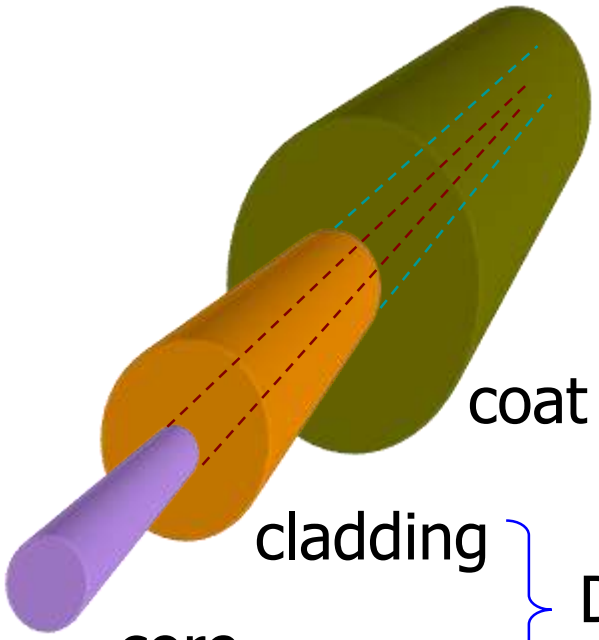
SERAT OPTIK

Kecilnya serat optik

- Struktur serat optik

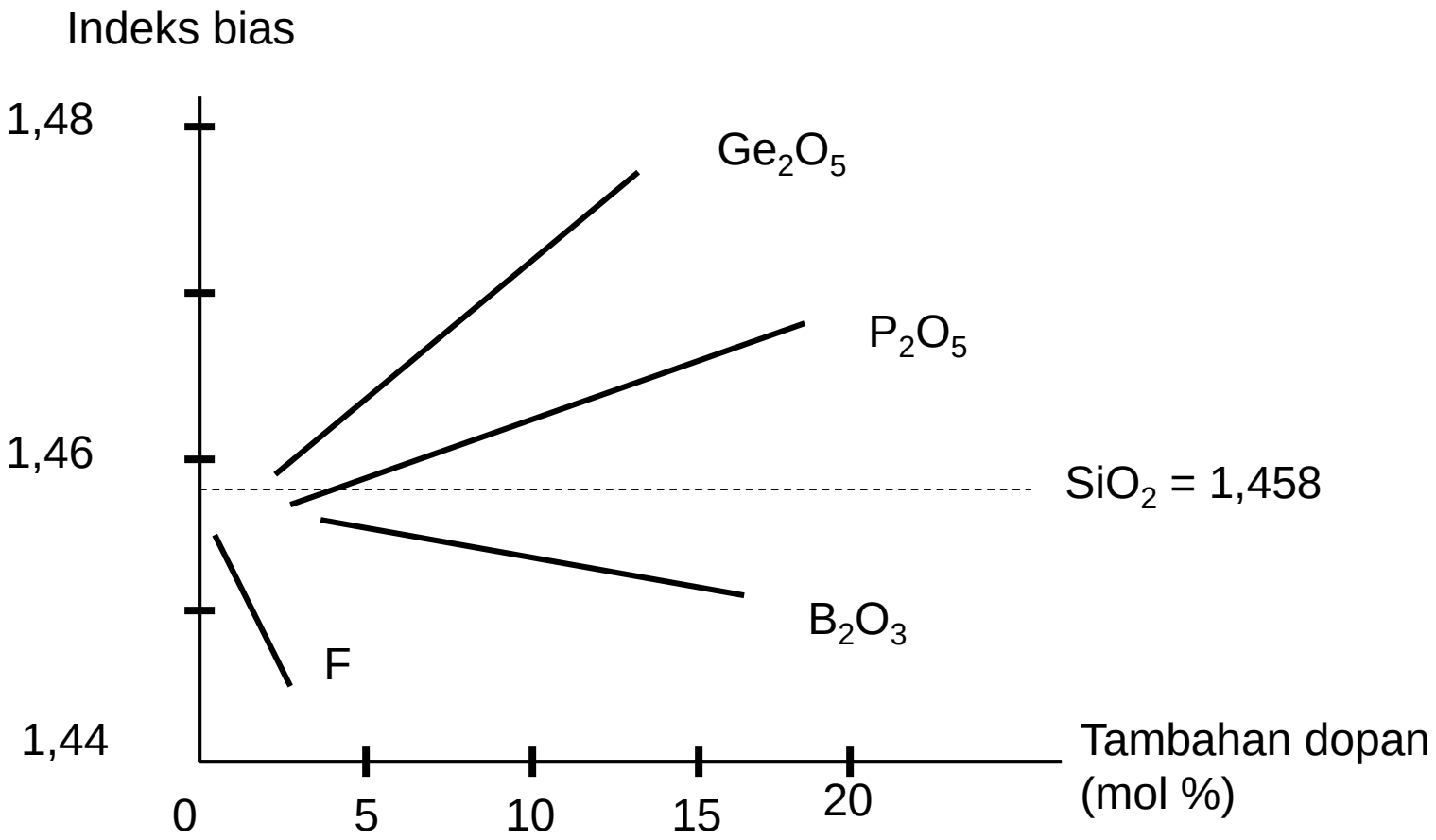


Material Serat Optik

- Syarat :
  - Harus dapat dibuat panjang
  - Harus tembus pandang ➔ efisien
  - Memungkinkan memiliki beda indeks bias kecil antara inti dan kulit.
- Yg memenuhi syarat :
  - Fiber gelas
  - Fiber gelas halida
  - Fiber gelas aktif
  - Fiber gelas berkulit plastik
  - Fiber plastik

Fiber gelas

Campuran fusi oksida logam, sulfida/selenida.



Contoh komposisi fiber

INTI	KULIT
GeO_2-SiO_2	SiO_2
P_2O_5-SiO_2	SiO_2
SiO_2	B_2O_3-SiO_2
GeO_2-B_2O_3-SiO2	B_2O_3-SiO_2

Fiber gelas halida

- Gelas fluorida ditemukan peneliti Universite de Rennes th 1970
- Memiliki rugi2 sangat rendah pd frek tengah infra merah (0,2 s/d 8 μm, terendah pd 2,55 μm)
- Unsur utama ZrF_4 disebut ZBLAN
- Utk indeks bias lebih rendah satu bagian ZrF_4 diganti dng HaF_4 shg menjadi ZHBLAN untuk kulit.
- Keuntungan redaman rendah 0,001 s/d 0,01 dB/Km
- Kerugian sulit dibuat panjang krn mudah tidak menjadi gelas (devitrification)

Unsur pokok ZBLAN

MATERIAL	PROSEN MOL
ZrF_4 (sirkon Fluor)	54
BaF_2(Barium Fluor)	20
LaF_3 (Lantan Fluor)	4,5
AlF_3 (Aluminium Fluor)	3,5
NaF (Natrium Fluor)	18

Fiber gelas aktif

- Erbium (E), neodium (Nd) dpt menghasilkan penguatan, redaman, perlambatan phasa
- Dpt diberikan doping gelas silika/gelas halida
- Dgn memperhatikan spektrum absorbsi dan fluorisasi ➔ sumber memancar pd spektrum optis

Rare-Earth Doped Fibers

Ion	Common host glasses	Important emission wavelengths
neodymium (Nd^{3+})	silicate and phosphate glasses	1.03–1.1 μm, 0.9–0.95 μm, 1.32–1.35 μm
ytterbium (Yb^{3+})	silicate glass	1.0–1.1 μm
erbium (Er^{3+})	silicate and phosphate glasses, fluoride glasses	1.5–1.6 μm, 2.7 μm, 0.55 μm
thulium (Tm^{3+})	silicate and germanate glasses, fluoride glasses	1.7–2.1 μm, 1.45–1.53 μm, 0.48 μm, 0.8 μm
praseodymium (Pr^{3+})	silicate and fluoride glasses	1.3 μm, 0.635 μm, 0.6 μm, 0.52 μm, 0.49 μm
holmium (Ho^{3+})	silicate glasses, fluorozirconate glasses	2.1 μm, 2.9 μm

Fiber gelas berkulit plastik (PCS)

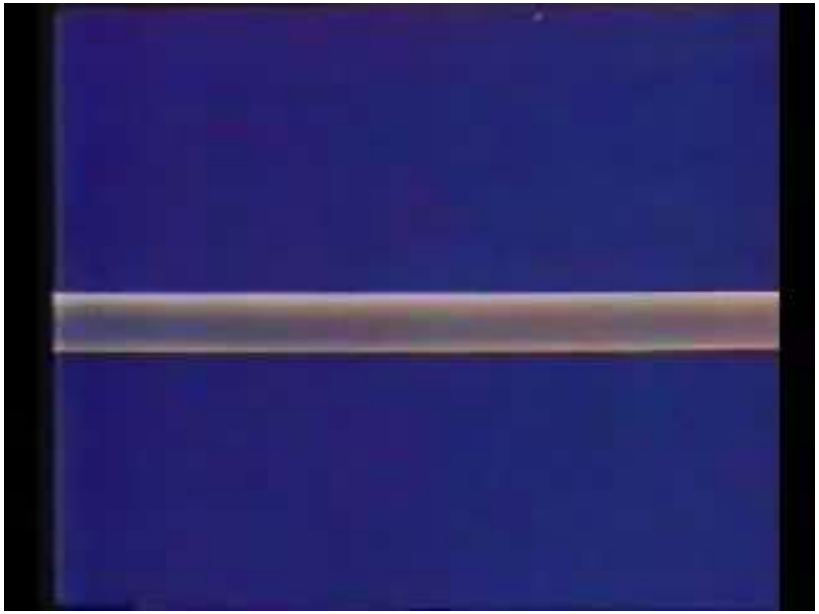
- Inti silika
- Kulit plastik/polimer (n=1,405 pd 850 nm) atau FEP (Fluoride Ethylene Propylene), n=1,338
- NA besar
- Hanya fiber step index
- Keuntungan murah & kopling dgn sumber baik
- Kerugian redaman besar, kualitas rendah
- Hanya cocok utk komunikasi jarak pendek

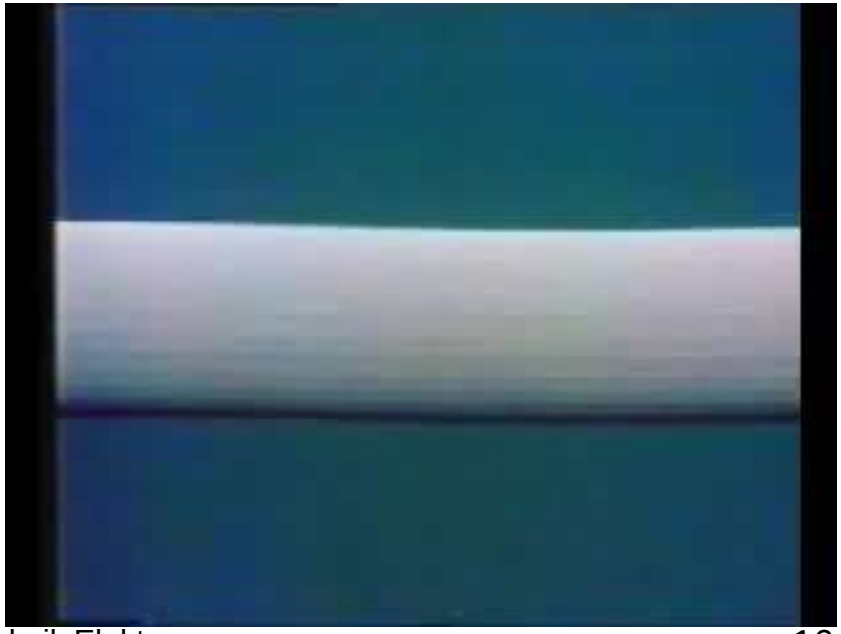
Fiber plastik

- Inti dan kulit plastik
- Contoh :
  - Inti polisterene (n=1,60), kulit methyl meta crylate (n=1,49)
  - Inti methyl meta crylate, kulit copolimernya (n=1,40)
- Keuntungan sudut penerimaan besar, murah, mudah dipelihara, fleksibel ➔ ukuran inti besar 110 s/d 1400 μm cocok dng LED
- Hanya cocok utk kom jarak sangat pendek ±100 m

Serat Optik

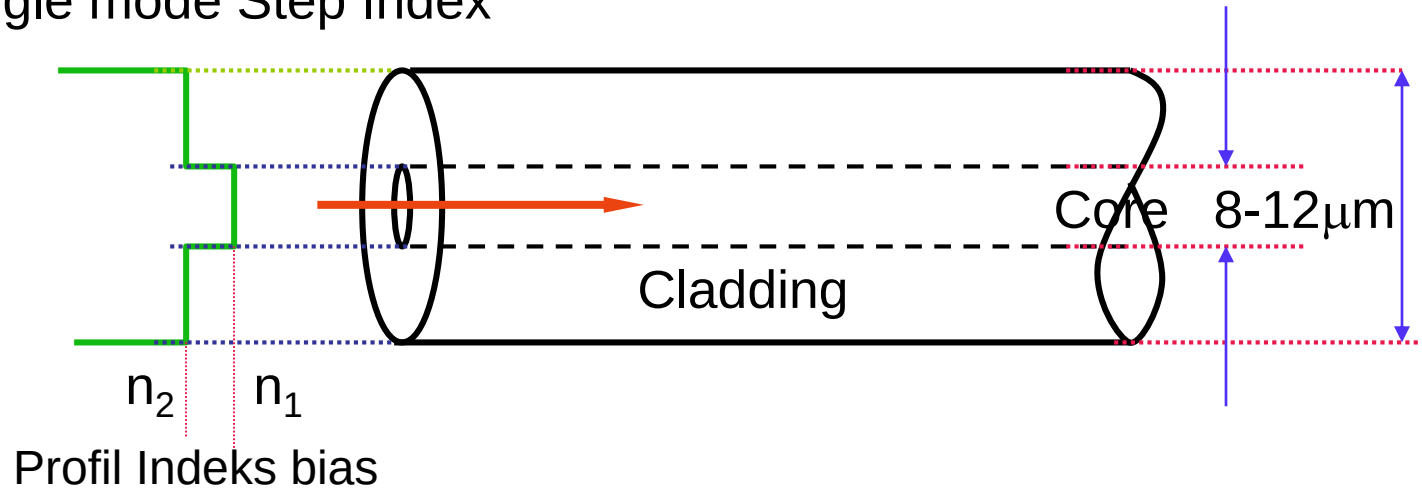
- Bagaimana cahaya merambat dalam serat optik ?





Serat Optik (Jenis serat optik)

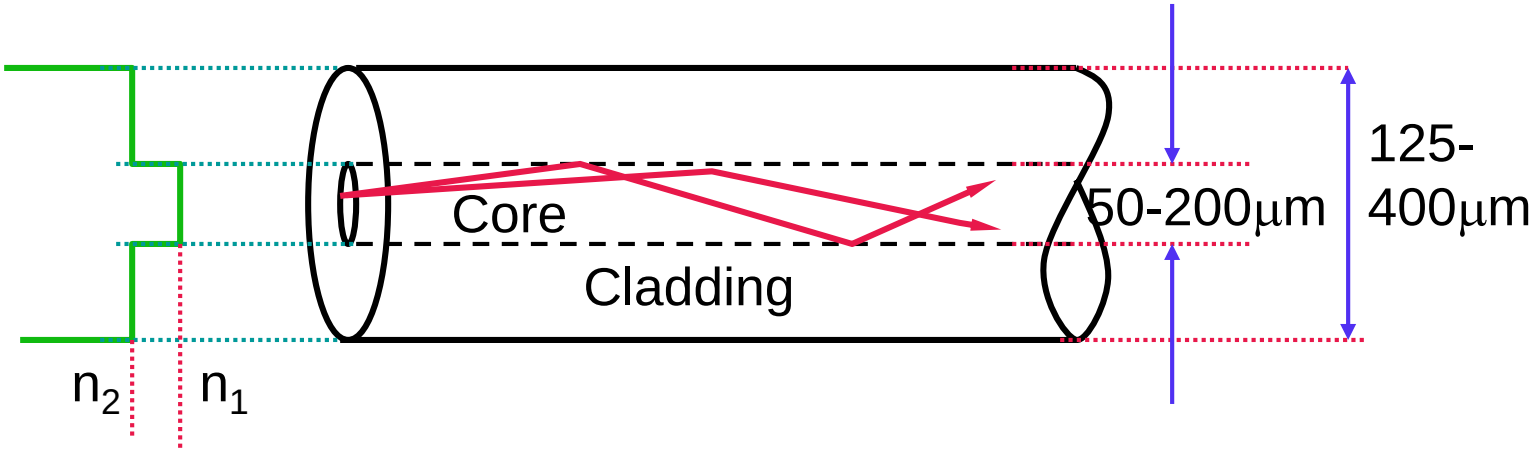
- Single mode Step Index



Kelebihan	Kekurangan
Dispersi minimum	NA Kecil : butuh ILD
BW Lebar	Sulit untuk terminasi
Sangat efisien	Mahal

Serat Optik (Jenis serat optik)

- Step Index Multimode

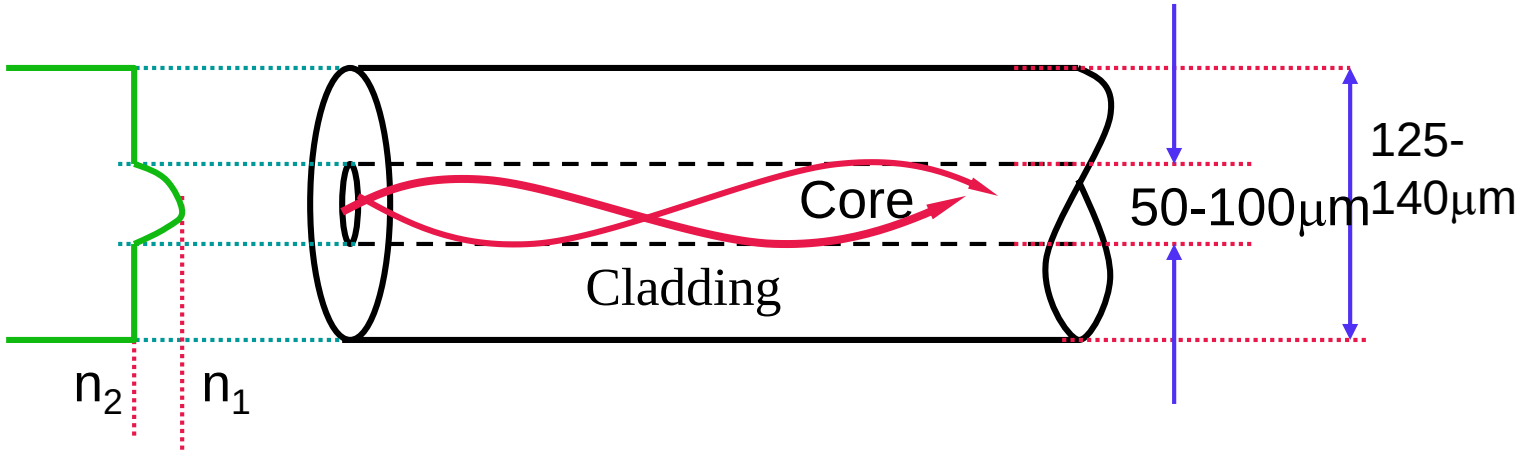


Profil Indeks bias

Kelebihan	Kekurangan
Mudah terminasi kopling efisien (NA>>) Tidak mahal	Dispersi lebar BW minimum

Serat Optik (Jenis serat optik)

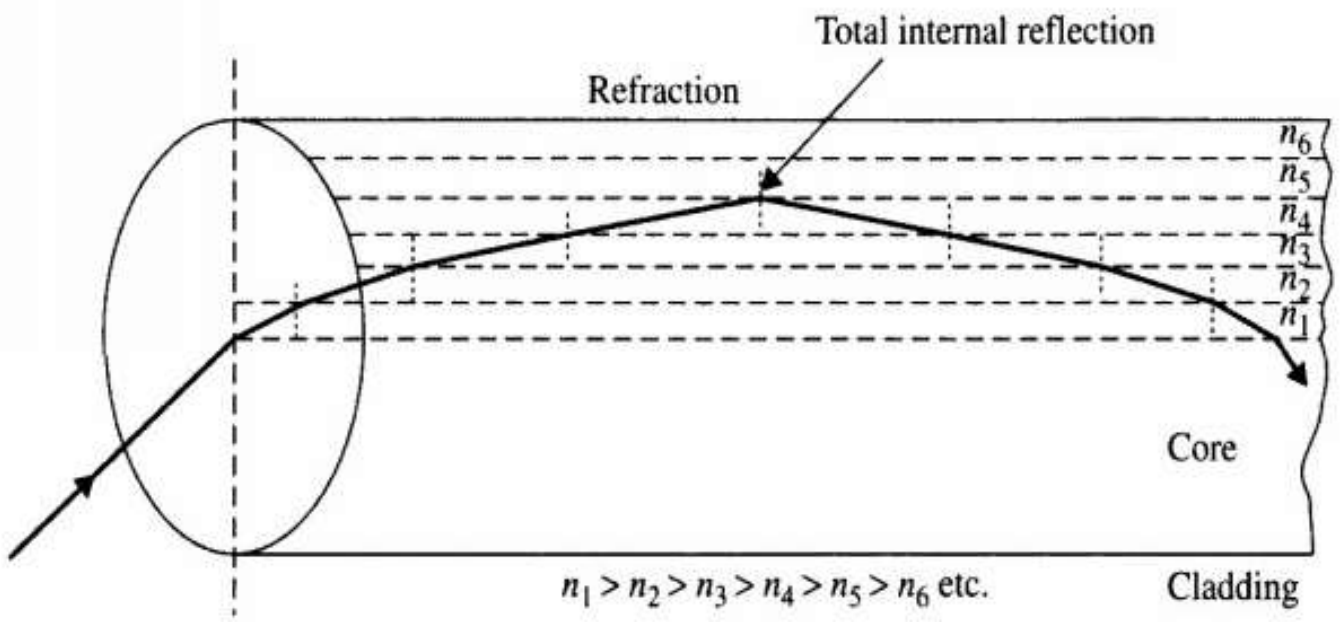
- Graded Index Multimode



Profil Indeks bias

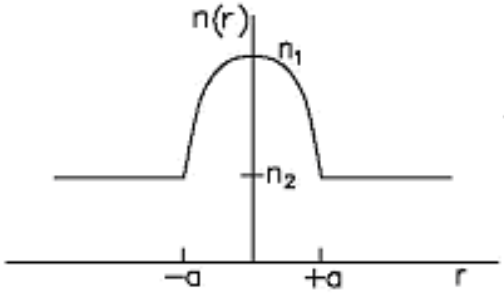
Serat optik graded indeks merupakan serat yang kelebihan dan kekurangannya berada diantara serat jenis single mode dan multimode step indeks

TIR pada Graded Index Fiber



Graded-Index Multimode (GI MM) Fibers

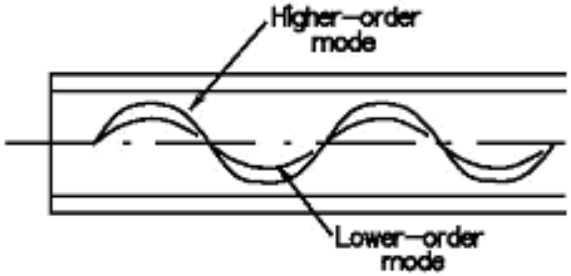
- Non-step-index profile *n(r)*



$$n(r) = \begin{cases} n_1\sqrt{1-2\Delta(r/a)^g} & r \le a \\ n_1\sqrt{1-2\Delta} \approx n_1(1-\Delta) = n_2 & r \ge a \end{cases}$$

g : gradient = Profile parameter

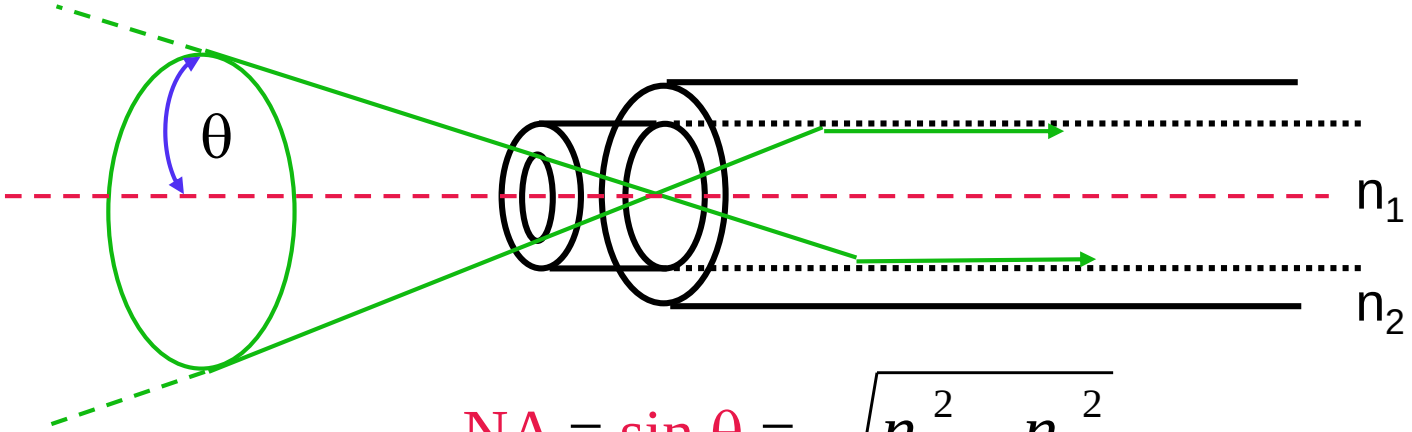
- Wave confinement by sinusoidal path within core



- Cladding
  - Only isolates core from outside world
  - No guiding action

Karakteristik Serat Optik

- Numerical Aperture (NA)



$$NA = \sin\theta = \sqrt{n_1^{\,2} - n_2^{\,2}}$$

Numerical Aperture adalah kemampuan serat optik untuk mengumpulkan cahaya

Karakteristik Serat Optik

Graded Index Fiber :

Nilai NA tergantung lokasi ➔ local NA

– ***Local NA***:

$$\mathrm{NA}(r) = \begin{cases} \mathrm{NA}(0)\left[1-(r/a)^{g}\right] & \text{for } r < a \\ 0 & \text{for } r \geq a \end{cases}$$

» **NA(0): NA at core center = sqrt(n_1^2-n_2^2)**

Karakteristik Serat Optik

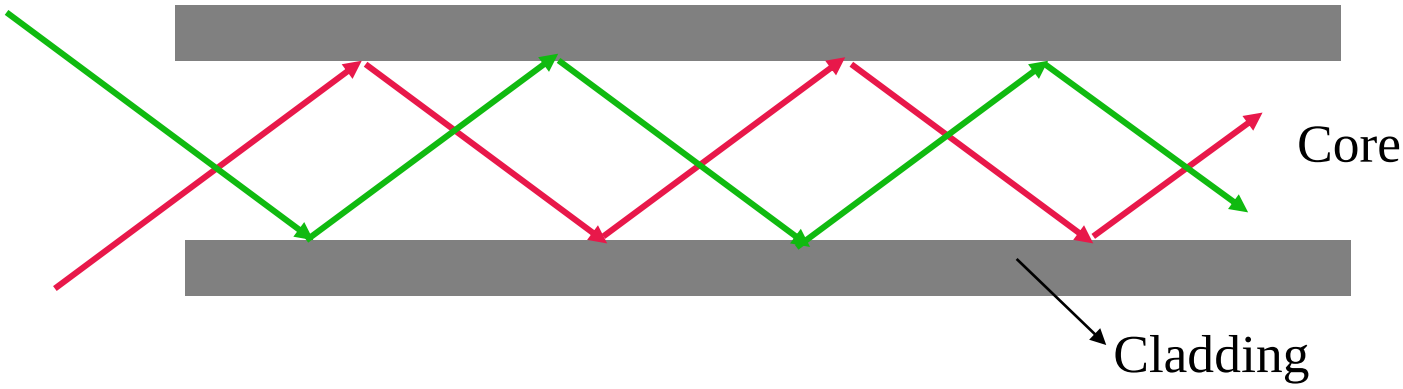
- Bandwidth-distance product
  - *Sebuah ukuran kapasitas informasi serat optik, dinyatakan dalam MHz.Km*

Contoh :

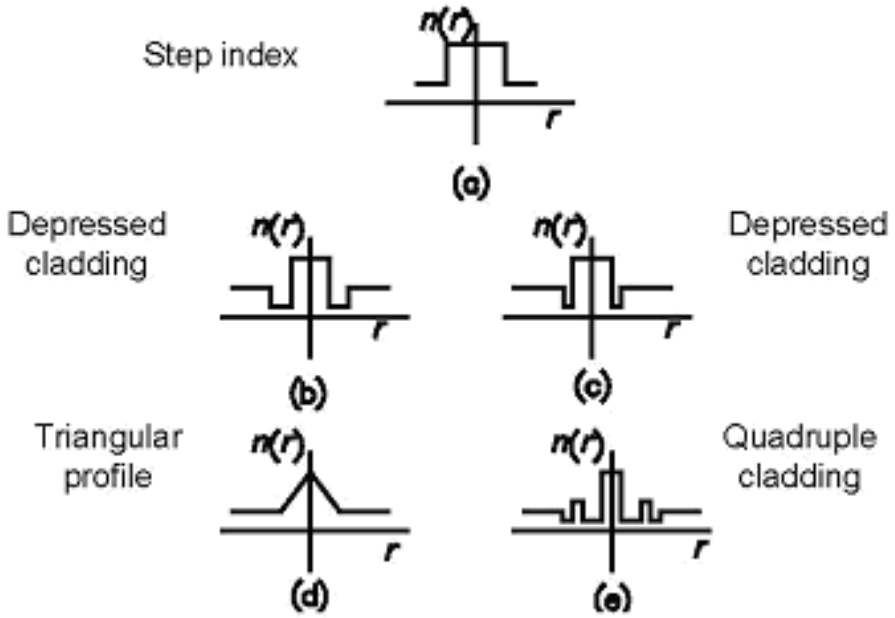
BW 400 MHz.Km, artinya sinyal 400 MHz dapat dikirim untuk 1 Km, atau dapat berarti pula BW x L $\leq$ 400

Karakteristik Serat Optik

- Karakteristik Mekanis
  - Strength
  - Static fatigue
- TIR (Total Internal Reflection)



Multi-Step Single-Mode Fibers



- **Pros: increased data rates, less loss susceptibility, more fiber design flexibility**
- **Cons: harder to fabricate, harder to model**

The **electric susceptibility** χe of a dielectric material is a measure of how easily it polarizes in response to an electric field.

Fiber Parameters: Summary

- Introduced
  - Fiber *core* and *cladding*
  - Fiber guiding properties
    - » Total internal reflection
    - » Guiding by refractive index change
  - Step-index or Graded-index refractive index profile
    - » GI: modeled with power-law profile
  - *Modes* in fibers
    - » *Single-mode fiber*
      - *Mode field diameter (MFD)*
      - *Cutoff wavelength*
    - » Multimode fiber
      - *V-parameter*
      - Core radius, *a*
      - *Numerical aperture*, NA

Fiber Parameters: Summary

- Multimode fibers
  - –Pro:
    - » Moderate distances and/or data rates
    - » Easier coupling (larger core & NA)
  - –Con:
    - » Lack extreme bandwidth capacity
    - » Mode mixing makes unpredictable behavior at joints

- Single-mode fibers
  - – Present fiber of choice
  - – Pro:
    - » High data rate-distance combinations
    - » Lower fiber attenuation
  - – Con:
    - » Lower fabrication tolerances
    - » Lower coupling efficiency
    - » Lower misalignment tolerance at joints
    - » Increased susceptibility to bending and spooling losses

- Costs:
  - – About equal
  - – Readily available