Optoelectronică, structuri şi tehnologii

Curs 5
2014/2015

Fotografii


Studentii care au trimis fotografiile
Grupa: 5402
Grupa: 5403
Grupa: 5404
Grupa: 5405
Nr. Nume
1 APETRII MARIA
1 ALEXANDRESCU SEBASTIAN
1 APERGHIS MIHAI-ALIN
1 ANGHELUS MARIU


Studentii care inca nu au trimis fotografiile
Grupa: 5304
Grupa: 5402
Grupa: 5403
Grupa: 5404
Nr. Nume

Reprezentare logaritmică

$dB = 10 \cdot \log_{10}(P_2 / P_1)$

$dBm = 10 \cdot \log_{10}(P / 1\ mW)$

0 dB	= 1
+ 0.1 dB	= 1.023 (+2.3%)
+ 3 dB	= 2
+ 5 dB	= 3
+ 10 dB	= 10
–3 dB	= 0.5
–10 dB	= 0.1
–20 dB	= 0.01
–30 dB	= 0.001

0 dBm	= 1 mW
3 dBm	= 2 mW
5 dBm	= 3 mW
10 dBm	= 10 mW
20 dBm	= 100 mW
–3 dBm	= 0.5 mW
–10 dBm	= 100 μW
–30 dBm	= 1 μW
–60 dBm	= 1 nW

[dBm] + [dB] = [dBm]

[dBm/Hz] + [dB] = [dBm/Hz]

[x] + [dB] = [x]

Lumina ca undă electromagnetică

Capitolul 2

Parametri, dependenta de mediu

$$\eta_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} = 377\Omega$$

$$c_0 = \frac{1}{\sqrt{\varepsilon_0 \cdot \mu_0}} = 2{,}99790 \cdot 10^8 \ m/s$$

$n = 1$

$$T = \frac{2\pi}{\omega} = \frac{1}{f}$$

$$\lambda_0 = \frac{2\pi}{\beta} = \frac{c_0}{f}$$

$$\eta = \frac{\eta_0}{n}$$

$$c = \frac{c_0}{n}$$

$n = \sqrt{\varepsilon_r}$

$$T = \frac{2\pi}{\omega} = \frac{1}{f}$$

$$\lambda = \frac{c_0}{n \cdot f} = \frac{\lambda_0}{n}$$

ITU G.692

"the allowed channel frequencies are based on a 50 GHz grid with the reference frequency at 193.10 THz"

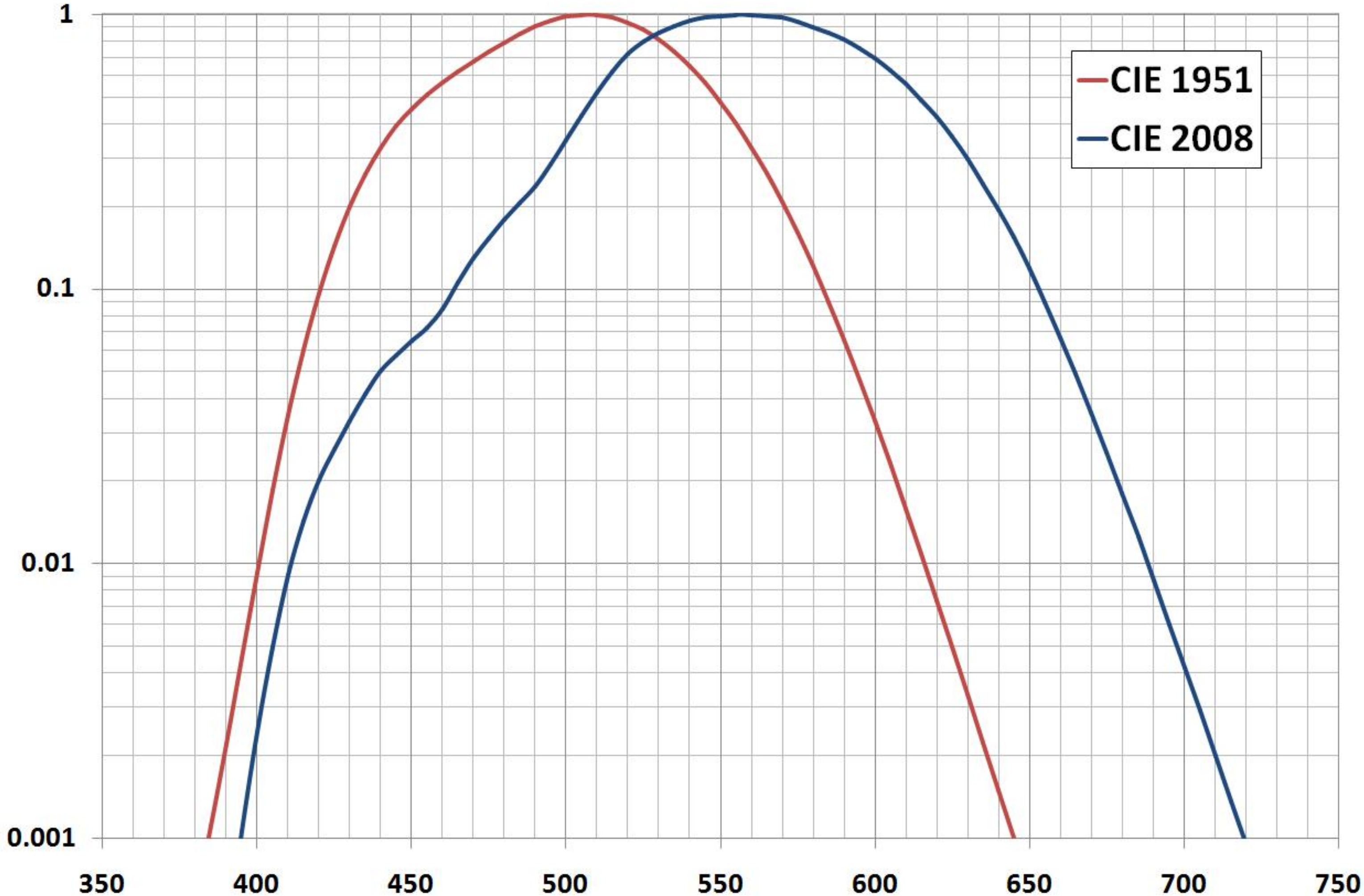
SI

"a source that emits monochromatic radiation of frequency $540 \cdot 10^{12}$ Hz"

Fotometrie şi radiometrie

Capitolul 4

CIE V(λ) fotopic / scotopic



Marimi luminoase

- Intensitatea
  - raportul dintre fluxul care părăseşte sursa şi se propagă într-un element de unghi solid ce conţine direcţia de propagare şi elementul de unghi solid.
  - o masura a puterii emise de o sursa intr-un element de unghi solid

Intensitatea			
Fotometrie		Radiometrie	
$I_v = \frac{d\Phi_v}{d\Omega}$	SI: cd	$I_e = \frac{d\Phi_e}{d\Omega}$	SI: W/sr

Marimi luminoase

- Iluminarea
  - raportul dintre fluxul primit de un element de suprafaţă conţinînd punctul şi aria acestui element (definita într-un punct al unei suprafeţe la **receptie**):
  - o masura a intensitatii luminii incidente pe o suprafata

Iluminarea			
Fotometrie		Radiometrie	
$E_v = \frac{d\Phi_v}{dS}$	SI: lx	$E_e = \frac{d\Phi_e}{dS}$	SI: W/m^2

Probleme

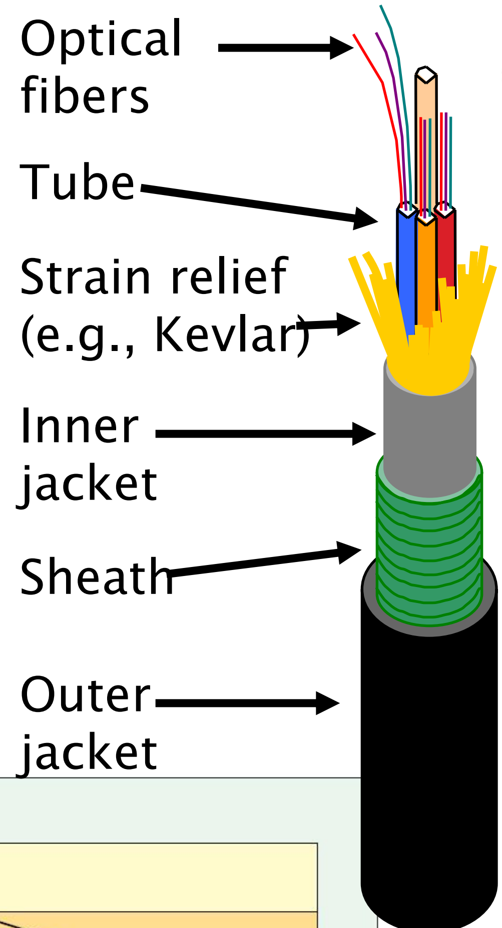
- Trebuie să proiectaţi un semafor cu LED-uri. LED-urile care intră în componenţa sa sunt caracterizate de eficienţă cuantică egală (aceeaşi tehnologie), iar parametrii de catalog pentru LED-ul roşu sunt …
- Proiectaţi semaforul, pentru a obţine o iluminare la 5m, pe direcţie normală, de 50 lx pe timp de zi şi 2 lx pe timp de noapte.
- Cerinţe: luminozitate egală pentru cele 3 culori, alegerea numărului de LED-uri (considerente electronice/practice), necesităţile de curent ale fiecărui LED, parametrii pentru sursa de alimentare, parametrii unui sistem de control a intensităţii luminoase pentru reglare zi/noapte.
- Rezolvari: http://rf-opto.etti.tuiasi.ro

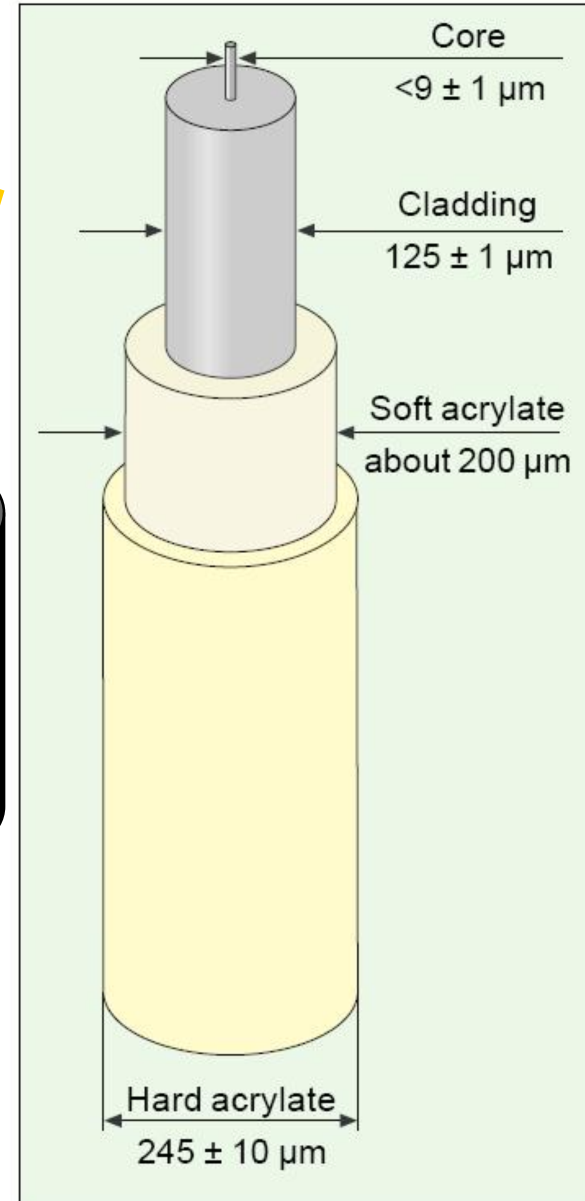
Fibra optică

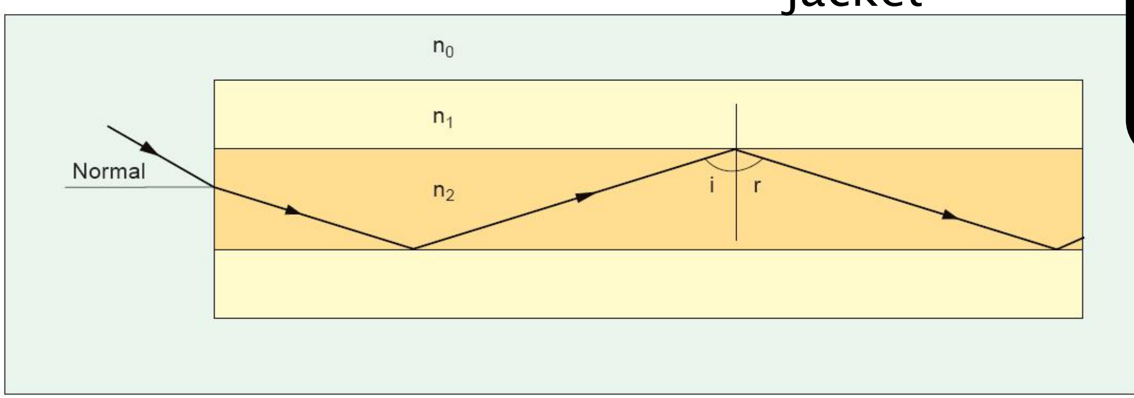
Capitolul 5

Fibra optica

- un ghid de unda dielectric
  - miez
  - teaca







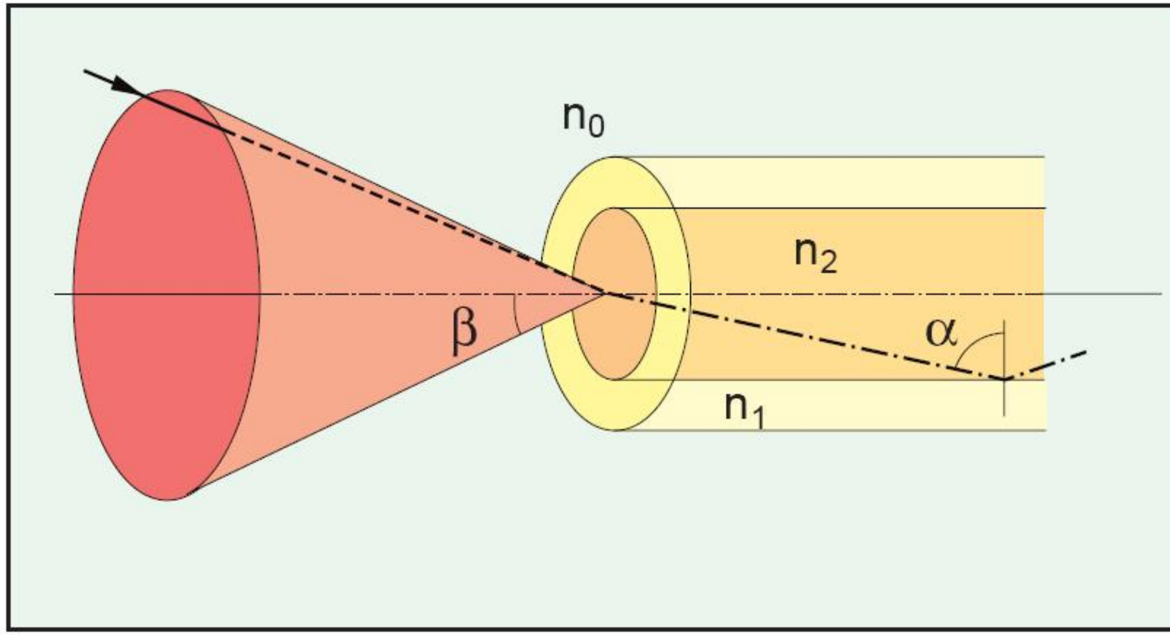
Unghi de acceptanta, apertura numerica

- Unghi de acceptanta

$$n_0 \cdot \sin\theta_{ACC} = n_2 \cdot \sin\phi_c$$

- Apertura numerica

$$NA = n_0 \cdot \sin\theta_{ACC}$$

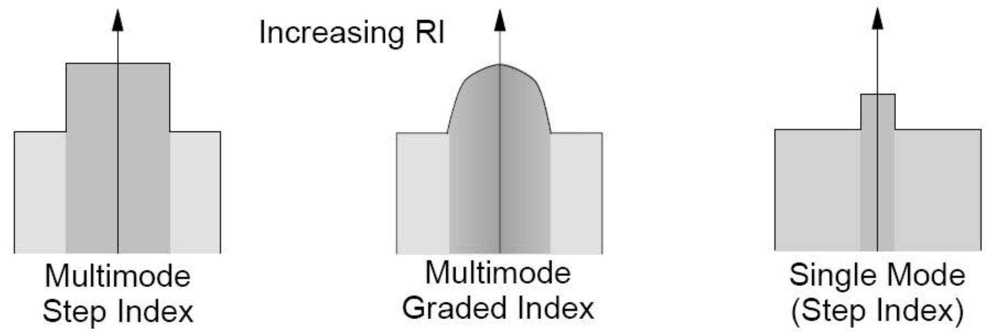


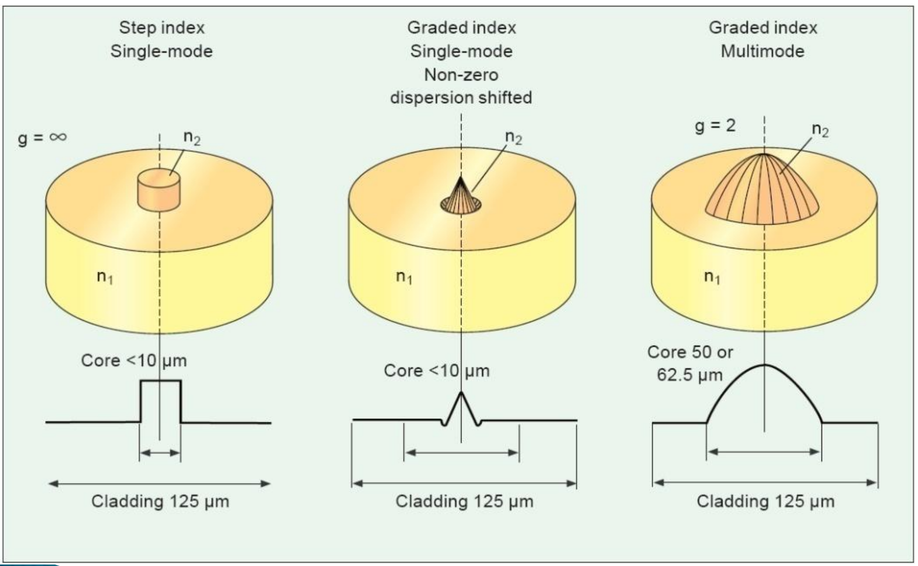
$$NA = n_2\sqrt{\frac{n_2^2 - n_1^2}{n_2^2}} = \sqrt{n_2^2 - n_1^2}$$

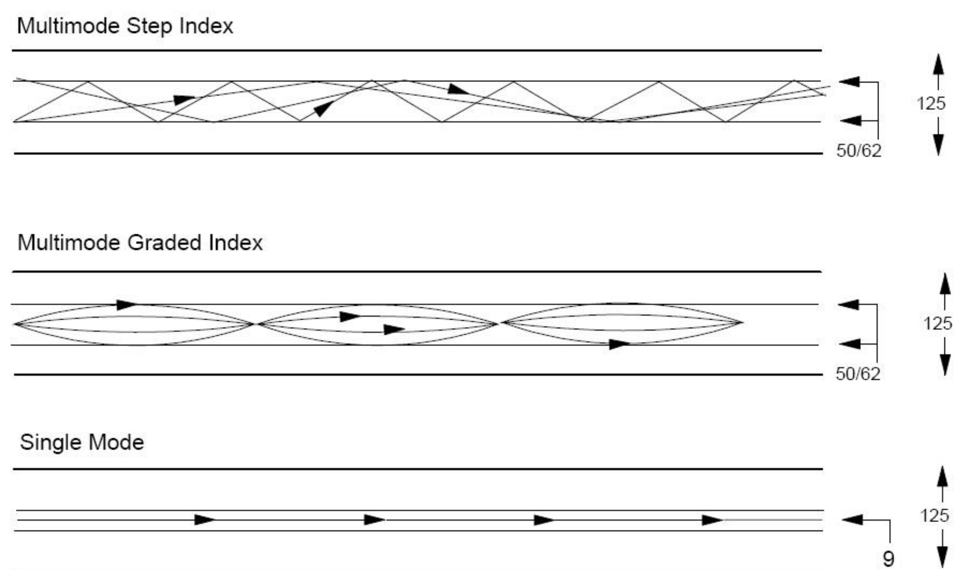
n_2 – miez
n_1 – teaca
$n_2 > n_1$!!

Tipuri de fibra

- Monomod
- Multimod
  - cu salt de indice
  - cu indice gradat

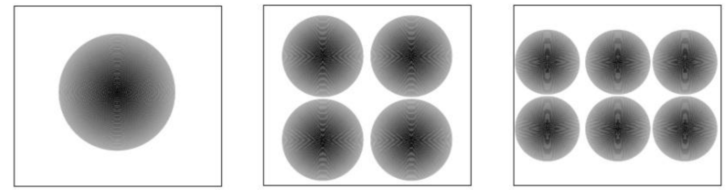






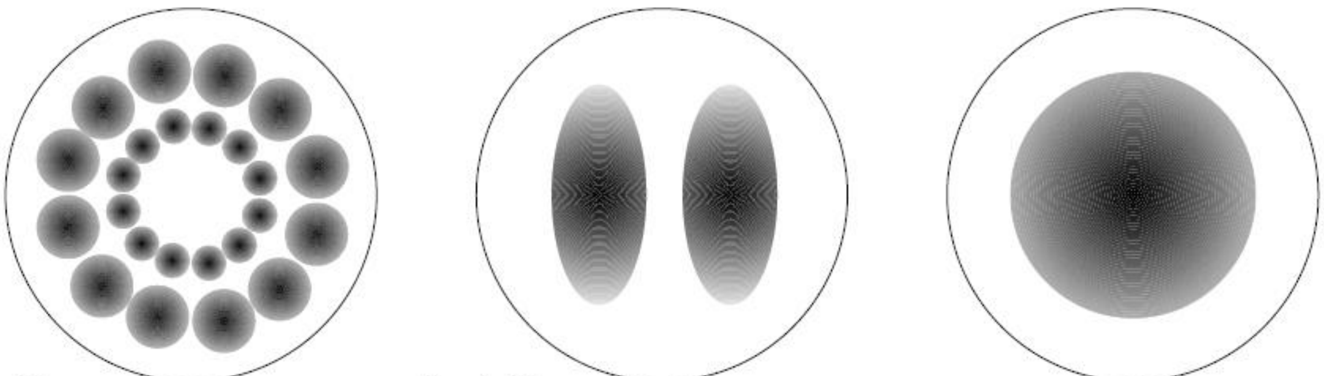
Moduri in fibra

- Moduri in ghid rectangular

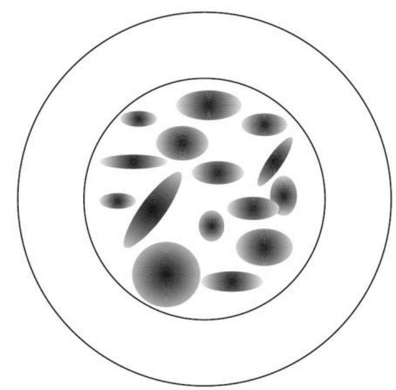


TEM_{00} TEM_{11} TEM_{21}

- Moduri linear polarizate in fibra



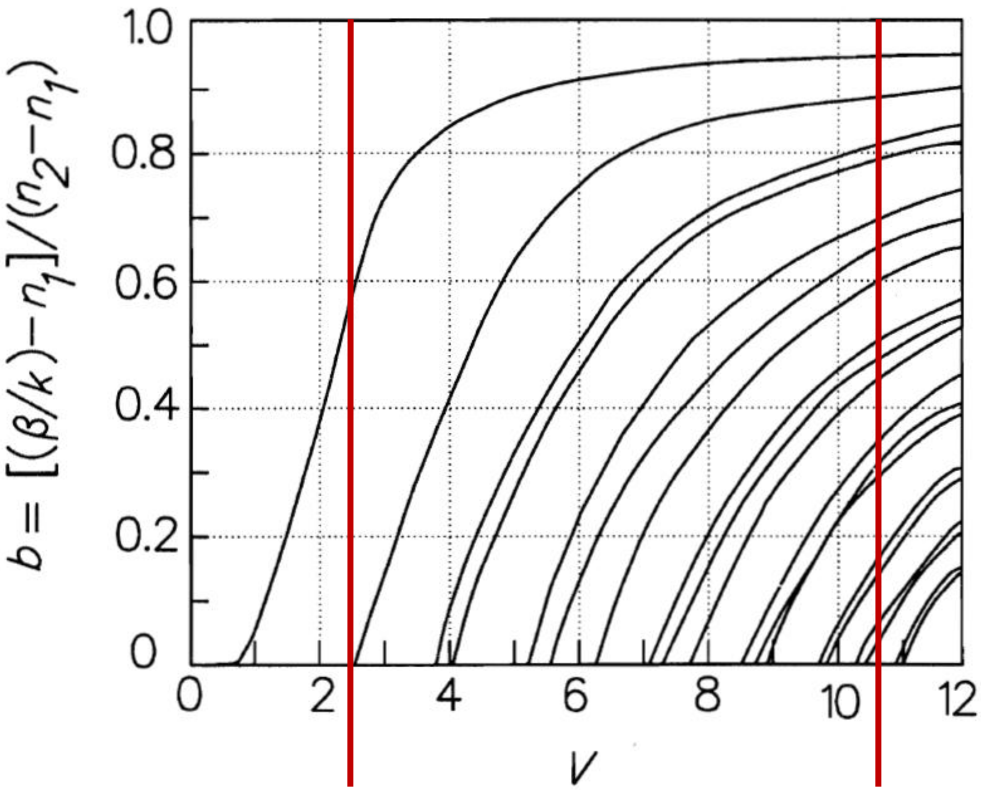
LP_{62} LP_{11} LP_{01}



"Sparkle" pattern

Frecventa normalizata – monomod

- Fibre monomod



b – coeficient de propagare modal relativ

$$V \le V_C = 2.405$$

exista un singur mod (solutii fc. Bessel)

$$\lambda \ge \lambda_C = \pi \frac{2a}{V_C} NA = \pi \frac{2a}{2.405} NA$$

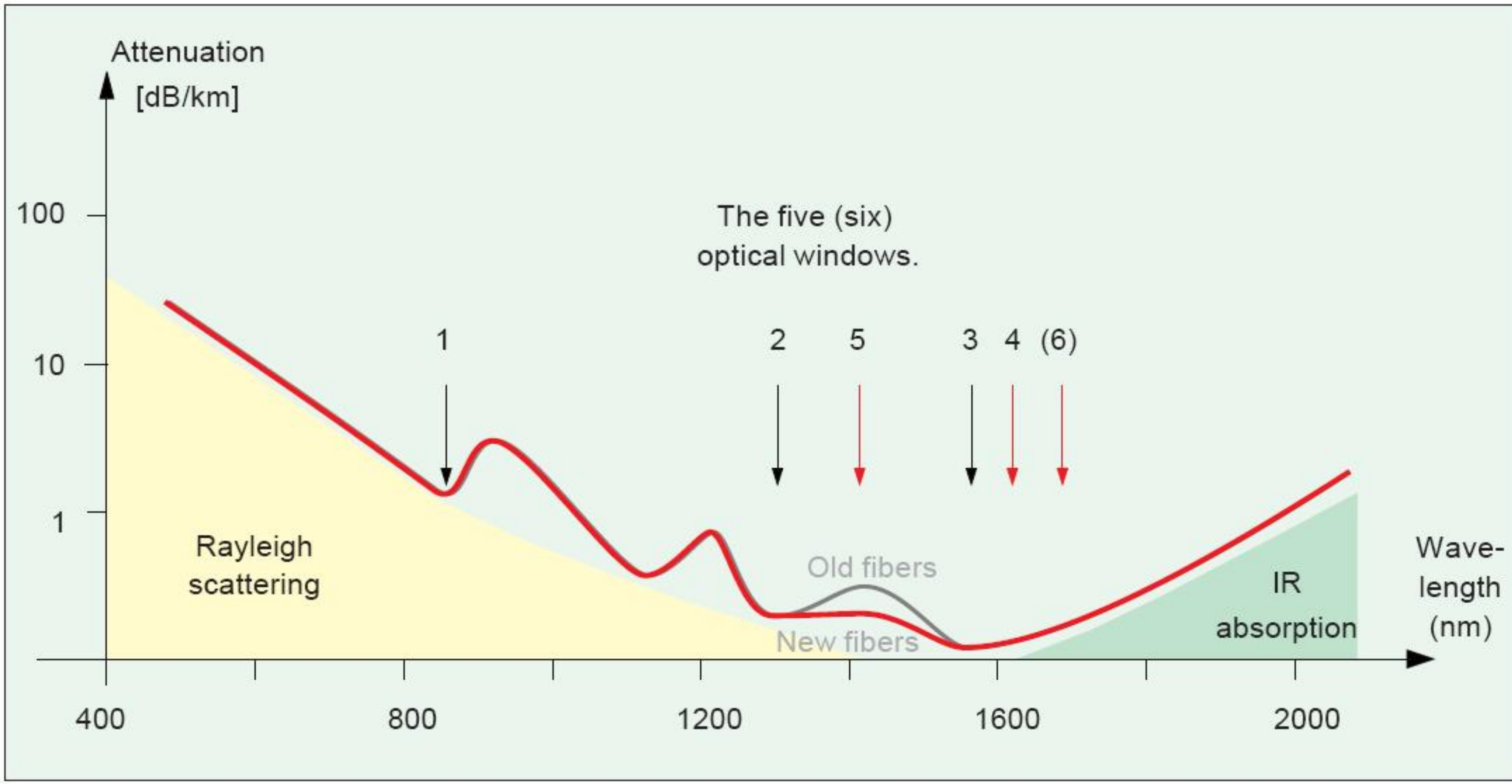
Exemplu:
2a = 8.5μm
NA = 0.11

$$\lambda_C = \pi \frac{8.5}{2.405} 0.11 = 1210\text{nm}$$

ATENUAREA

- Macrocurburi
- Microcurburi
- Imprastiere
- Absorbtie

Absorbtie

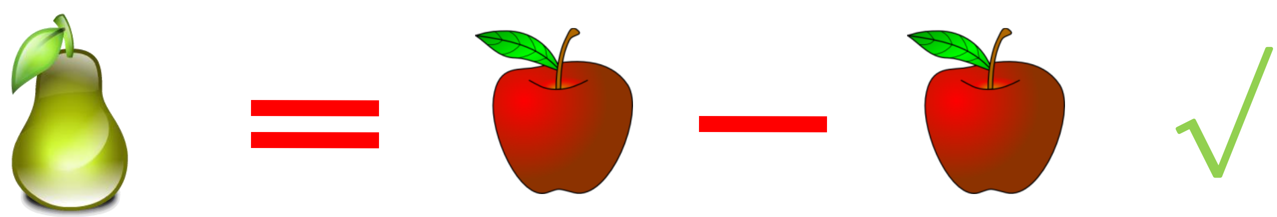

Attenuation
[dB/km]
100
10
1
The five (six)
optical windows.
1
2
5
3
4
(6)
Rayleigh
scattering
Old fibers
New fibers
IR
absorption
Wave-
length
(nm)
400
800
1200
1600
2000

Calculul atenuarii

$$\text{Pierderi} = \frac{P_{out}}{P_{in}}$$

$$\text{Pierderi}[\text{dB}] = [-]10 \cdot \log_{10}\left(\frac{P_{out}}{P_{in}}\right)$$

$$\text{Pierderi}[\text{dB}] = [-]\left(P_{out}[\text{dBm}] - P_{in}[\text{dBm}]\right)$$

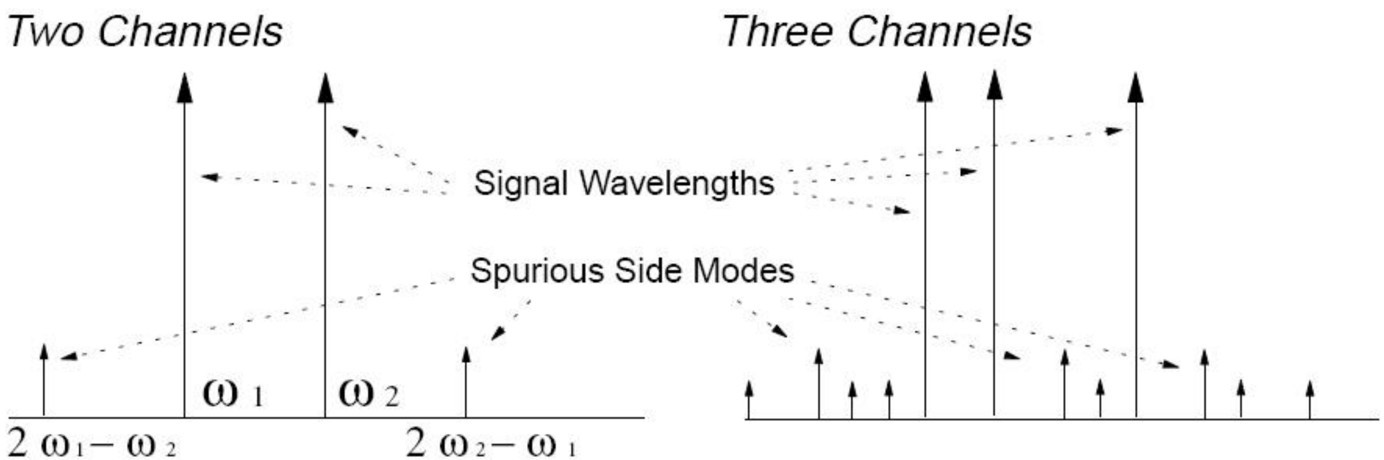


$$\text{Atenuare}[\text{dB/km}] = \frac{\text{Pierderi}[\text{dB}]}{\text{lungime}[\text{km}]}$$

Efecte neliniare in fibra

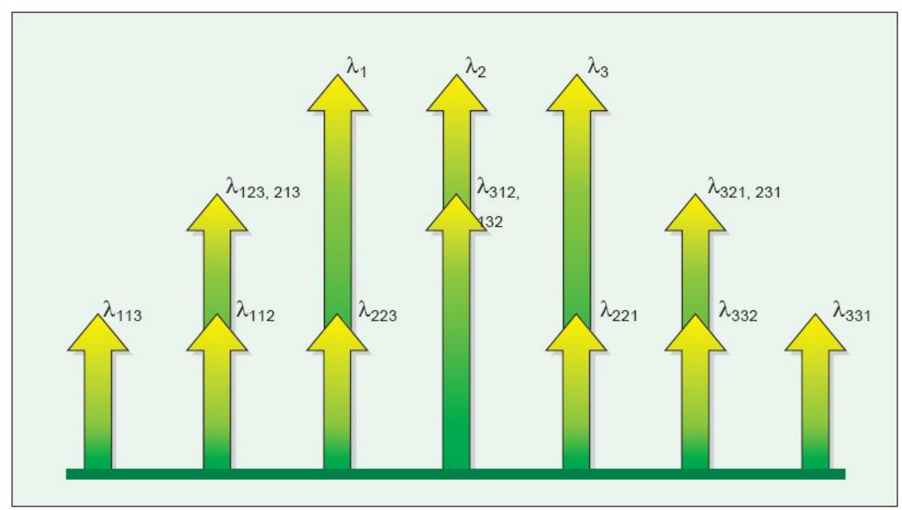
- Stimulated Brillouin Scattering, SBC
  - difractia luminii inspre emitator datorita undelor mecano-acustice generate in fibra
  - 6-10 dBm
- Stimulated Raman Scattering, SRS
  - interactiunea luminii cu vibratiile moleculare
  - 27 dBm (~1W)
- Self Phase Modulation, SPM
  - Frontiera impulsului implica indice de refractie variabil in timp moduland faza impulsului
  - 5 dBm
  - Cross Phase Modulation, CPM
- Four-Wave Mixing, FWM
  - 0 dBm

Four-Wave Mixing, FWM



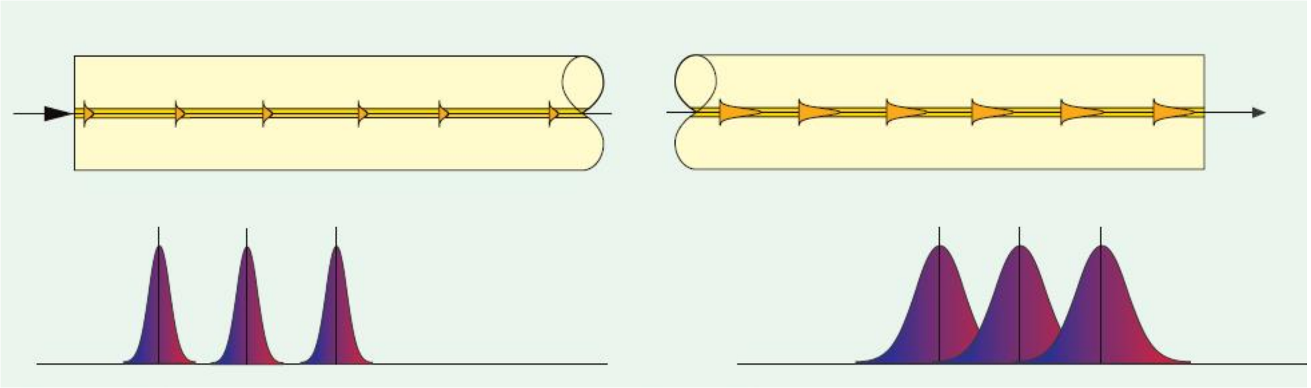
$$NL = \frac{1}{2}\left(N^3 - N^2\right)$$

N = 2, NL = 4
N = 3, NL = 9
N = 16, NL = 1920

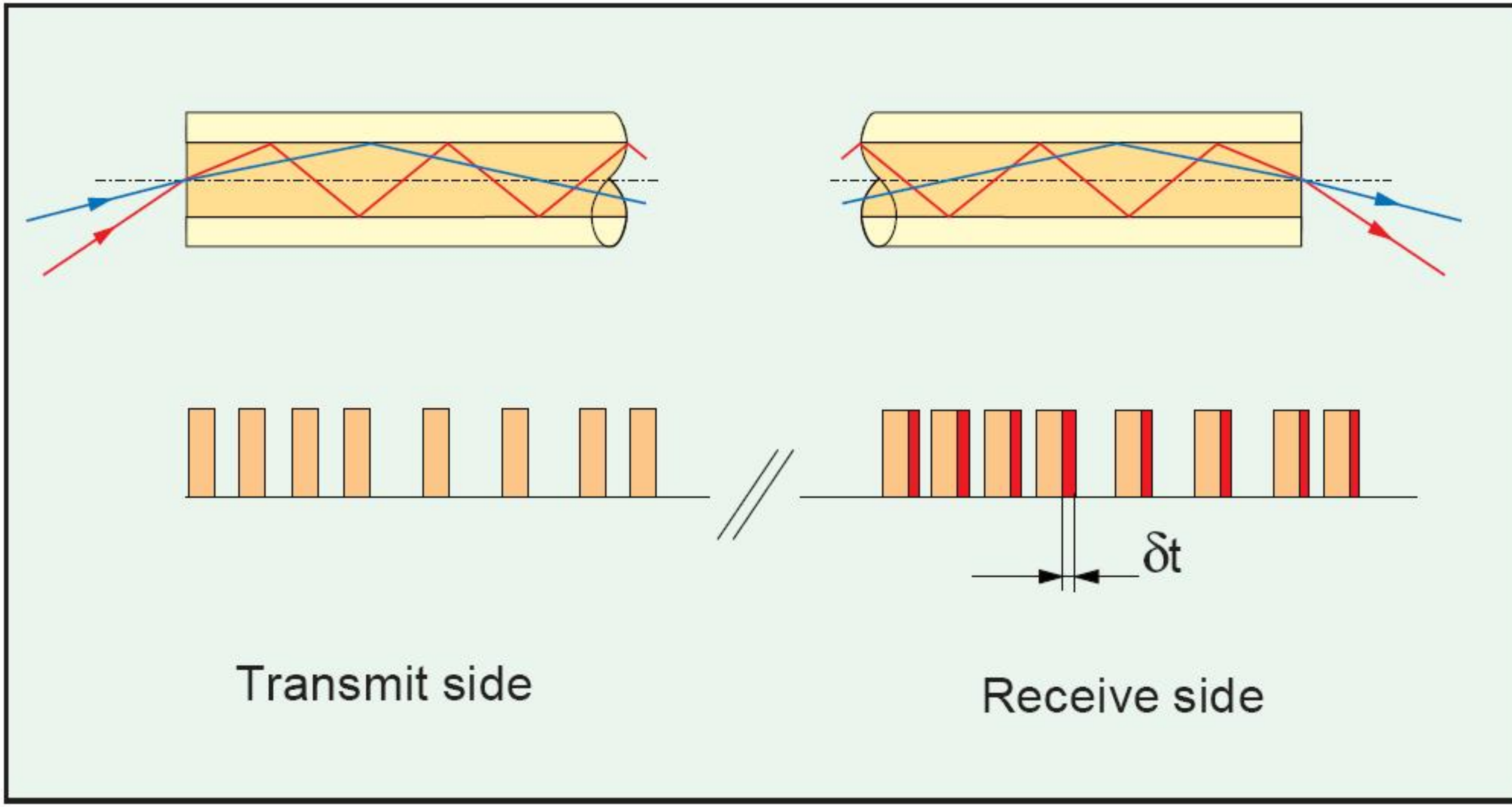


Dispersia

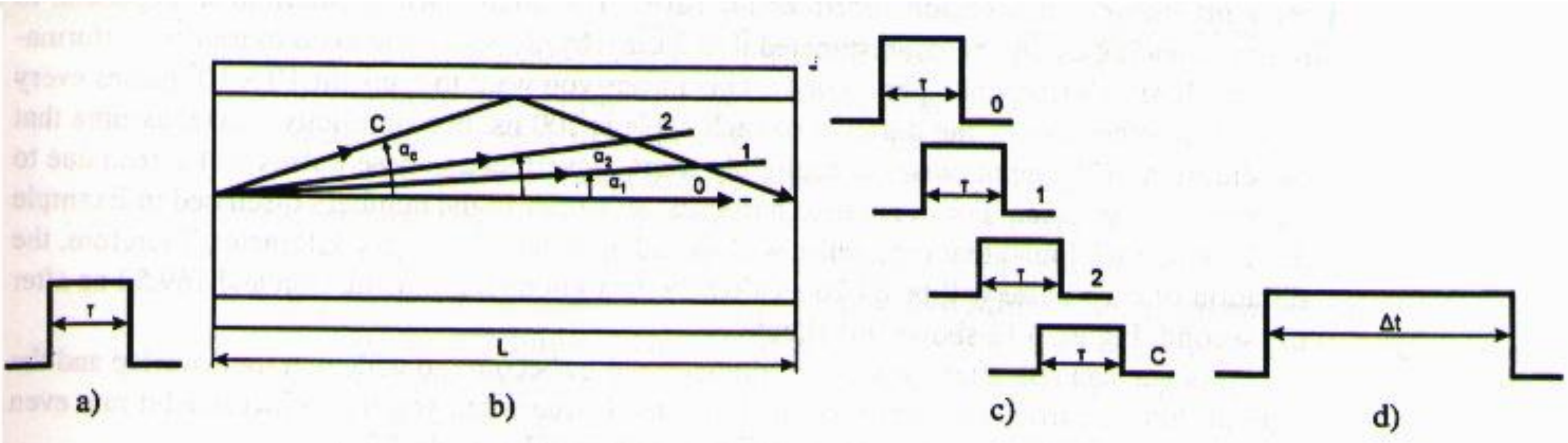
- Propagarea cu viteze diferite a radiatiilor cu lungimi de unda diferite
  - intermodala (modala – depinde de prezenta modurilor)
  - intramodala (cromatica – depinde de lungimea de unda)
    - de material
    - de ghid



Dispersia modala



Dispersia modala



$$t_0 = \frac{L}{v} \qquad t_C = \frac{L}{v \cdot \cos\alpha_C} \qquad v = \frac{c}{n_2} \qquad \cos\alpha_C = NA$$

$$\Delta t_{SI} = t_C - t_0 = \frac{L \cdot n_2}{c} \cdot \left(\frac{n_2 - n_1}{n_2} \right) \qquad \Delta t_{SI} = t_C - t_0 = \frac{L \cdot n_2}{c} \cdot \Delta$$

$$\Delta = \frac{n_2 - n_1}{n_1} << 1 \qquad \Delta t_{SI} = t_C - t_0 \approx \frac{L}{2 \cdot c \cdot n_2} \cdot (NA)^2$$

Dispersia modala

- salt de indice

$$dt = \frac{L \cdot n_2^2}{c \cdot n_1}\left(\frac{n_2 - n_1}{n_2}\right) \approx \frac{L \cdot NA^2}{2 \cdot c \cdot n_2}$$

intarzierea intre moduri cand $\Delta = \dfrac{n_2 - n_1}{n_1} << 1$

$$\Delta\tau_{\mathrm{mod}}^2 = \frac{1}{3}\left(\frac{dt}{2}\right)^2$$

$$\Delta\tau_{\mathrm{mod}} \cong \frac{L \cdot n_2 \cdot \Delta}{2\sqrt{3} \cdot c} \approx \frac{L \cdot NA^2}{4\sqrt{3} \cdot c \cdot n_2}$$

- indice gradat

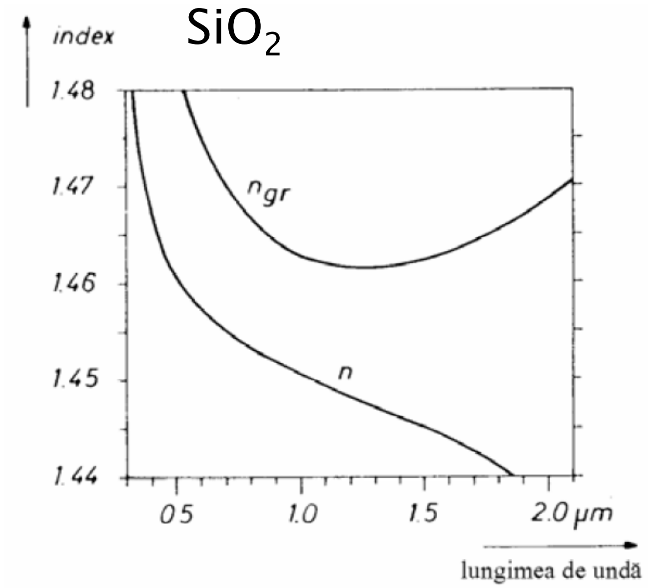
$$dt = \frac{L \cdot n_2 \cdot \Delta^2}{2c} \approx \frac{L \cdot NA^4}{8 \cdot c \cdot n_2^3}$$

$$\Delta\tau_{\mathrm{mod}} \cong \frac{L \cdot n_2 \cdot \Delta^2}{4\sqrt{3} \cdot c}$$

$$NA = 0.1 \div 0.2 < 1$$

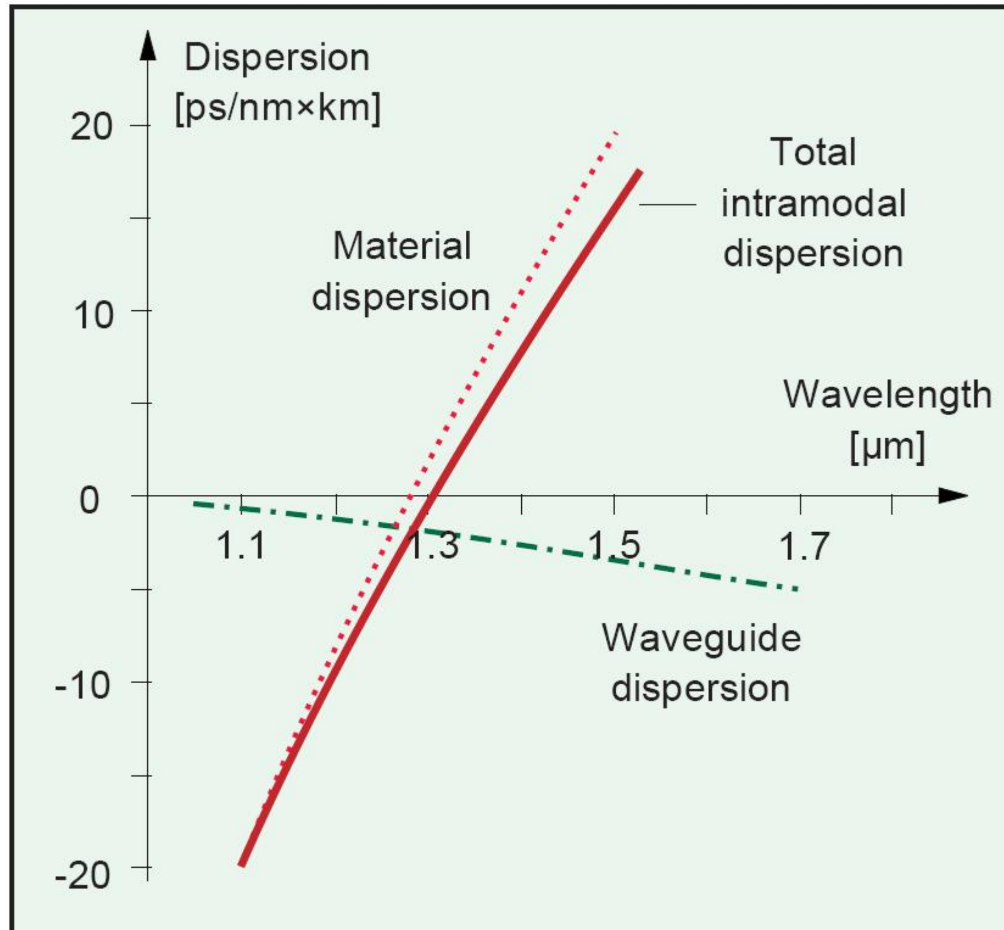
n_2 – miez
n_1 – teaca
$n_2 > n_1$!!

Dispersia de material



$$n_{gr} = n - \lambda \frac{dn}{d\lambda}$$

$$\Delta\tau_{mat} = \frac{L \cdot \lambda \cdot \Delta\lambda}{c} \cdot \frac{d^2 n}{d\lambda^2}$$

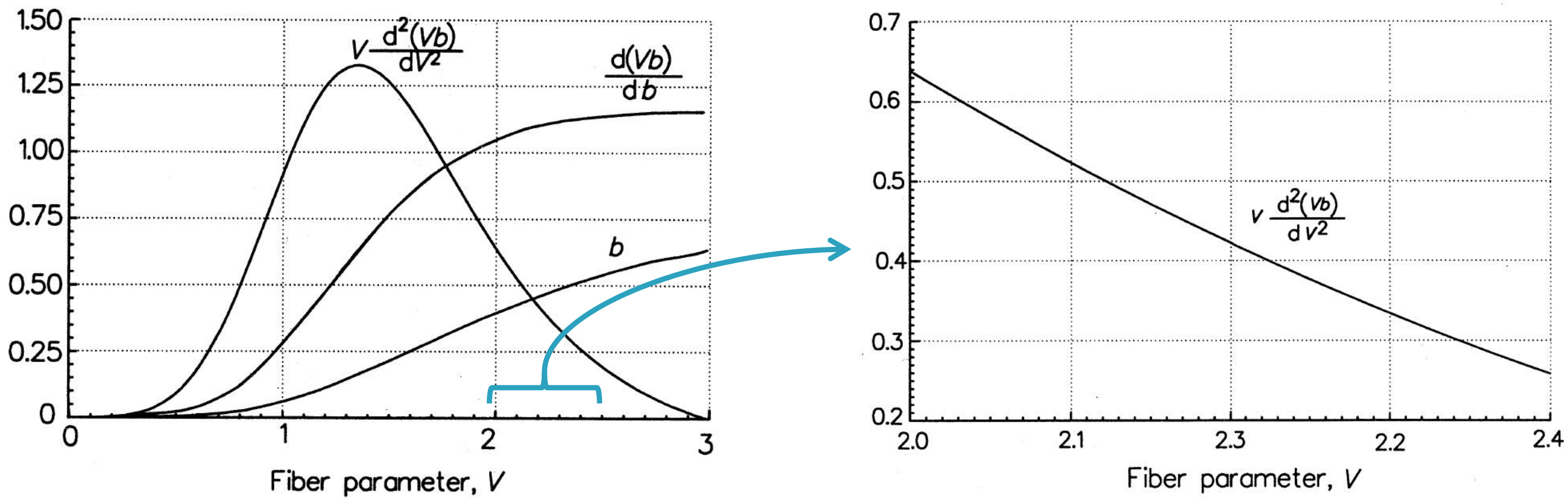


Dispersia de ghid

- Neglijabila in fibrele multimod fata de dispersia modala

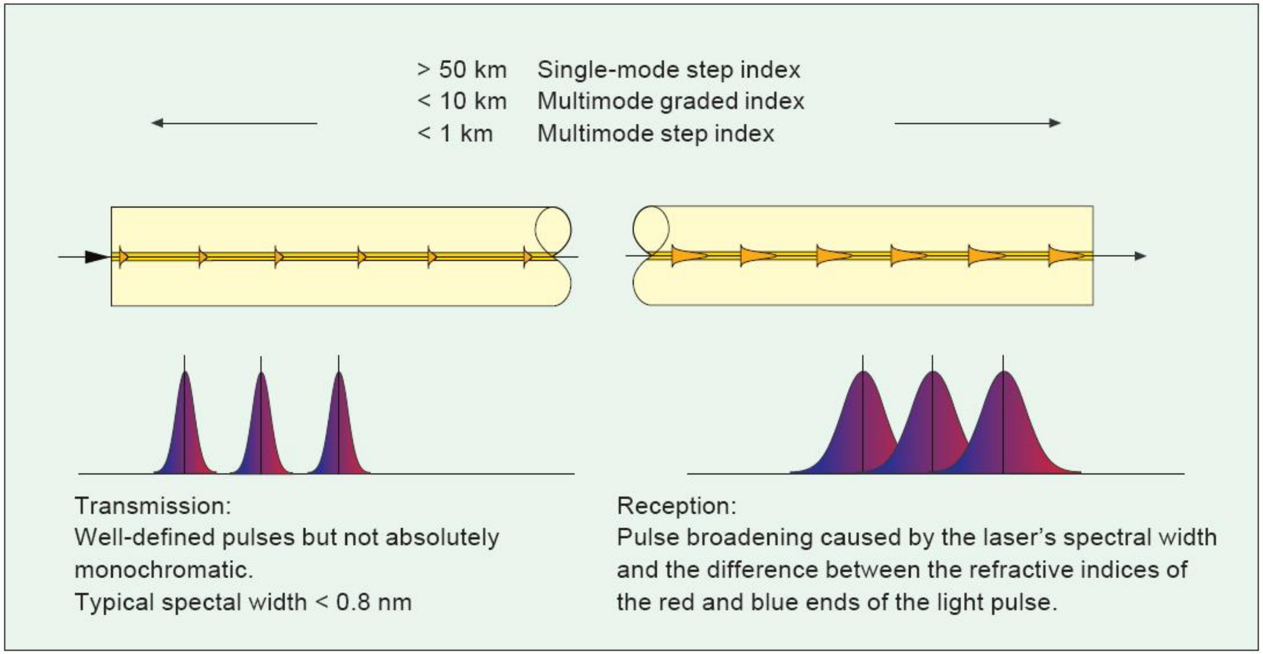
$$\Delta\tau_{gh} = \frac{n \cdot L \cdot \Delta}{c} \cdot \frac{\Delta\lambda}{\lambda} \cdot \left(V \frac{d^2(Vb)}{dV^2} \right)$$

b – constanta de propagare normalizata



$$V \le V_C = 2.405$$

Dispersia cromatica (gh+mat)



$$\Delta\tau_{cr} = D(\lambda)\cdot\Delta\lambda\cdot L$$

$$D(\lambda) = \frac{S_0}{4}\cdot\left(\lambda - \frac{\lambda_0^4}{\lambda^3}\right)$$

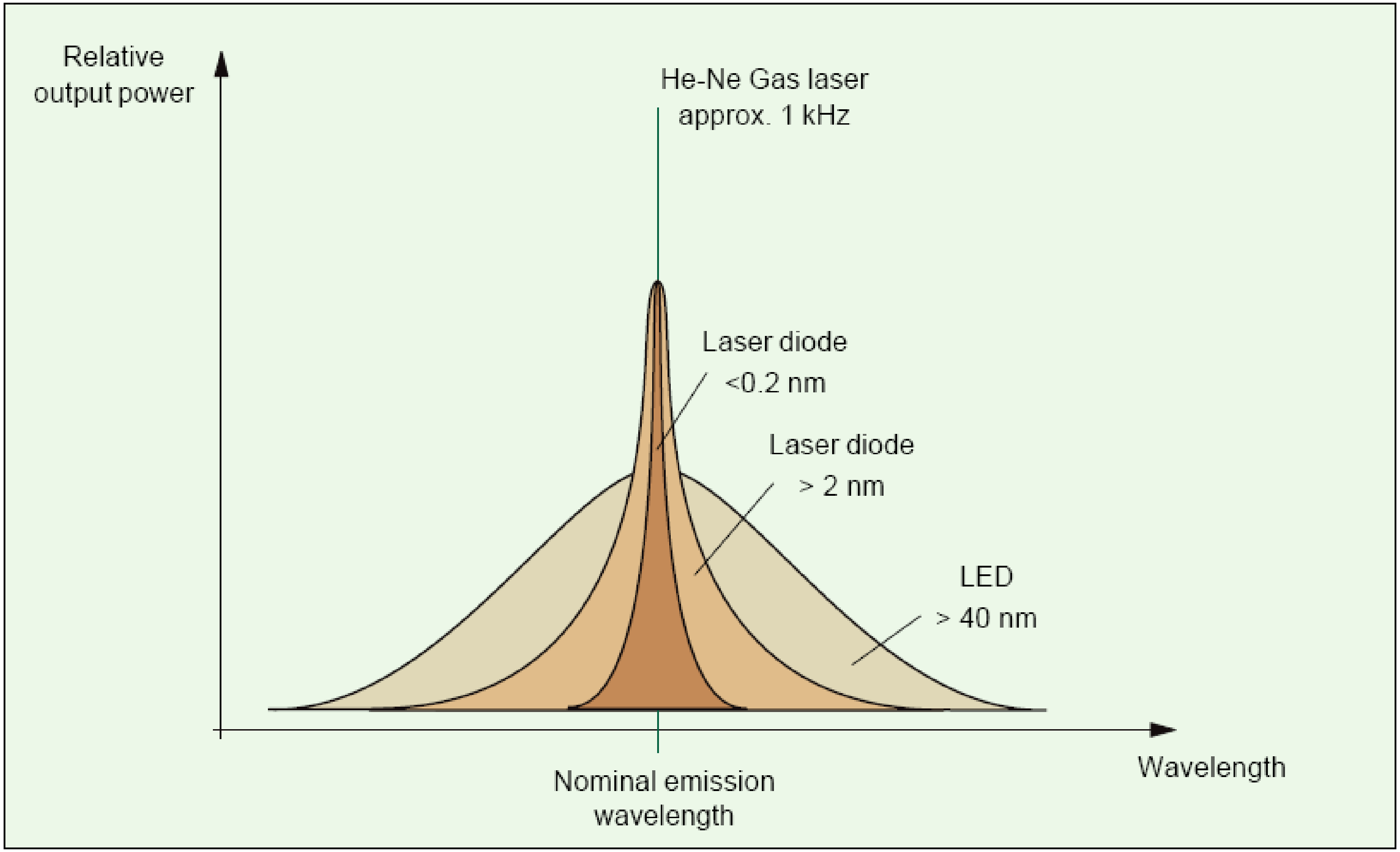
S_0 panta dispersiei – ps/nm^2/km

$$D(\lambda_0) = 0$$

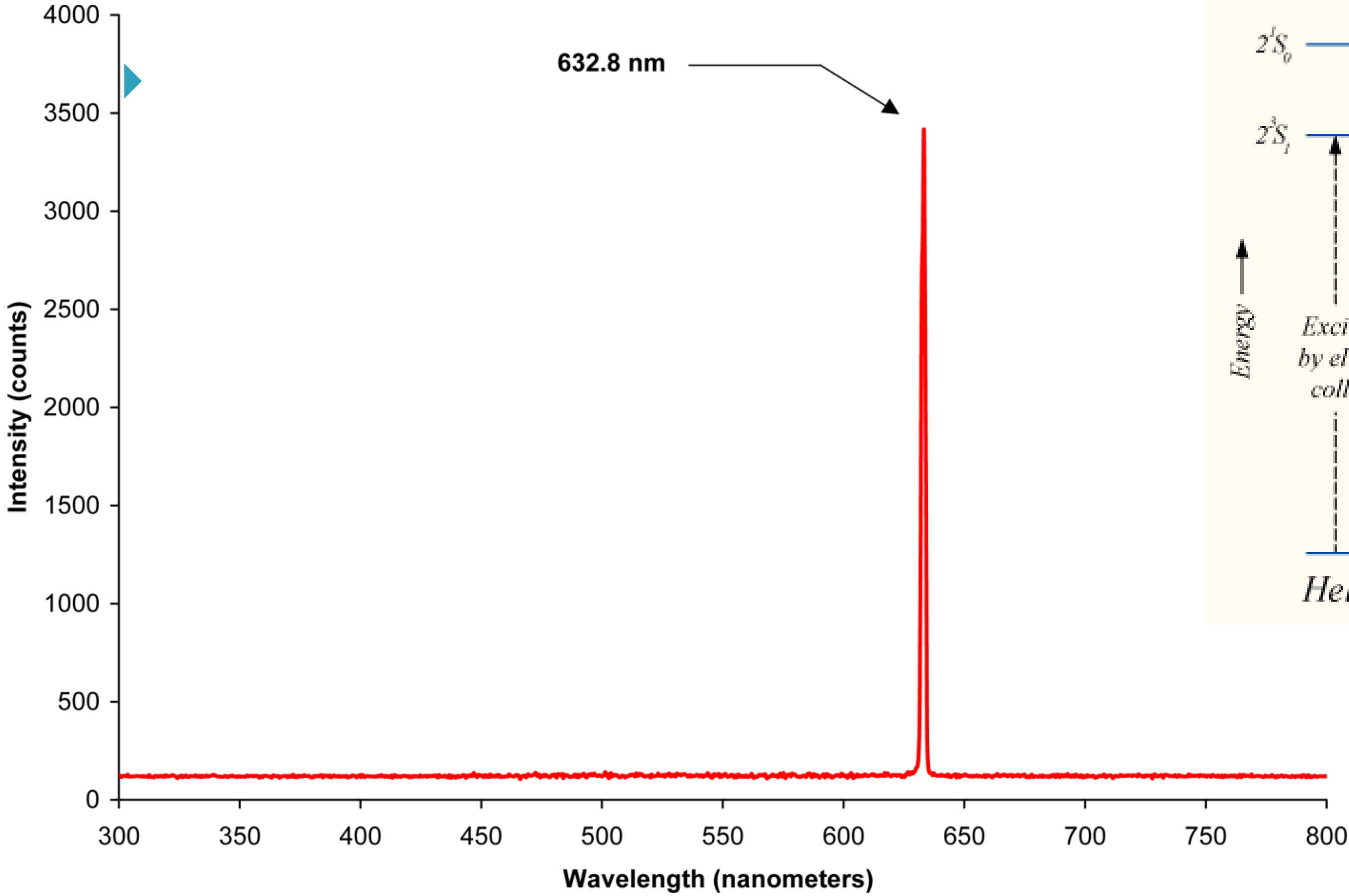
- $D(\lambda) \approx 100 + 0.4\ (850 - \lambda)$ [ps/nm/km] pentru $800 < \lambda < 900$ nm
- $D(\lambda) \leq 3{,}5$ ps/nm/km pentru $1285 < \lambda < 1330$ nm
- $D(\lambda) \leq 17$ ps/nm/km pentru $1525 < \lambda < 1575$ nm

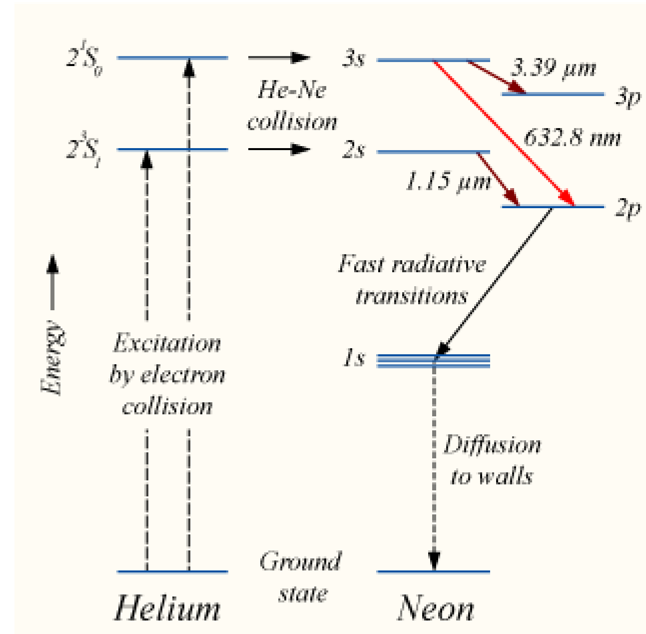
$$D(\lambda) = \frac{S_0}{4}\cdot\left(\lambda - \frac{\lambda_0^4}{\lambda^3}\right)$$

Calitatea spectrală a emiţătorilor optici



He-Ne Laser





$$\Delta\lambda = 0.002\ nm$$

Banda

- Dispersia totala

$$\Delta\tau_{tot} = \sqrt{\Delta\tau_{cr}^2 + \Delta\tau_{\mathrm{mod}}^2}$$

- Banda

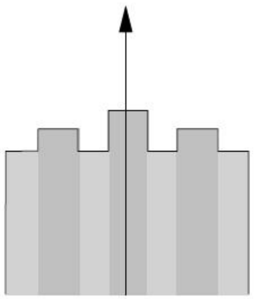
$$B_{opt} = \frac{0.44}{\Delta\tau_{tot}[ns]} \quad [GHz]$$

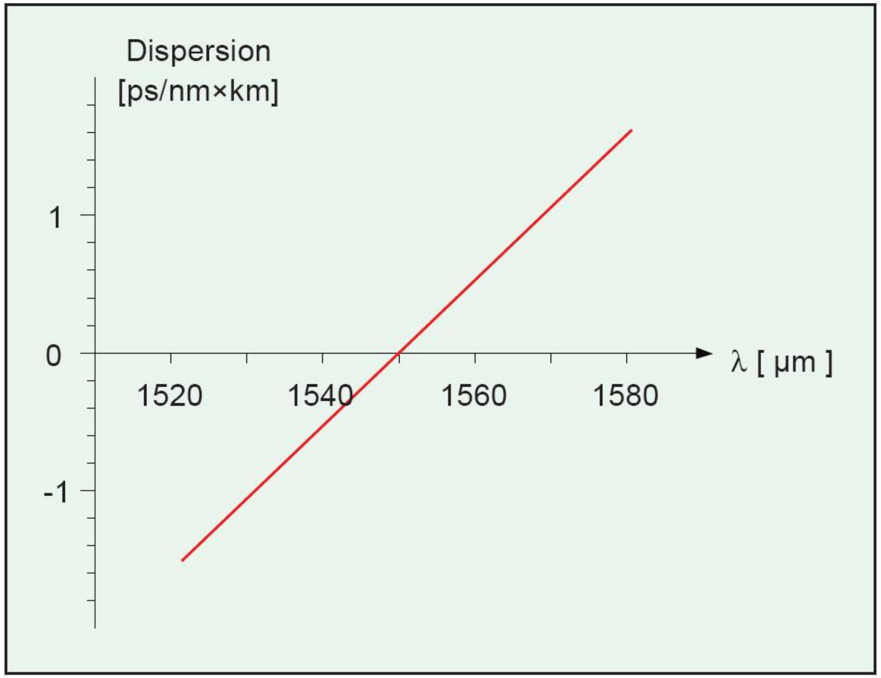
- Banda optica la 3 dB corespunde unei benzi electrice la 6 dB
  - $P_{opt} \sim I; \quad P_{el} \sim I^2$ $\qquad B_{opt} = \sqrt{2}B_{el}$
- Viteza legaturii

$$V[Gb/s] \cong 2 \cdot B_{el}[GHz]$$

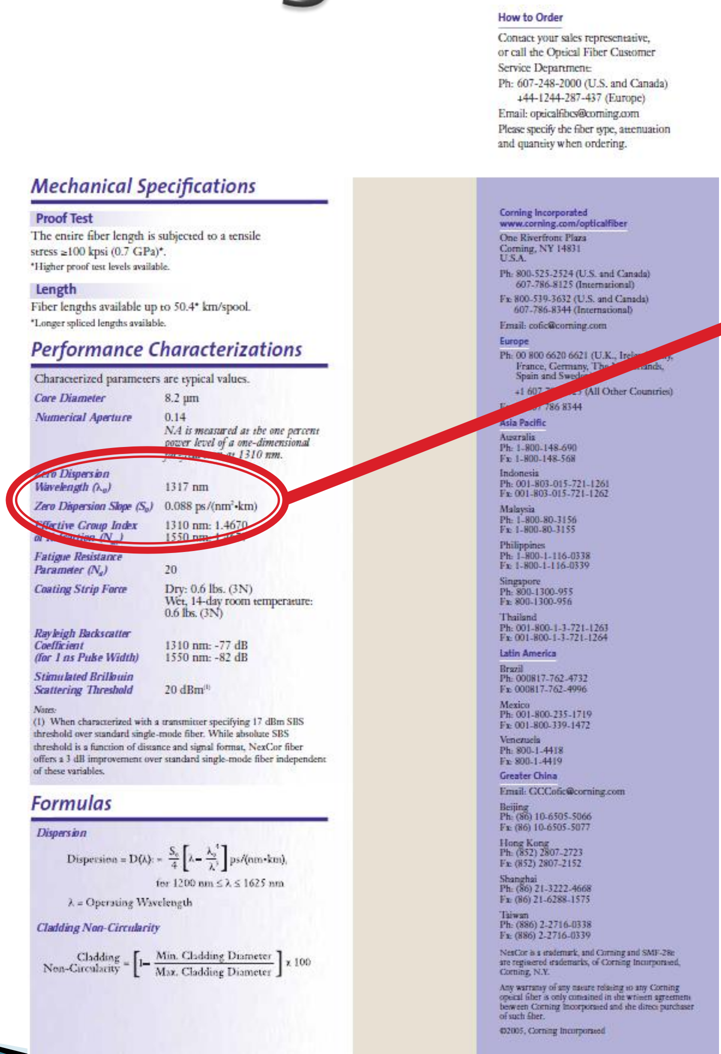
Dispersion shifted fibers

- Atenuarea e mai mica la 1550 nm
- EDFA(Erbium doped fibre amplifiers) opereaza in banda aceasta
- Sistemele WDM (Wavelength division Multiplexing) necestia banda larga amplificata





Catalog



Mechanical Specifications

Proof Test

The entire fiber length is subjected to a tensile stress ≥100 kpsi (0.7 GPa)*.

*Higher proof test levels available.

Length

Fiber lengths available up to 50.4* km/spool.

*Longer spliced lengths available.

Performance Characterizations

Characterized parameters are typical values.

Core Diameter	8.2 µm
Numerical Aperture	0.14 *NA is measured at the one percent power level of a one-dimensional [illegible] at 1310 nm.*
[illegible]ro Dispersion Wavelength (λ_0)	1317 nm
Zero Dispersion Slope (S_0)	0.088 ps/(nm²•km)
[illegible]ffective Group Index [illegible]	1310 nm: 1.4670 1550 nm: [illegible]
Fatigue Resistance Parameter (N_d)	20
Coating Strip Force	Dry: 0.6 lbs. (3N) Wet, 14-day room temperature: 0.6 lbs. (3N)
Rayleigh Backscatter Coefficient (for 1 ns Pulse Width)	1310 nm: -77 dB 1550 nm: -82 dB
Stimulated Brillouin Scattering Threshold	20 dBm(1)

Notes:
(1) When characterized with a transmitter specifying 17 dBm SBS threshold over standard single-mode fiber. While absolute SBS threshold is a function of distance and signal format, NexCor fiber offers a 3 dB improvement over standard single-mode fiber independent of these variables.

Formulas

Dispersion

$$\text{Dispersion} = D(\lambda) := \frac{S_0}{4}\left[\lambda - \frac{\lambda_0^4}{\lambda^3}\right] \text{ps/(nm•km)},$$

for 1200 nm ≤ λ ≤ 1625 nm

λ = Operating Wavelength

Cladding Non-Circularity

$$\text{Cladding Non-Circularity} = \left[1 - \frac{\text{Min. Cladding Diameter}}{\text{Max. Cladding Diameter}}\right] \times 100$$

How to Order

Contact your sales representative, or call the Optical Fiber Customer Service Department:
Ph: 607-248-2000 (U.S. and Canada)
+44-1244-287-437 (Europe)
Email: opticalfiber@corning.com
Please specify the fiber type, attenuation and quantity when ordering.

Corning Incorporated
www.corning.com/opticalfiber
One Riverfront Plaza
Corning, NY 14831
U.S.A.

Ph: 800-525-2524 (U.S. and Canada)
607-786-8125 (International)
Fx: 800-539-3632 (U.S. and Canada)
607-786-8344 (International)
Email: cofic@corning.com

Europe
Ph: 00 800 6620 6621 (U.K., Irel[illegible], France, Germany, The [illegible]lands, Spain and Swed[illegible]
+1 607 [illegible] (All Other Countries)
F[illegible] 786 8344

Asia Pacific
Australia
Ph: 1-800-148-690
Fx: 1-800-148-568

Indonesia
Ph: 001-803-015-721-1261
Fx: 001-803-015-721-1262

Malaysia
Ph: 1-800-80-3156
Fx: 1-800-80-3155

Philippines
Ph: 1-800-1-116-0338
Fx: 1-800-1-116-0339

Singapore
Ph: 800-1300-955
Fx: 800-1300-956

Thailand
Ph: 001-800-1-3-721-1263
Fx: 001-800-1-3-721-1264

Latin America
Brazil
Ph: 000817-762-4732
Fx: 000817-762-4996

Mexico
Ph: 001-800-235-1719
Fx: 001-800-339-1472

Venezuela
Ph: 800-1-4418
Fx: 800-1-4419

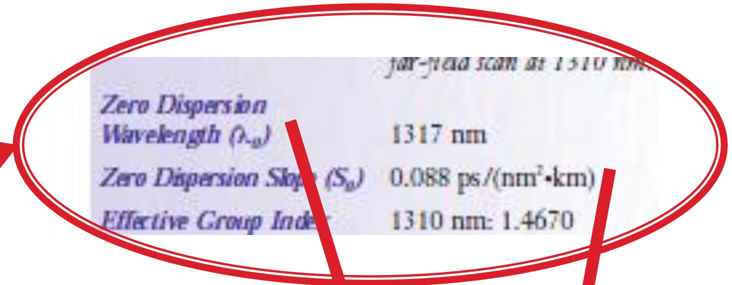
Greater China
Email: GCCofic@corning.com

Beijing
Ph: (86) 10-6505-5066
Fx: (86) 10-6505-5077

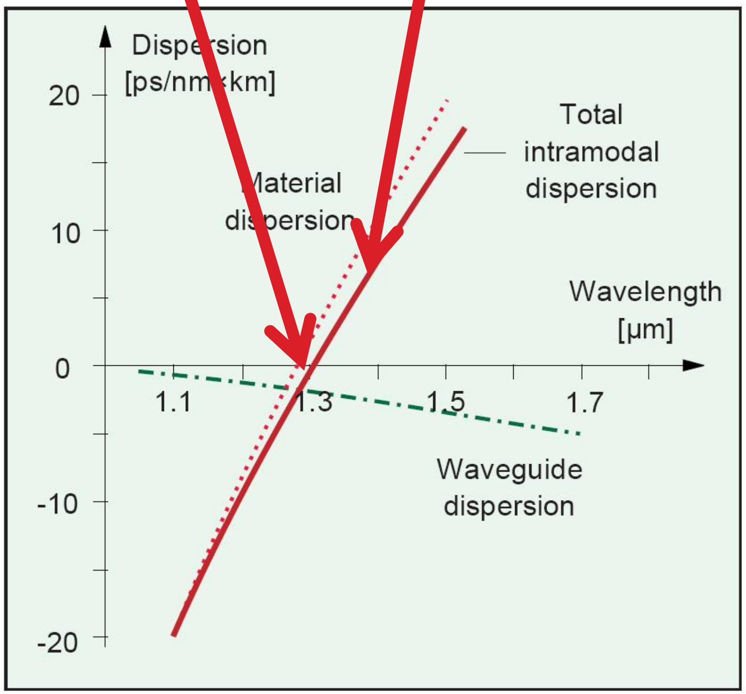
Hong Kong
Ph: (852) 2807-2723
Fx: (852) 2807-2152

Shanghai
Ph: (86) 21-3222-4668
Fx: (86) 21-6288-1575

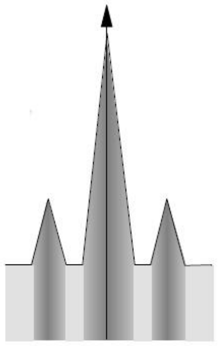
Taiwan
Ph: (886) 2-2716-0338
Fx: (886) 2-2716-0339



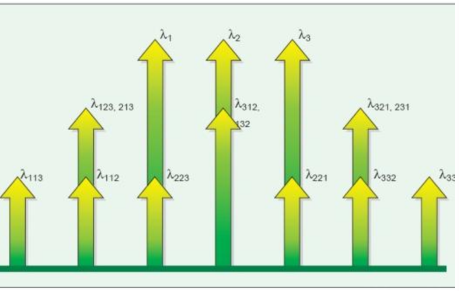
Zero Dispersion Wavelength (λ_0)	1317 nm
Zero Dispersion Sl[illegible] (S_0)	0.088 ps/(nm²•km)
Effective Group Inde[illegible]	1310 nm: 1.4670

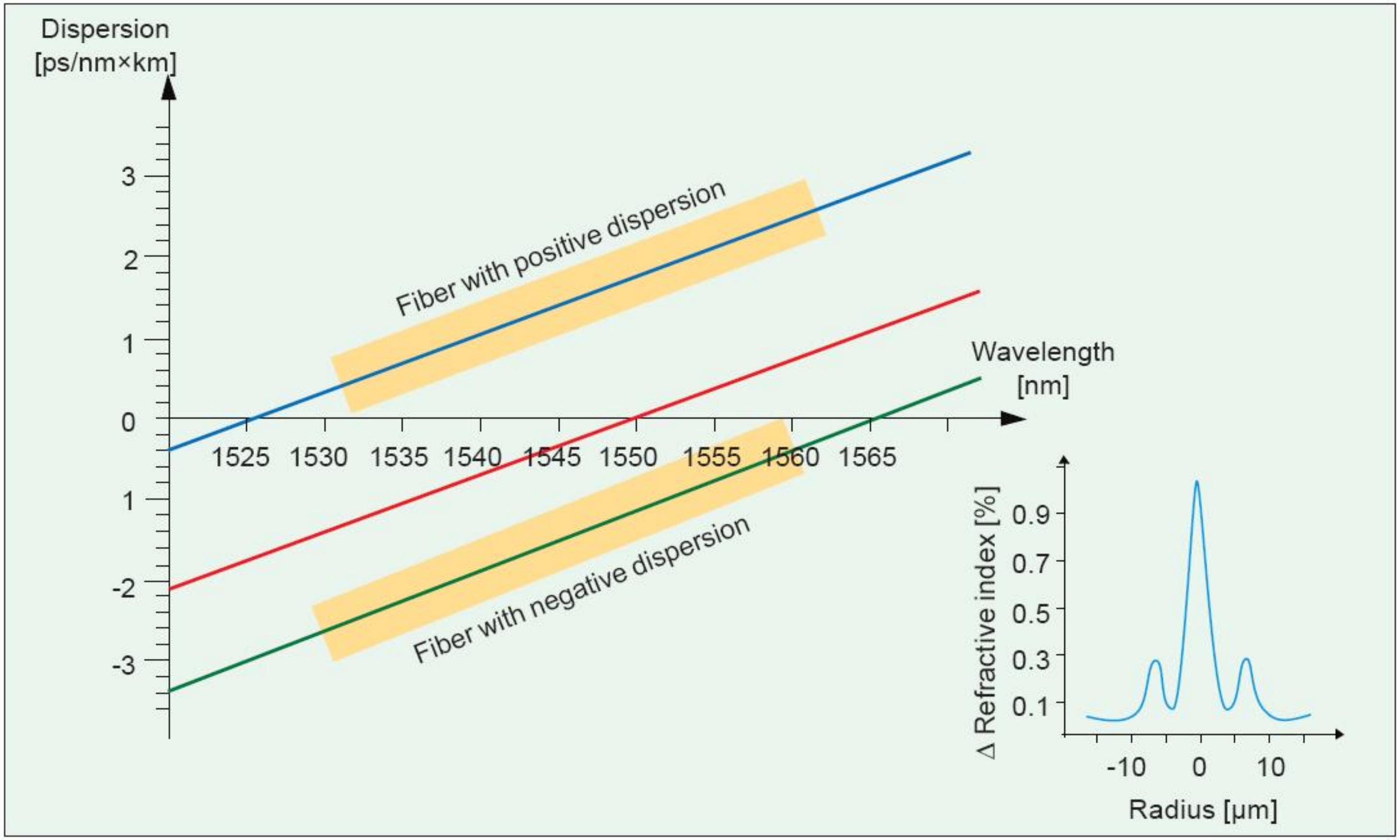


Non-zero Dispersion shifted fibers

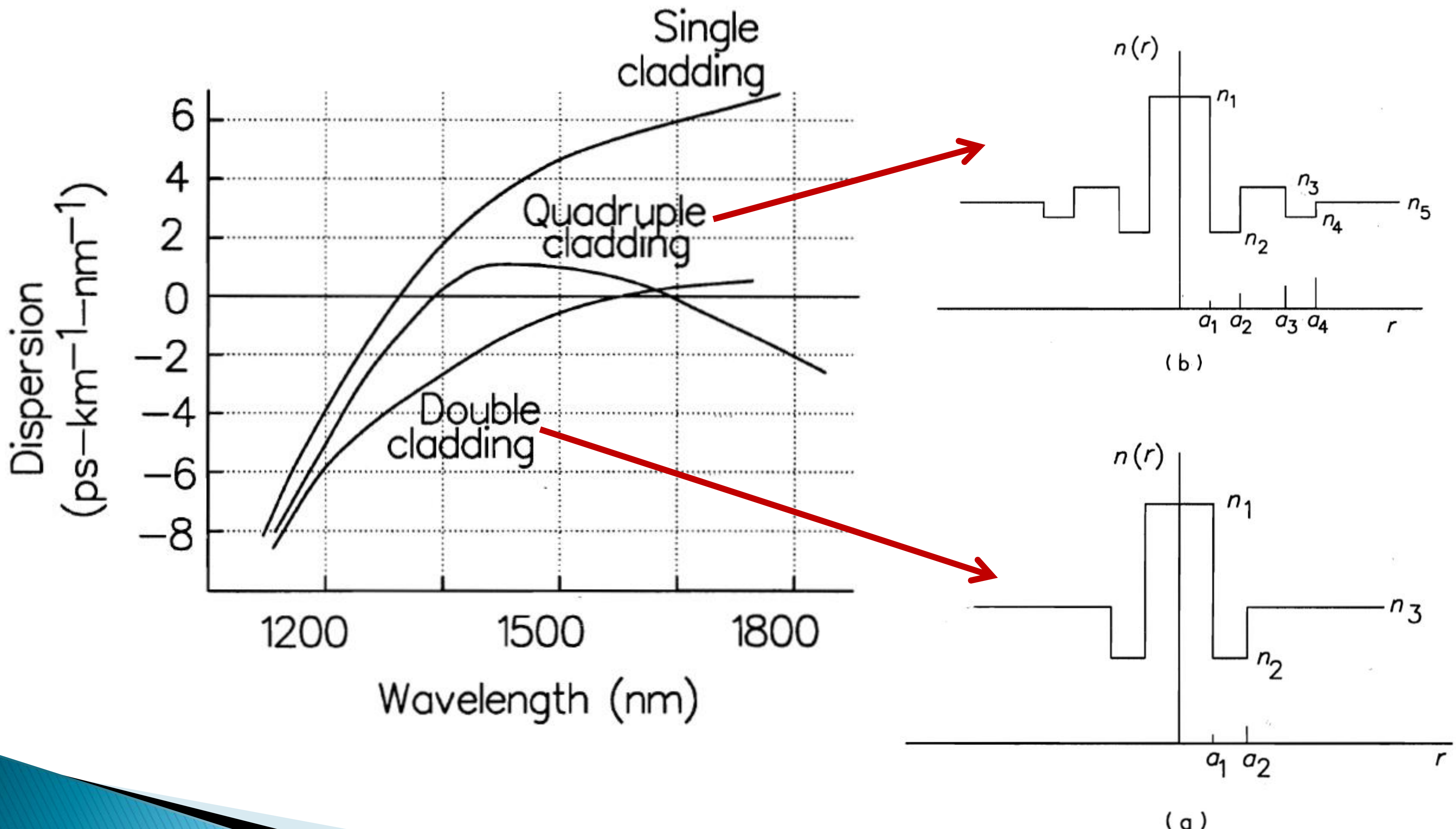


FWM





Dispersion shifted fibers



Contact

- Laboratorul de microunde si optoelectronica
- http://rf-opto.etti.tuiasi.ro
- rdamian@etti.tuiasi.ro