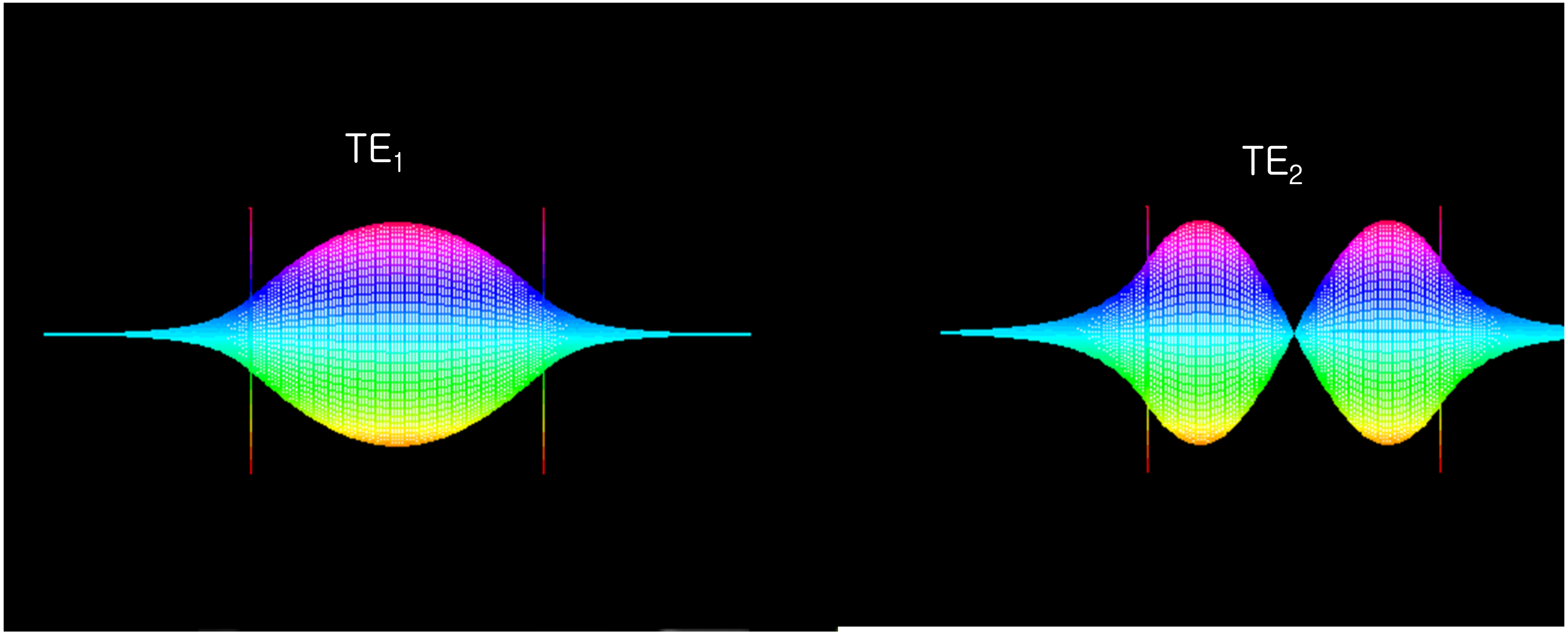
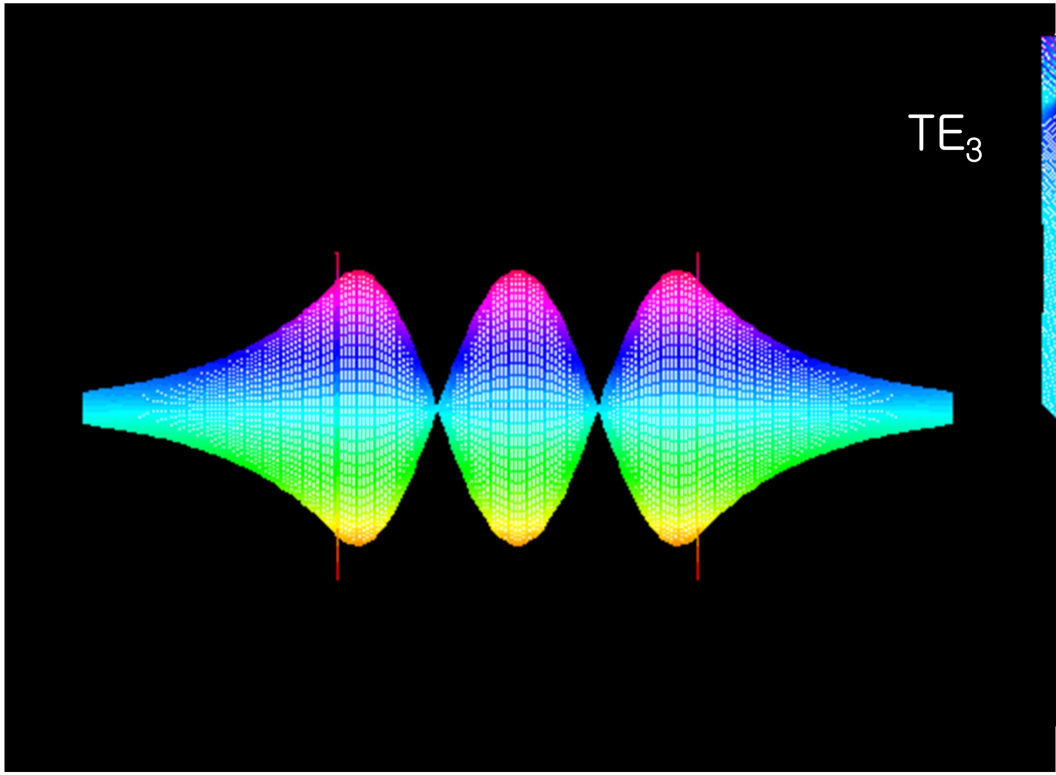
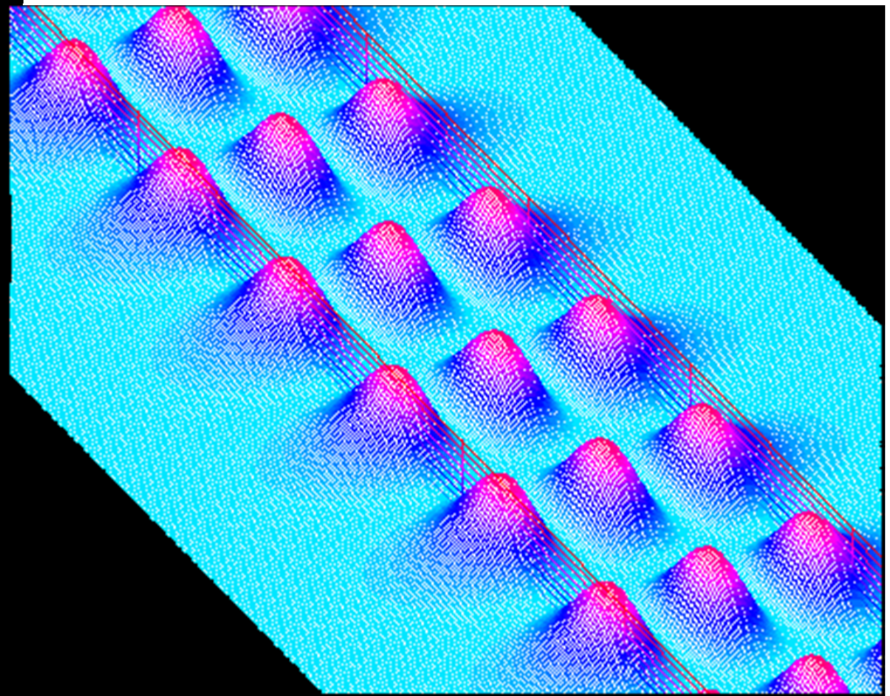
# Lect. 13: Dielectric Waveguides (2)

E(y) profile: $n_1$=1.5, $n_2$=1.495, d=10μm, λ=1μm



E(y) profile: $n_1$=1.5, $n_2$=1.495, d=10μm, λ=1μm



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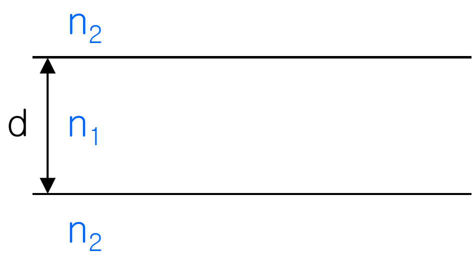
– Effective index: $n_{eff} = \beta / k_0$




How does $n_{eff}$ changes for different modes?

– Confinement factor: $\Gamma$

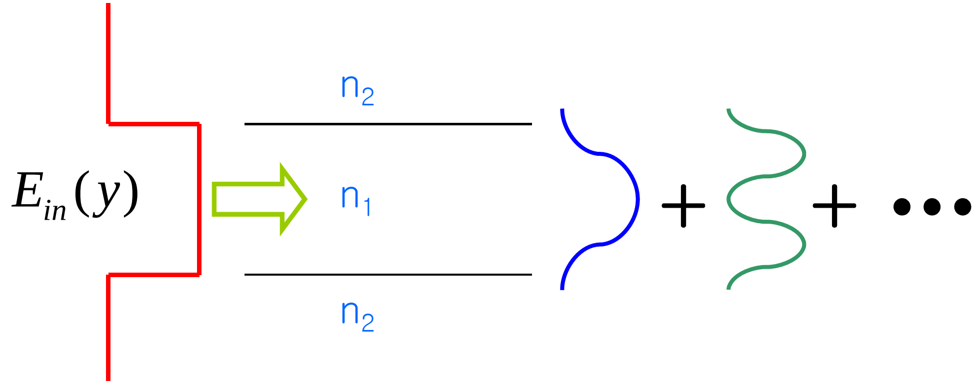
How much power is confined within the core

$$\Gamma = \frac{\text{Power inside core}}{\text{Total Power}} = \frac{\displaystyle\int_{y=-\frac{d}{2}}^{y=\frac{d}{2}} \left| E(y) \right|^2 dy}{\displaystyle\int_{y=-\infty}^{y=\infty} \left| E(y) \right|^2 dy}$$

How does $\Gamma$ change for different modes?

# Lect. 13: Dielectric Waveguides (2)

Partitioning of input field into different guided modes




$$E_{in}(y) \sim \sum_m a_m E_m(y)$$

For $a_m$, use the fact that $E_m(y)$'s are orthogonal: $\int E_m(y)E_n(y)dy = 0$ if $m \neq n$

$$\int E_{in}(y)E_m(y)dy \sim \int \left[ \sum_n a_n E_n(y) \right] E_m(y)dy = \sum_n \int a_n E_n(y)E_m(y)dy = \int a_m E_m{}^2(y)dy$$

$$\therefore a_m = \frac{\int E_{in}(y)E_m(y)dy}{\int E_m{}^2(y)dy}$$

Dot product between $E_{in}(y)$ and $E_m(y)$
Or projection of $E_{in}(y)$ into basis $E_m(y)$

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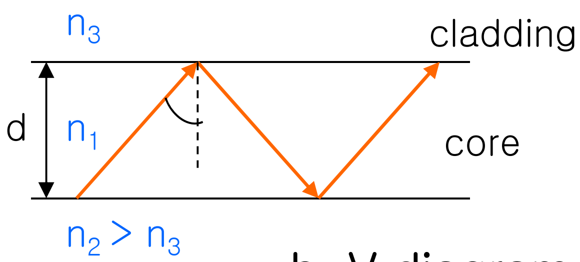
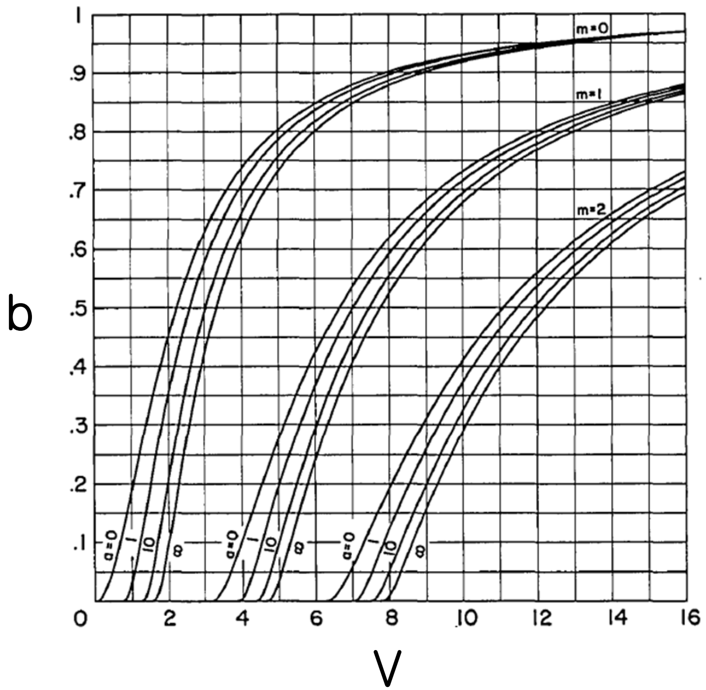



Asymmetric waveguide?

- Numerical solution

- Graphical solution

b−V diagram




(Kogelnik, Applied Optics, 13, p. 1857, 1974)

$$V = k_0 d (n_1^2 - n_2^2)^{1/2}$$

(Normalized $k$)

$$a = \frac{n_2^2 - n_3^2}{n_1^2 - n_2^2}$$

(Asymmetry factor)

$$b = \frac{\left(\beta / k_0\right)^2 - n_2^2}{n_1^2 - n_2^2}$$

(Normalized $\beta$)

For a given waveguide: V,a ➔ b from the diagram

Then, determine β

Larger V, smaller a ➔ larger β

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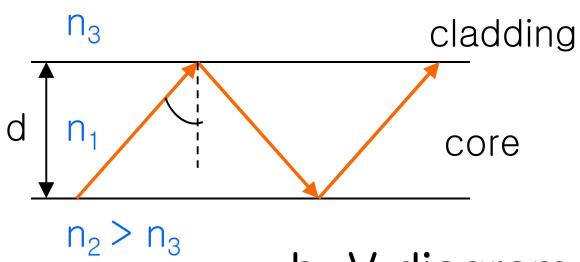
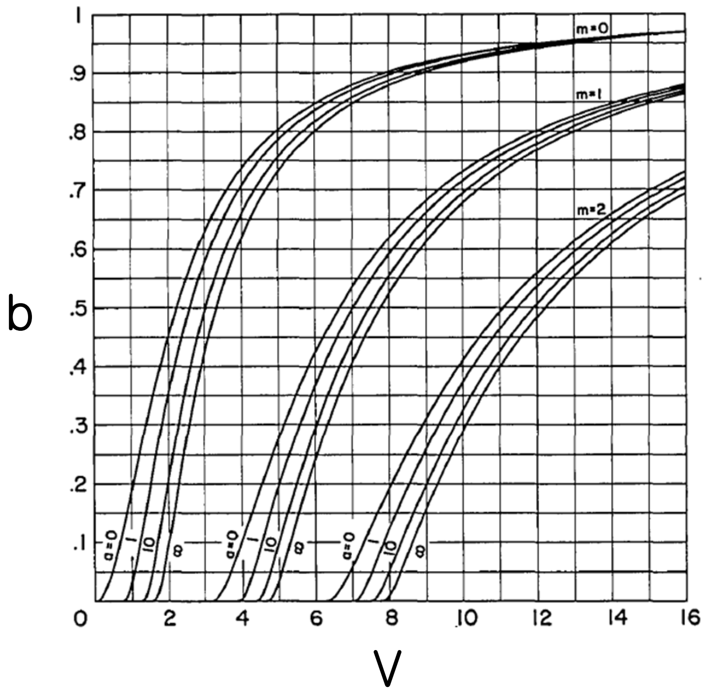



b-V diagram




TM modes ?

– Different boundary conditions

➔ Similar types of solutions but with different β values

– Same b-V diagram with

$$V = k_0 d(n_1^2 - n_2^2)^{1/2}$$

(Normalized $k$)

$$a = \frac{n_1^4}{n_3^4}\frac{n_2^2 - n_3^2}{n_1^2 - n_2^2}$$

(Asymmetry factor)

$$b = \frac{\left(\beta / k_0\right)^2 - n_2^2}{n_1^2 - n_2^2}$$

(Normalized $\beta$)

TM has smaller β than TE for the same waveguide

# Lect. 13: Dielectric Waveguides (2)

Homework

Several different types of waveguides having the same core material and thickness are shown below.

| | I | II | III | IV | |
|---|---|---|---|---|---|
| | $n_2 = 1$ | $n_2 = 1$ | $n_2 = 1.5$ | $n_2 = 1$ | |
| $y = d$ | | | | | |
| | $n_1 = 2$ | $n_1 = 2$ | $n_2 = 2$ | $n_2 = 2$ | $d$ |
| $y = 0$ | | | | | |
| | $///\sigma \to \infty///$ | $n_2 = 1$ | $n_2 = 1.5$ | $n_2 = 1.5$ | |

(a) If we sketch the fundamental mode power distribution for each waveguide, which waveguide has the largest y value for the peak power position? Explain.

(b) Between Type II and III waveguides, which has the largest value for the fundamental mode effective index? Explain.

(c) Between Type II and III waveguides, which has the largest value for the fundamental mode confinement factor? Explain.