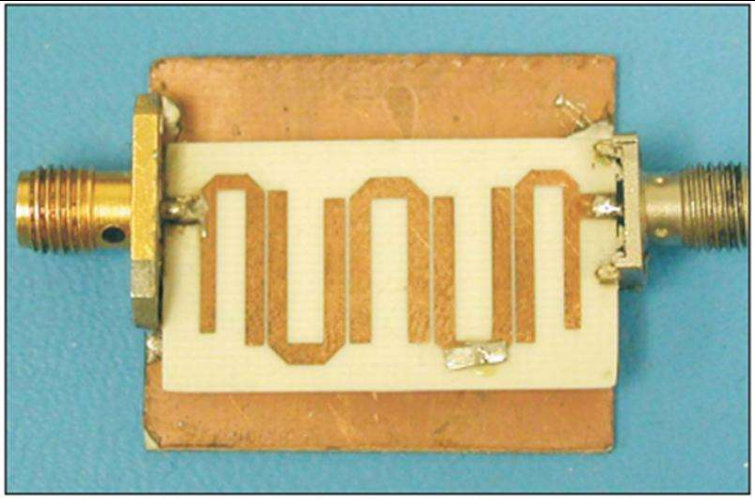
二、 微带线



- 微带——采用金属薄膜工艺

基片 → 打孔 → 蒸发 → 光刻 → 腐蚀 → 电镀

- 和有源器件、半导体管构成放大、混频和振荡。



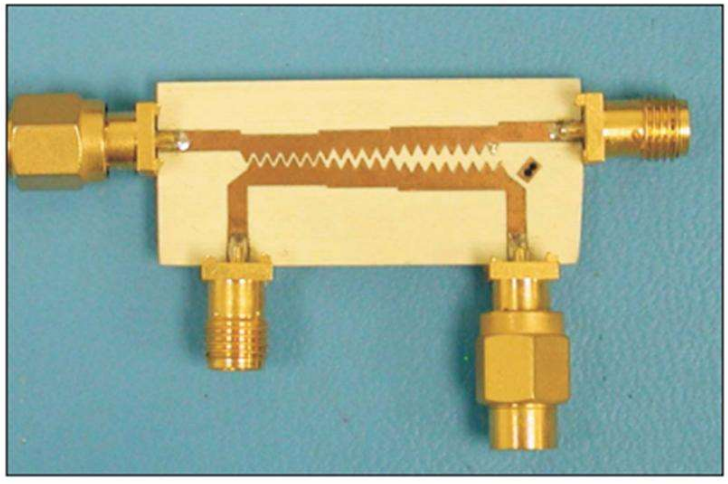
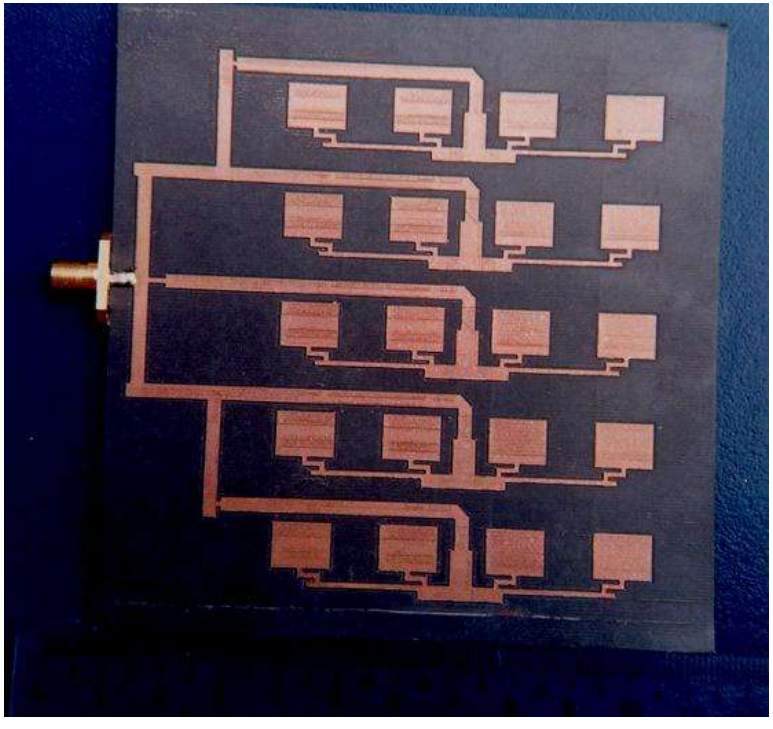
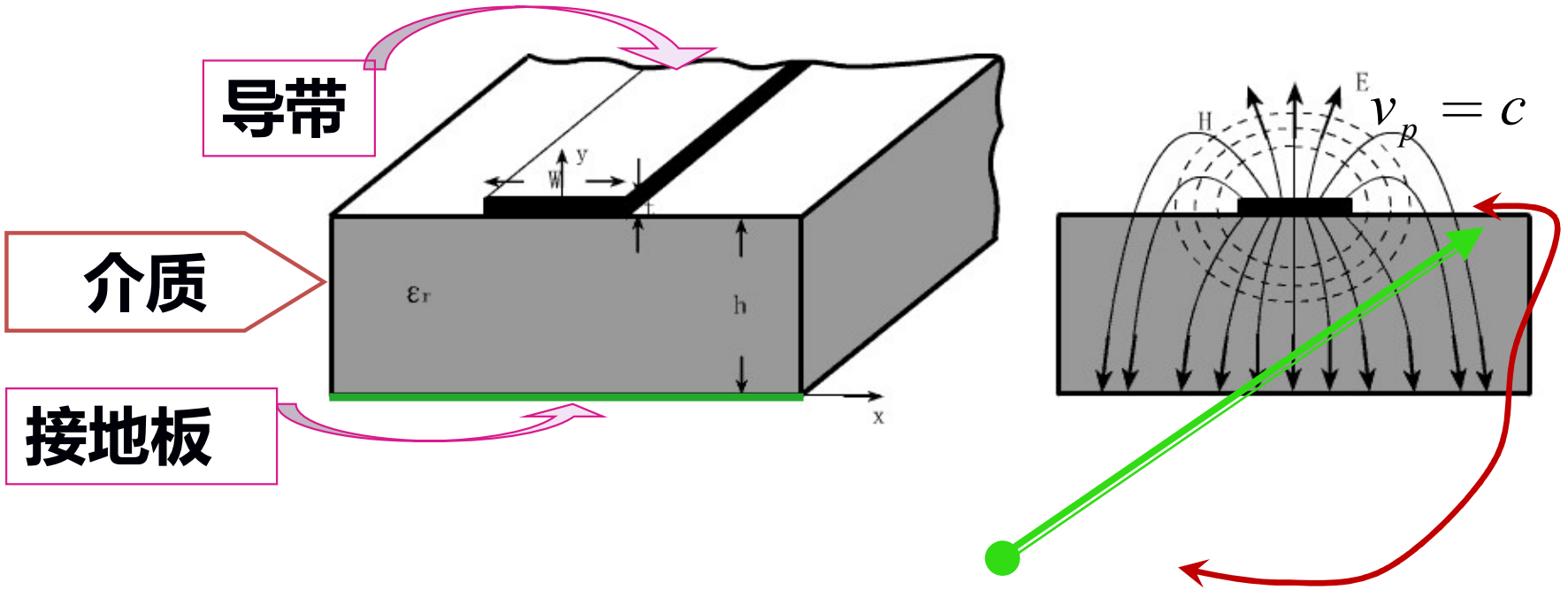


图 14，3.7 到 4.2GHz 发夹型滤波器的样品板照片

5，使用 Schiffm





相速在两分界面上对TEM模不匹配。

1、特性阻抗与相速

$$v_p = c/\sqrt{\varepsilon_e} \qquad v_p = c/\sqrt{\varepsilon_r}$$

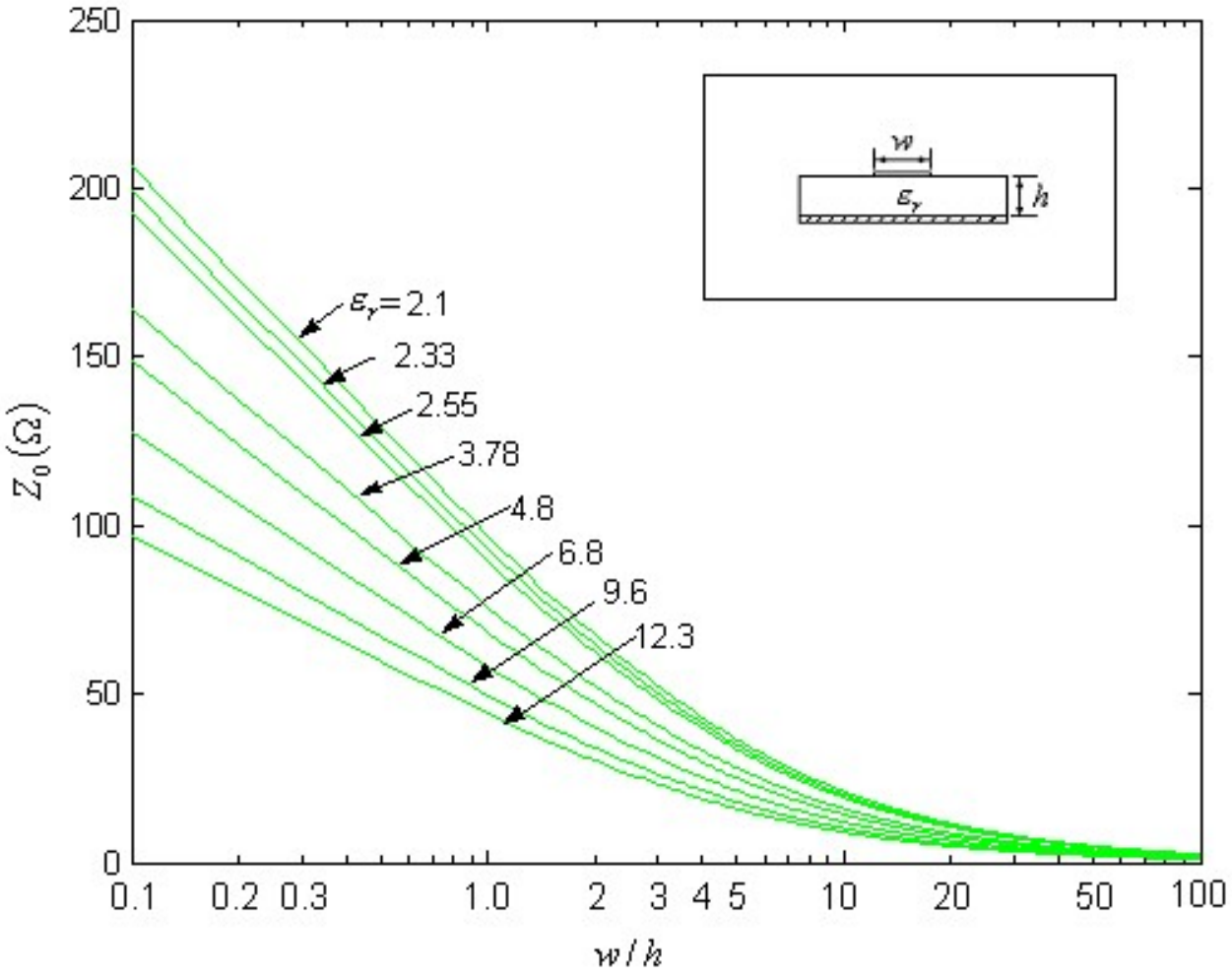
$$\lambda_p = \frac{\lambda_0}{\sqrt{\varepsilon_e}}$$

ε_e 有效介电常数

$$Z_0 = Z_0^a/\sqrt{\varepsilon_e}$$

Z_0^a 空气微带线的特性阻抗

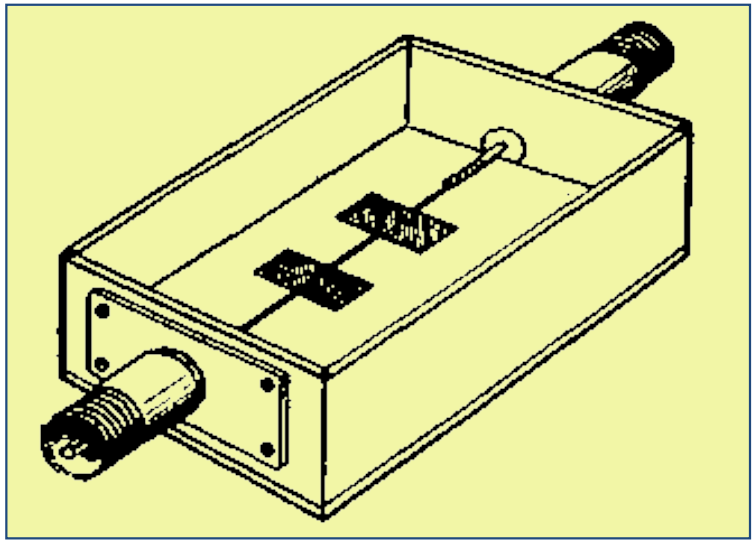
微带特性阻抗与*w*/*h*的关系



Z0随着*w*/*h*增大而减小；

相同尺寸下，ε_r越大，Z0越小。

2、 衰减常数



介质损耗 α_d：介质分子交替极化和晶格来回碰撞----热损耗

导体损耗 α_c：截面较小，导体损耗大

辐射损耗：由半开放性所引起，故微带线常放在金属屏蔽盒中—可避免辐射损耗

无辐射损耗时

$$\alpha = \alpha_c + \alpha_d$$

3、色散(dispersive)特性

设不考虑色散时的频率为f_{max}，对于给定结构的微带线来说其f_{max} 是一定的。

$$f_{\max}=\frac{0.955}{\sqrt[4]{\varepsilon_r-1}}\sqrt{\frac{Z_0}{h}}(\mathrm{GHz})$$

其中， Z_0的单位为Ω，h的单位是mm。

4、高次模与微带尺寸的选择

➢波导模式存在于导带与接地板之间

$$\lambda_{cTM_{01}}=2h\sqrt{\varepsilon_r}$$

$$\lambda_{cTE_{10}}=4h\sqrt{\varepsilon_r-1}$$

➢表面波模式则只要在接地板上有介质基片即能存在

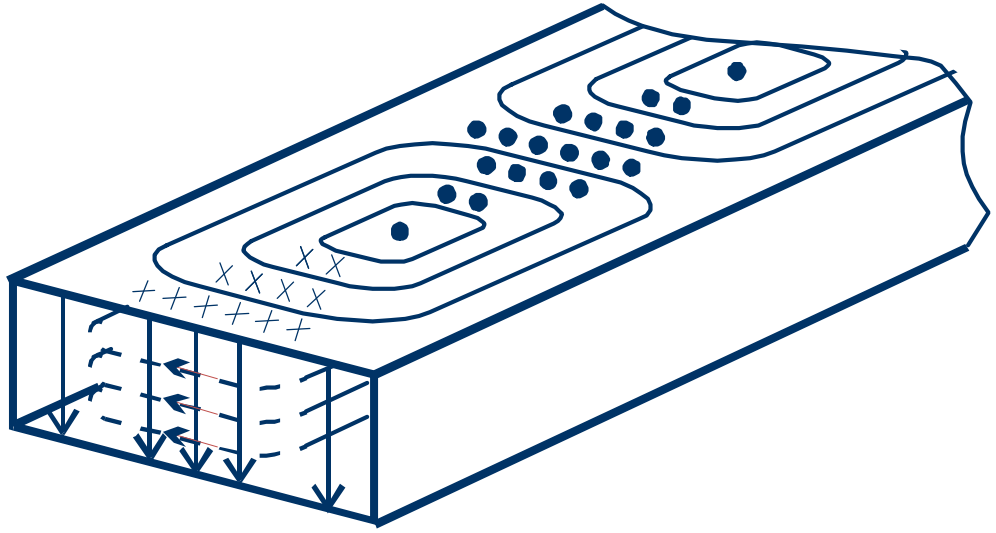
为抑制高次模的产生

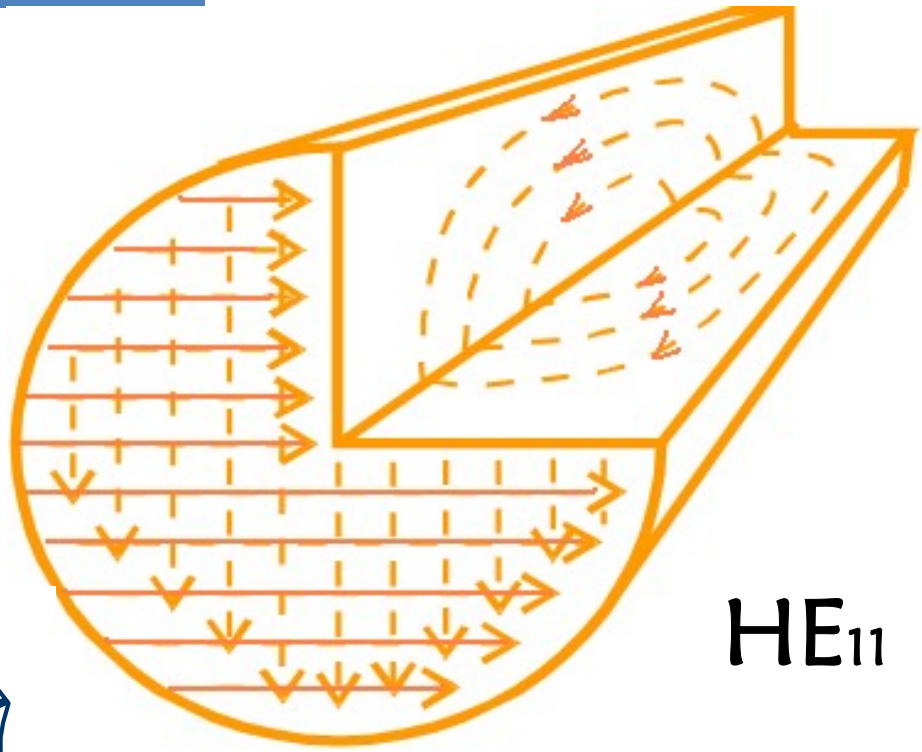
$$w<\frac{(\lambda_0)_{min}}{2\sqrt{\varepsilon_r}}-0.4h$$

$$h<\min[\frac{(\lambda_0)_{\min}}{2\sqrt{\varepsilon_r}},\frac{(\lambda_0)_{\min}}{4\sqrt{\varepsilon_r-1}}]$$

§3-2 介质波导

一、圆形介质波导

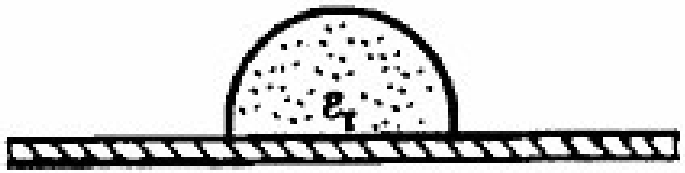




HE_{11}

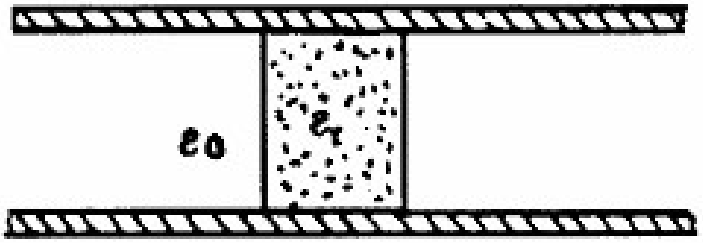
①不具有截止波长
②损耗较小
③可直接由矩形波导的主模TE_{10}激励

二、介质镜像线



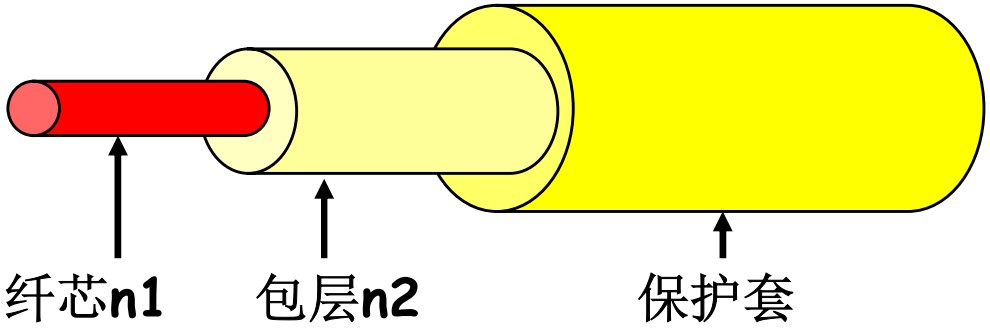
可以解决介质波导的屏蔽和支架的困难。

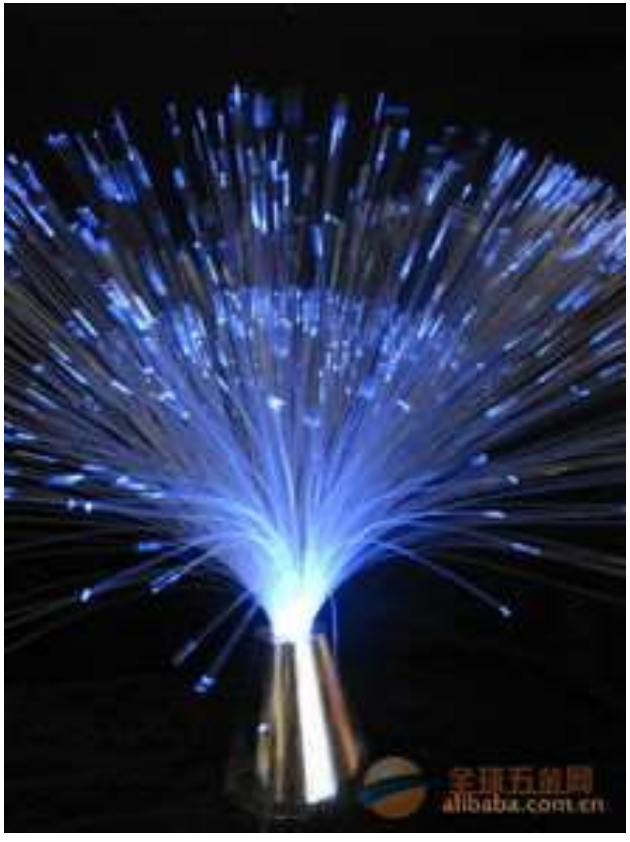
三、H形波导

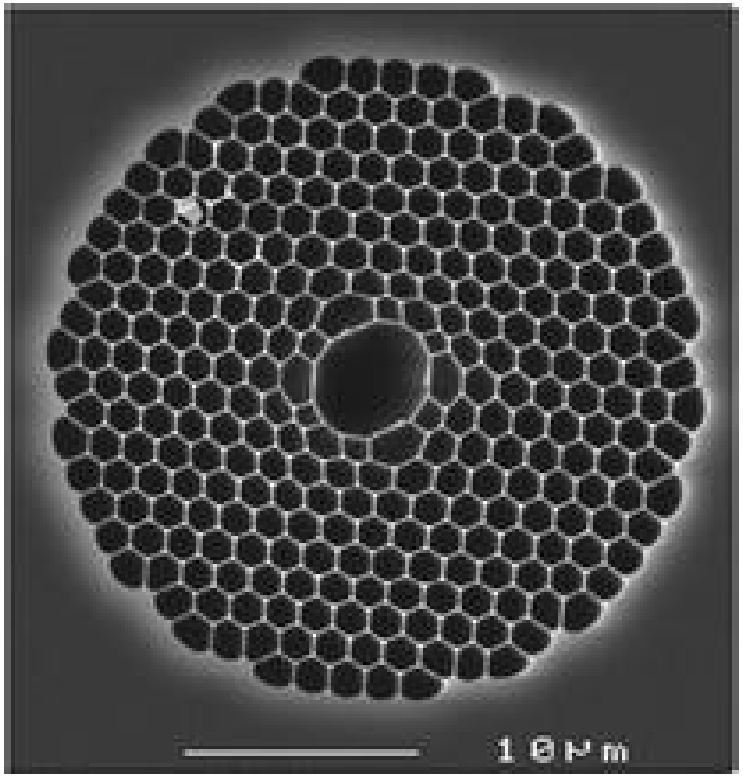


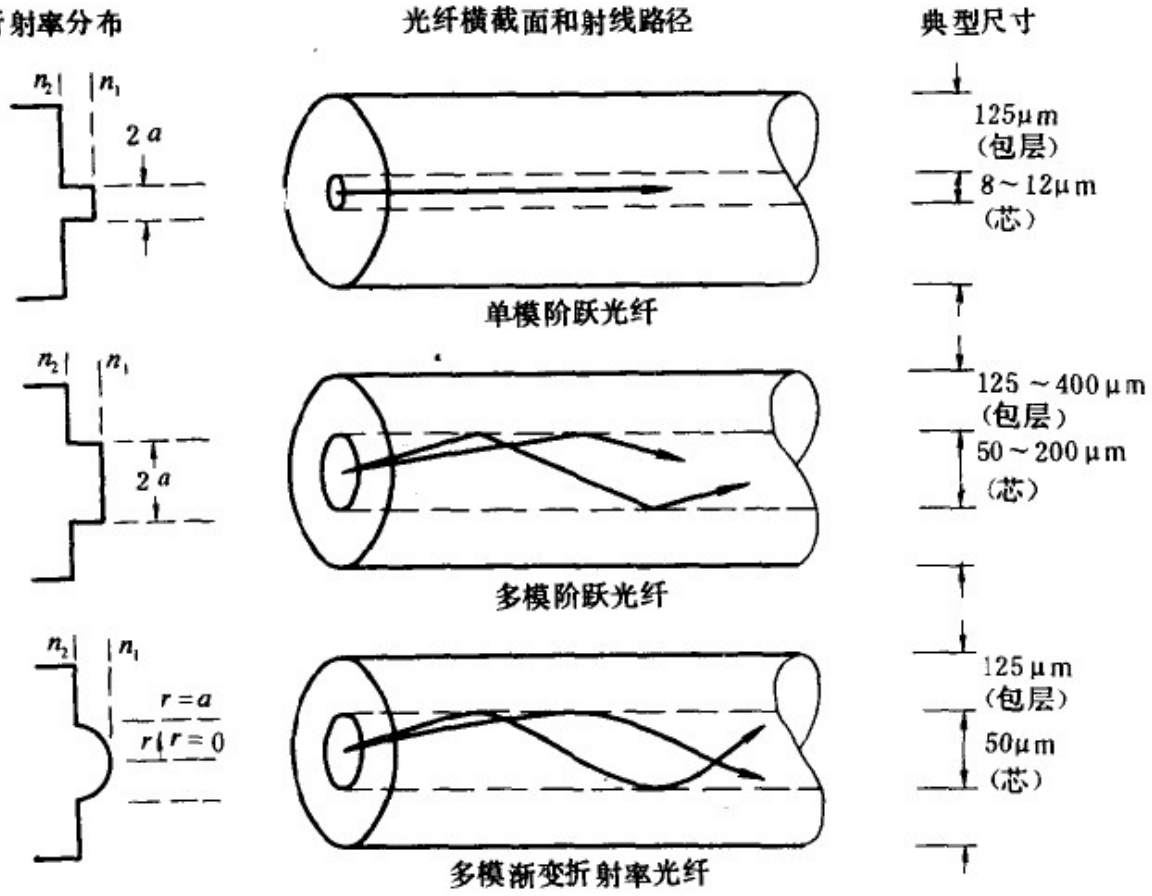
制作工艺简单、损耗小、功率容量大、激励方便

四、光纤

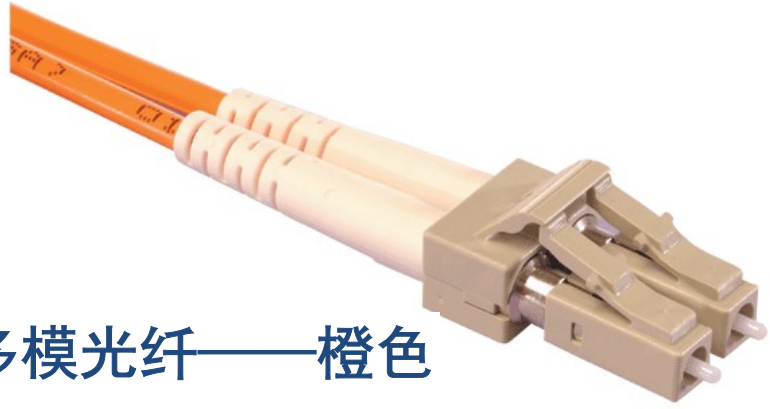





10μm



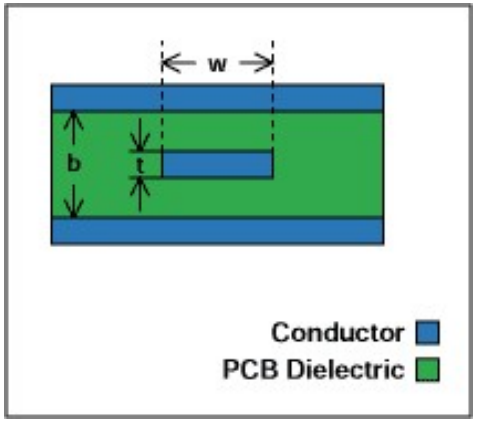
单模光纤——黄色



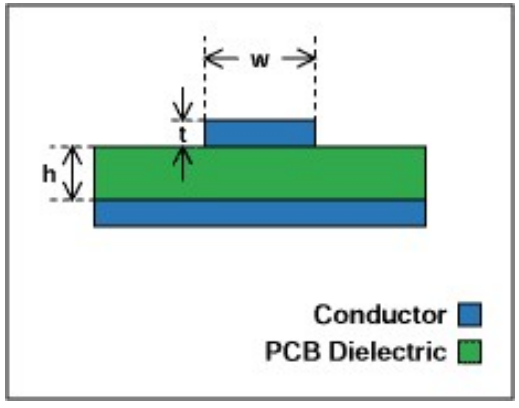
多模光纤——橙色

小　结

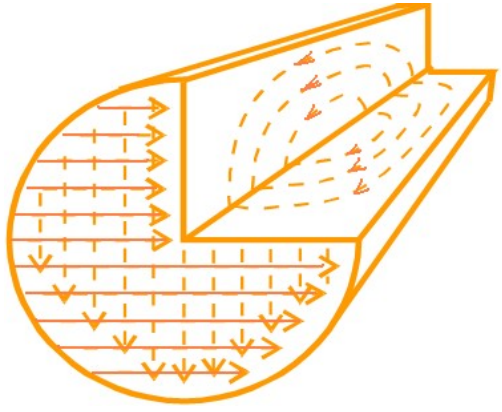
1．带状线

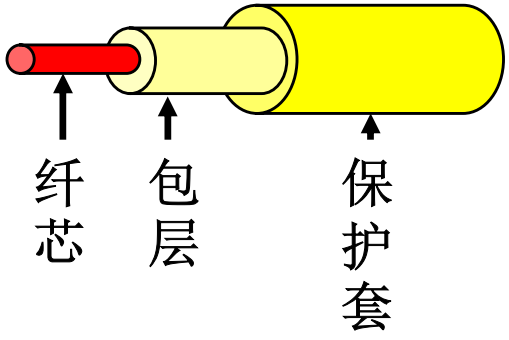


2．微带线



3、介质波导





掌握概念、特性，
计算不作要求