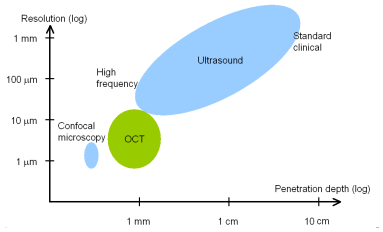
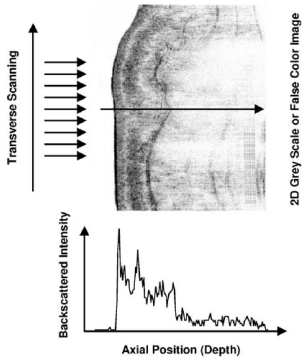
OPTYCZNA TOMOGRAFIA (CZĘŚCIOWO)KOHERENTNA

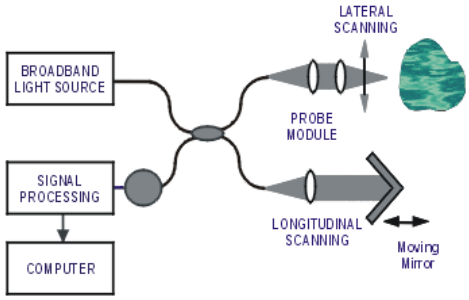
CZĘŚCIOWO-KOHERENTNA INTERFEROMETRIA

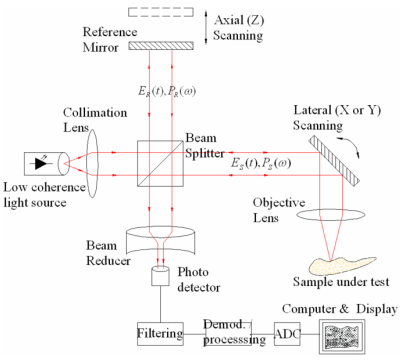


SWIATŁO ODBIJA SIĘ OD TKANKI



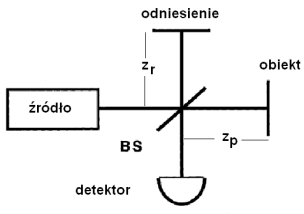
INTERFEROMETR MICHELSONA lub TWYMANA-GREENA





Typical optical setup of single point OCT. Scanning the light beam on the sample enables non-invasive cross-sectional imaging up to 3 mm in depth with micrometer resolution.

INTERFEROMETR MICHELSONA lub TWYMANA-GREENA



ODBICIE OD JEDNEJ POWIERZCHNI

wiązka odniesienia:

$$U_r(t) = A_r(\nu)\exp\{-2\pi\nu(t-\tau_r)\} \qquad \tau_r = z_r/c$$

wiązka obiektowa:

$$U_p(t) = A_p(\nu)\exp\{-2\pi\nu(t-\tau_p)\} \qquad \tau_p = z_p/c$$

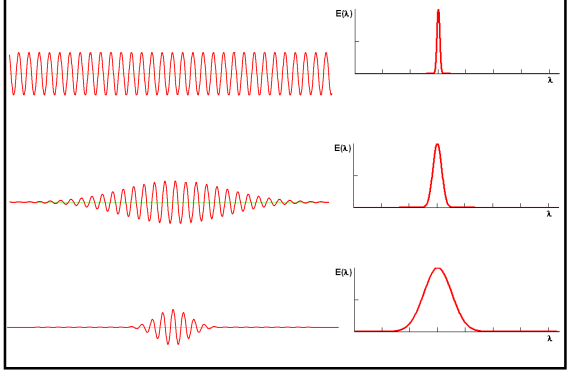
inteferencja:

$$J_r(\nu) + J_p(\nu) + 2\sqrt{J_r(\nu)J_p(\nu)}\cos[2\pi\nu(\tau_r - \tau_p)]$$

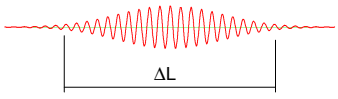
$$\Gamma(\tau) = \int U(t)U^*(t-\tau)dt$$

$$\Gamma_r(0) + \Gamma_p(0) + 2\,\mathrm{Re}\{\Gamma(\tau_r - \tau_p)\}$$

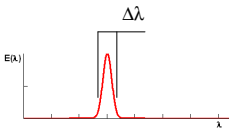
KOHERENCJA CZASOWA - MONOCHROMATYCZNOŚĆ



KOHERENCJA CZASOWA - MONOCHROMATYCZNOŚĆ



Długość koherencji (droga koherencji)

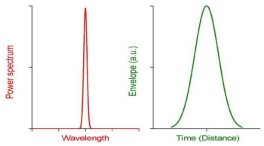


Szerokość widmowa (połówkowa)

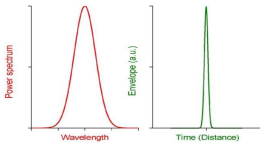
$$\Delta\lambda \cdot \Delta L = const$$

KOHERENCJA CZASOWA - MONOCHROMATYCZNOŚĆ

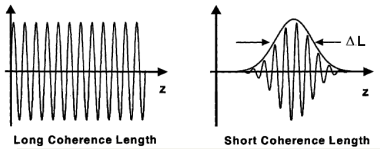
„lepsza" monochromatyczność



„gorsza" monochromatyczność



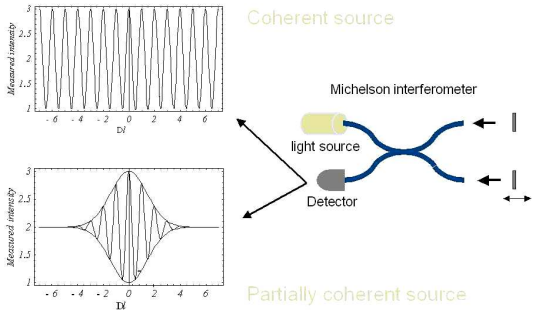
INTERFEROMETR MICHELSONA lub TWYMANA-GREENA



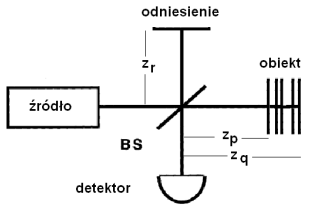
$$\Gamma_r(0) + \Gamma_p(0) + 2\,\mathrm{Re}\{\Gamma(\tau_r - \tau_p)\}$$

$$J_r + J_p + 2\left|\Gamma(\tau_r - \tau_p)\right|\cos[2\pi\nu(z_r - z_p)/c]$$

INTERFEROMETR MICHELSONA lub TWYMANA-GREENA



INTERFEROMETR MICHELSONA lub TWYMANA-GREENA



ODBICIE OD WIELU POWIERZCHNI

wiązka odniesienia:

$$A_r(\nu)\exp\{-2\pi\nu(t-\tau_r)\} \qquad \tau_r = z_r/c$$

wiązka obiektowa:

$$\sum_p A_p(\nu)\exp\{-2\pi\nu(t-\tau_p)\} \qquad \tau_p = z_p/c$$

inteferencja:

$$J_r(\nu)+\sum_p J_p(\nu)+$$
$$+2\sum_{p\neq q}\sqrt{J_p(\nu)J_q(\nu)}\cos\left[2\pi\nu(\tau_p-\tau_q)\right]+$$
$$+2\sum_p\sqrt{J_r(\nu)J_p(\nu)}\cos\left[2\pi\nu(\tau_r-\tau_p)\right]$$

ODBICIE OD WIELU POWIERZCHNI

inteferencja:

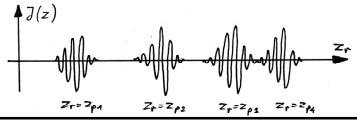
$$\Gamma_r(0)+\sum_p\Gamma_p(0)+$$
$$+2\sum_{p\neq q}\mathrm{Re}\{\Gamma_{p,q}(\tau_p-\tau_q)\}+2\sum_p\mathrm{Re}\{\Gamma_{r,p}(\tau_r-\tau_p)\}$$

$$J_r+$$
$$+\sum_p J_p+$$
$$+2\sum_{p\neq q}\left|\Gamma_{p,q}(\tau_p-\tau_q)\right|\cos\left[2\pi(z_p-z_q)/c\right]+$$
$$+2\sum_p\left|\Gamma_{r,p}(\tau_r-\tau_p)\right|\cos\left[2\pi(z_r-z_p)/c\right]$$

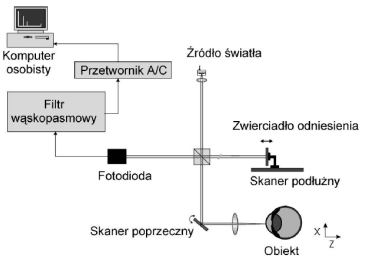
ODBICIE OD WIELU POWIERZCHNI
METODA CZASOWA

Przesuwane zwierciadło odniesienia $z_r = v\cdot t$

$$J_r+ \qquad \textbf{constans}$$
$$+\sum_p J_p+ \qquad \textbf{constans}$$
$$+2\sum_{p\neq q}\left|\Gamma_{p,q}(\tau_p-\tau_q)\right|\cos\left[2\pi(z_p-z_q)/c\right]+ \qquad \textbf{constans}$$
$$+2\sum_p\left|\Gamma_{r,p}(\tau_r-\tau_p)\right|\cos\left[2\pi(z_r-z_p)/c\right] \qquad \textbf{zmienia się}$$



ODBICIE OD WIELU POWIERZCHNI
METODA CZASOWA



ODBICIE OD WIELU POWIERZCHNI
METODA SPEKTRALNA (WIDMOWA)

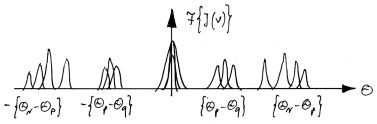
$$J_r(\nu)+\sum_p J_p(\nu)+$$
$$+2\sum_{p\neq q}\sqrt{J_p(\nu)J_q(\nu)}\cos\left[2\pi\nu(\tau_p-\tau_q)\right]+$$
$$+2\sum_p\sqrt{J_r(\nu)J_p(\nu)}\cos\left[2\pi\nu(\tau_r-\tau_p)\right]$$

w dziedzinie transformat Fouriera

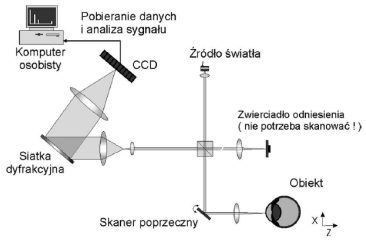
$$\Gamma_r(\theta)\otimes\delta(\theta)+\sum_p\Gamma_p(\theta)\otimes\delta(\theta)+$$
$$+2\sum_{p\neq q}\Gamma_{p,q}(\theta)\otimes\delta\left[\theta-(\theta_p-\theta_q)\right]+2\sum_{p\neq q}\Gamma_{p,q}(\theta)\otimes\delta\left[\theta+(\theta_p-\theta_q)\right]$$
$$+2\sum_p\Gamma_{p,p}(\theta)\otimes\delta\left[\theta-(\theta_r-\theta_p)\right]+2\sum_p\Gamma_p(\theta)\otimes\delta\left[\theta+(\theta_r-\theta_p)\right]$$

ODBICIE OD WIELU POWIERZCHNI
METODA SPEKTRALNA (WIDMOWA)

$$\Gamma_r(\theta)\otimes\delta(\theta)+\sum_p\Gamma_p(\theta)\otimes\delta(\theta)+$$
$$+2\sum_{p\neq q}\Gamma_{p,q}(\theta)\otimes\delta\left[\theta-\left(\theta_p-\theta_q\right)\right]+2\sum_{p\neq q}\Gamma_{p,q}(\theta)\otimes\delta\left[\theta+\left(\theta_p-\theta_q\right)\right]$$
$$+2\sum_p\Gamma_{p,p}(\theta)\otimes\delta\left[\theta-\left(\theta_r-\theta_p\right)\right]+2\sum_p\Gamma_p(\theta)\otimes\delta\left[\theta+\left(\theta_r-\theta_p\right)\right]$$



ODBICIE OD WIELU POWIERZCHNI
METODA SPEKTRALNA (WIDMOWA)



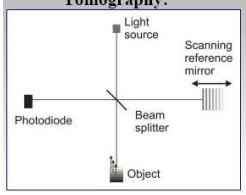
(CZĘŚCIOWO)KOHERENTNA TOMOGRAFIA OPTYCZNA

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos(2\pi\tau\nu)$$

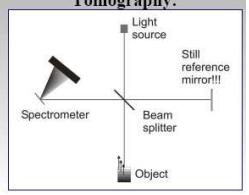
zmienna τ zmienna ν

τ – opóźnienie
ν – częstość optyczna

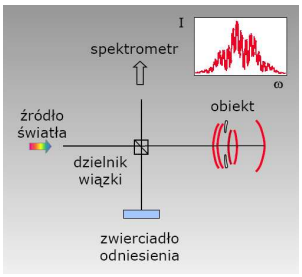
Time domain Optical Coherence Tomography:



Fourier domain Optical Coherence Tomography:



(CZĘŚCIOWO)KOHERENTNA TOMOGRAFIA OPTYCZNA
METODA SPEKTRALNA (WIDMOWA)



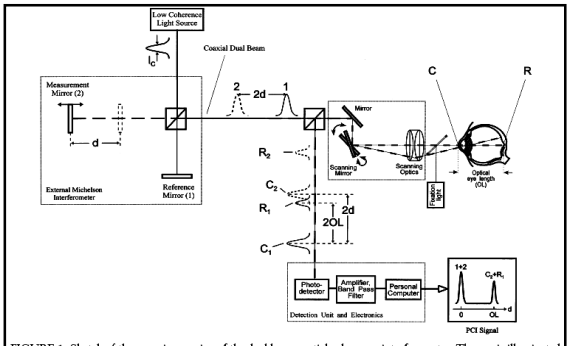
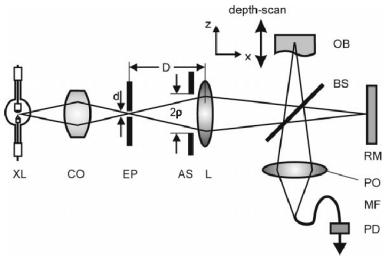


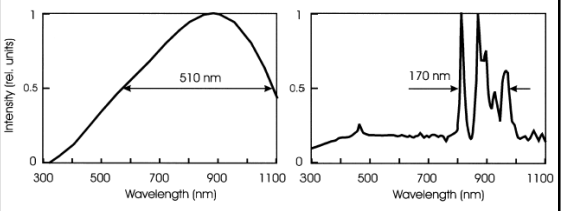
FIGURE 1. Sketch of the scanning version of the dual beam partial coherence interferometer. The eye is illuminated via an external interferometer that produces a coaxial dual beam. Reflected signals from the eye, for example C1, C2, R1, and R2, are superimposed on and detected by a photodetector. A partial coherence interferometry signal of the optical distance (OL) indicating the optical axial eye length is depicted. Measurements at a specific angle between vision axis and measurement direction, or along a completely linear or circular scan, are performed using a computer-controlled scanning mirror and special scanning optics.

ŹRÓDŁA SWIATŁA



OCT device with a thermal light source. The LCI scan is performed by moving the object. AS, aperture stop; BS, beam splitter; CO, condenser; EP, entrance pupil of the interferometer; L, focusing lens; MF, multimode fiber; OB, object; PD, photodetector; PO, photodetetor optics; RM, reference mirror; XL, xenon arc lamp.

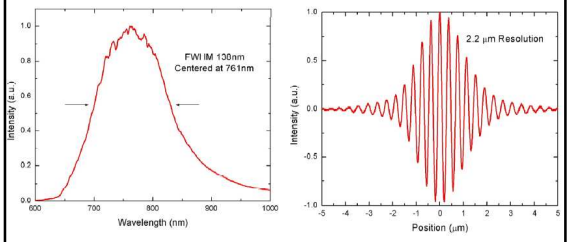
ŹRÓDŁA SWIATŁA



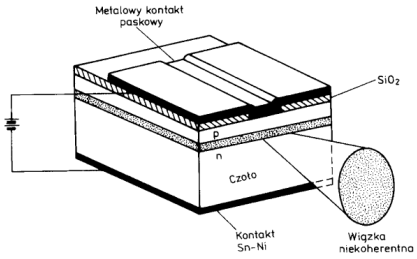
żarówka wolframowa halogenowa niskowoltowa OSRAM 64625

xenonowa wysokociśnieniowa lampa łukowa OSRAM XBO 75

ŹRÓDŁA SWIATŁA
dioda superluminescencyjna

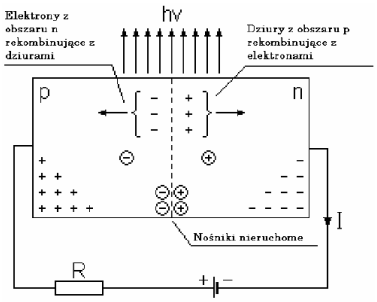


ŹRÓDŁA SWIATŁA
dioda superluminescencyjna



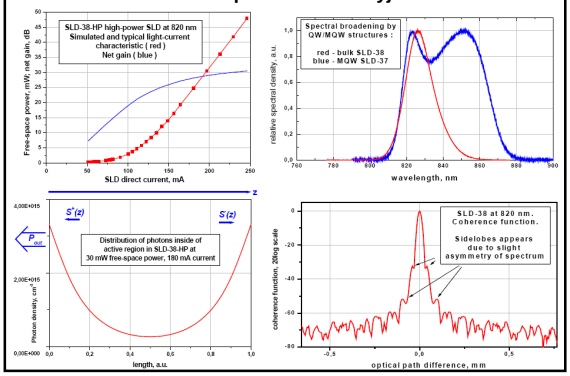
Struktura diody superluminescencyjnej.

ŹRÓDŁA SWIATŁA
dioda superluminescencyjna

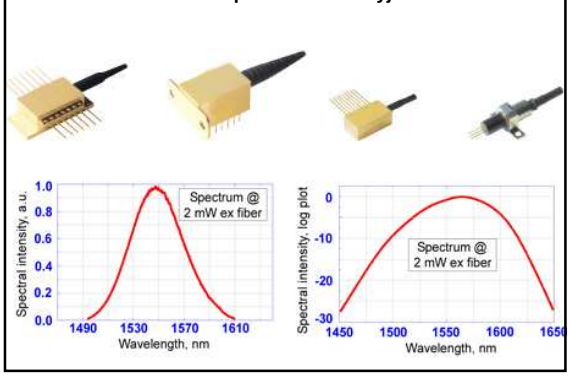


Zasada działania diody elektroluminescencyjnej. (Kierunek przewodzenia)

ŹRÓDŁA SWIATŁA
dioda superluminescencyjna

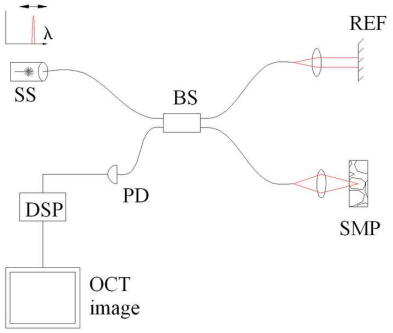


ŹRÓDŁA SWIATŁA
dioda superluminescencyjna



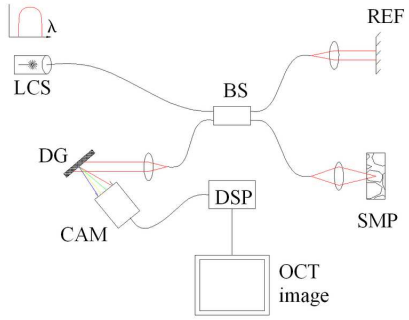
(CZĘŚCIOWO)KOHERENTNA TOMOGRAFIA OPTYCZNA

METODA SPEKTRALNA – PRZEMIATANIE CZĘSTOTLIWOŚCIĄ



(CZĘŚCIOWO)KOHERENTNA TOMOGRAFIA OPTYCZNA

METODA SPEKTRALNA – ANALIZOWANIE CZĘSTOTLIWOŚCI



(CZĘŚCIOWO)KOHERENTNA TOMOGRAFIA OPTYCZNA

METODA CZASOWA – DWIE WIĄZKI

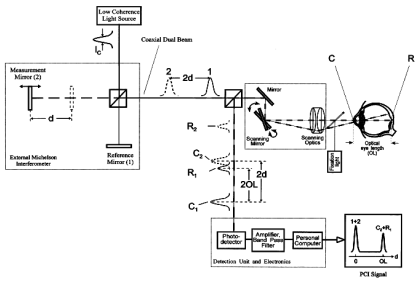
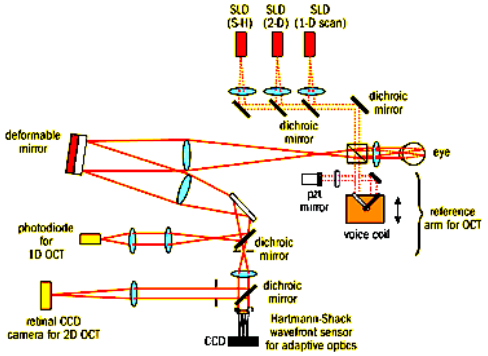


FIGURE 1. Sketch of the scanning version of the dual beam partial coherence interferometer. The eye is illuminated via an external interferometer that produces a coaxial dual beam. Reflected signals from the eye, for example C1, C2, R1, and R2, are superimposed on and detected by a photodetector. A partial coherence interferometry signal of the optical distance (OL) indicating the optical axial eye length is depicted. Measurements at a specific angle between vision axis and measurement direction, or along a completely linear or circular scan, are performed using a computer-controlled scanning mirror and special scanning optics.

(CZĘŚCIOWO)KOHERENTNA TOMOGRAFIA OPTYCZNA



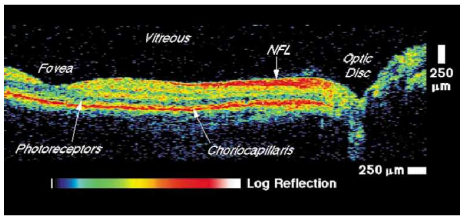
(CZĘŚCIOWO)KOHERENTNA TOMOGRAFIA OPTYCZNA

OCT w wydaniu komercyjnym

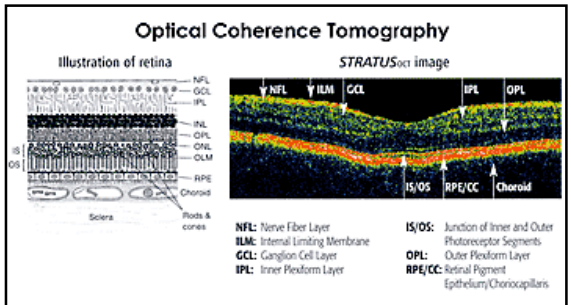
(CZĘŚCIOWO)KOHERENTNA TOMOGRAFIA OPTYCZNA

OCT w wydaniu komercyjnym

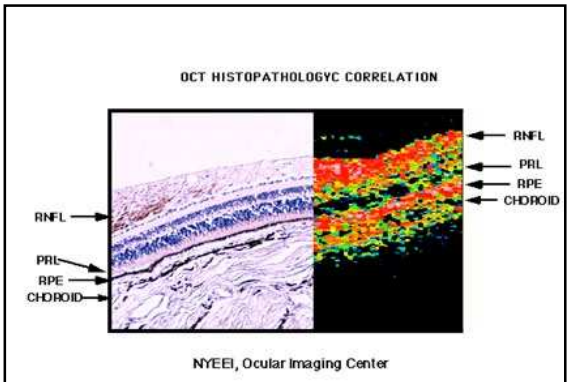
OPTOPOL



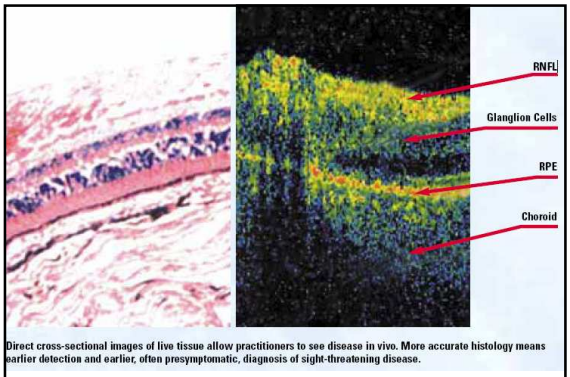
OCT image of the human retina papillary–macular axis illustrating the ability to discriminate structural morphology in vivo. The highly backscattering retinal nerve fiber layer (NFL) and choriocapillaris appear red. The optic disk as well as several of the retinal layers are observed. From [12]: Hee M.R. et al., Optical coherence tomography of the human retina, Arch. Ophthalmol. 113 (1995) 325–332.



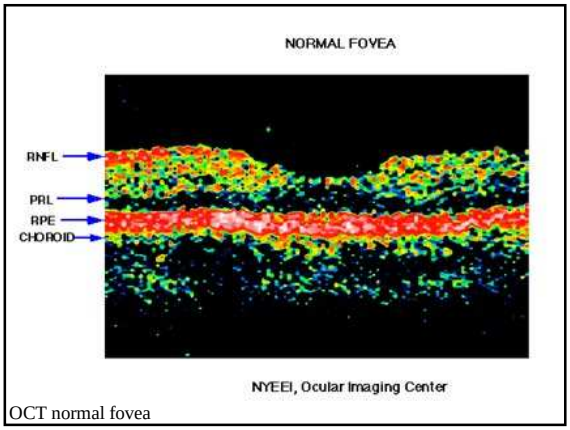
OCT – przekrój siatkówki



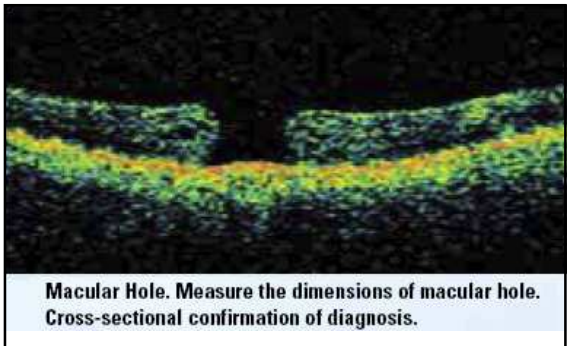
Porównanie histopatologii z OCT



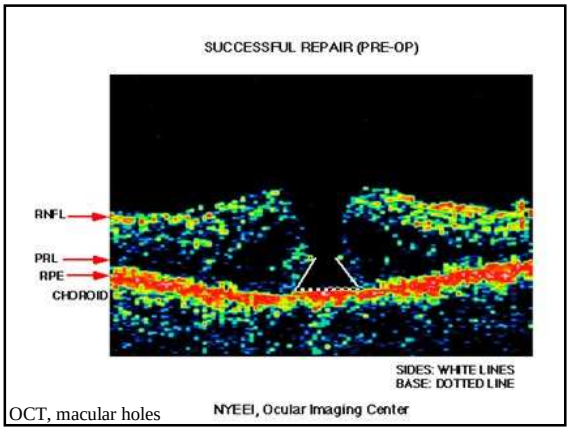
Porównanie histopatologii z OCT



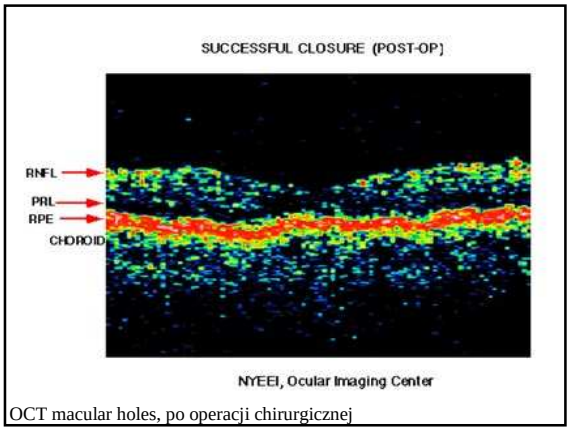
OCT normal fovea



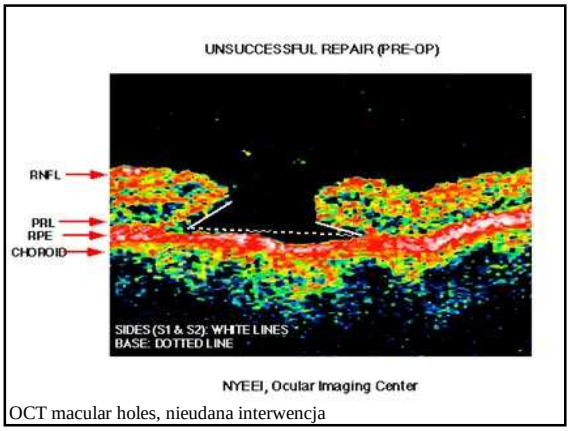
OCT macular hole



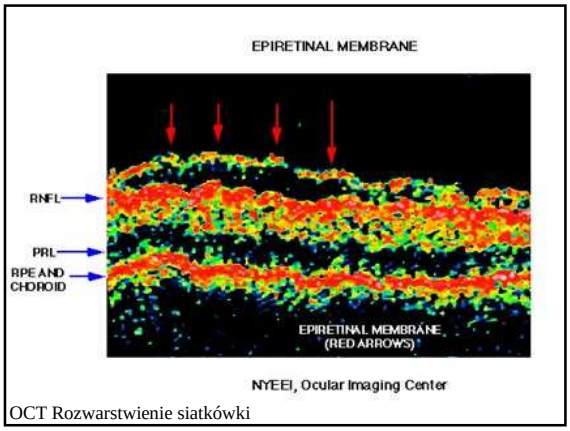
OCT, macular holes



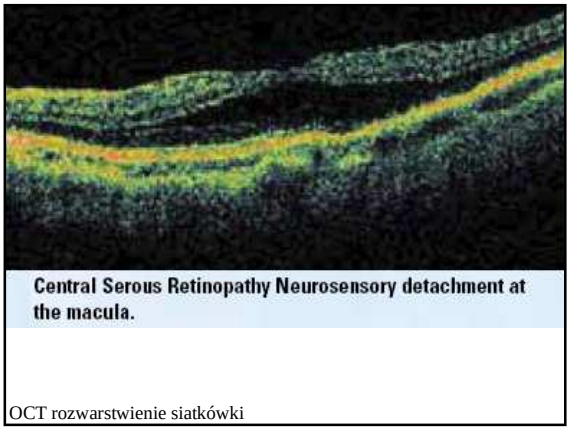
OCT macular holes, po operacji chirurgicznej



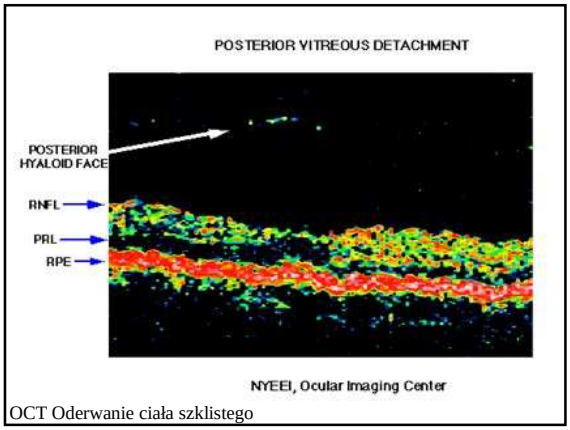
OCT macular holes, nieudana interwencja



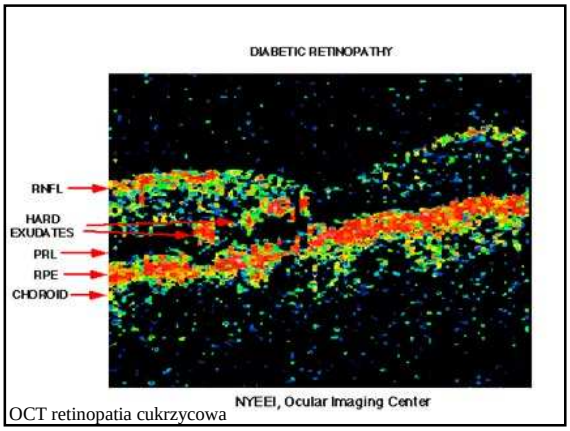
OCT Rozwarstwienie siatkówki



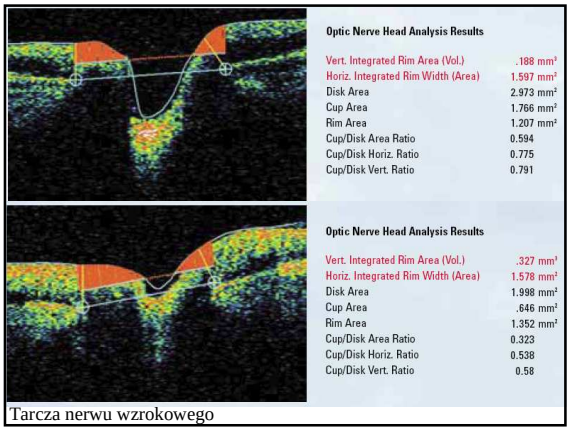
OCT rozwarstwienie siatkówki



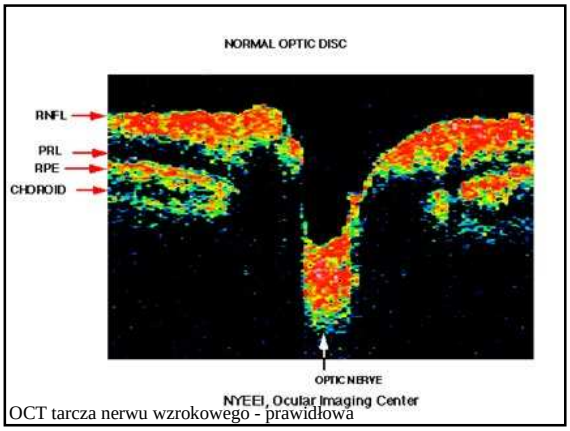
OCT Oderwanie ciała szklistego



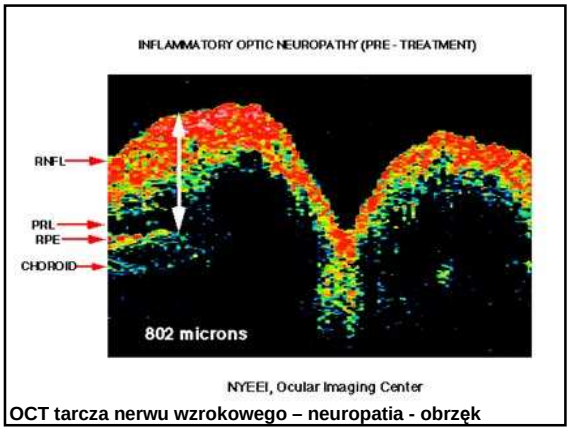
OCT retinopatia cukrzycowa



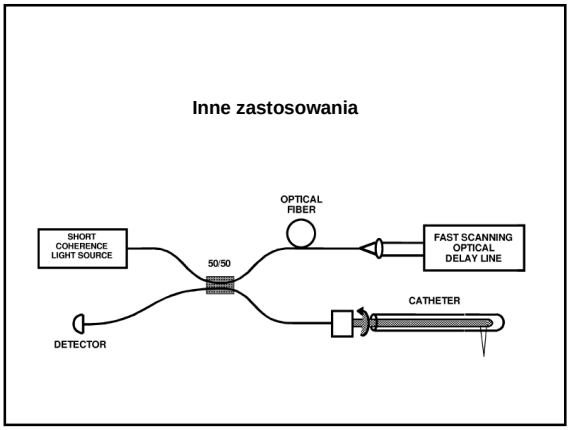
Tarcza nerwu wzrokowego

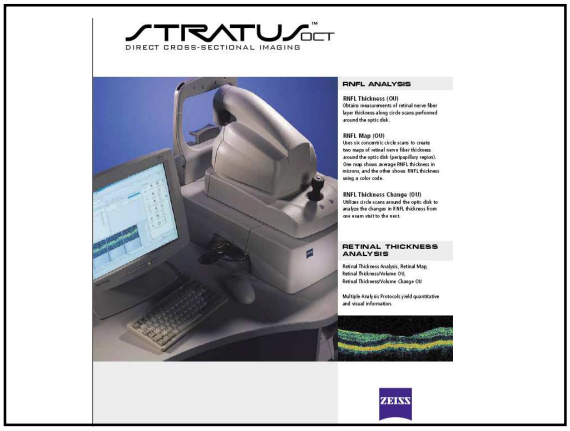


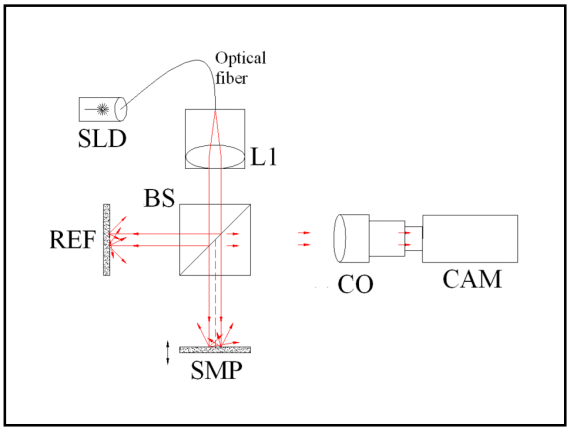
OCT tarcza nerwu wzrokowego - prawidłowa

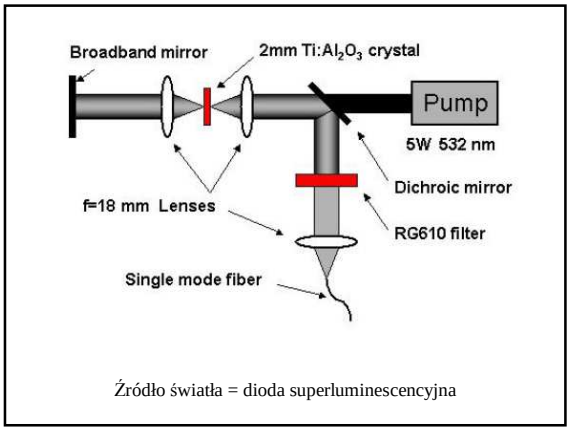


OCT tarcza nerwu wzrokowego – neuropatia - obrzęk









Źródło światła = dioda superluminescencyjna