Optical Coherence Tomography (OCT) products from General Photonics

Optical coherence tomography (OCT) is an optical imaging technique which can provide high resolution, cross-sectional tomographic (or 3-dimensional) imaging of the internal microstructure of materials and biological systems by measuring backscattered or backreflected light. The resolution of the OCT image is 1 to 15 µm, about 100 times better than conventional ultrasound, and therefore has profound implications for the diagnosis of internal problems in biological tissues (such as human bodies) as well as inorganic samples. It has become increasingly popular for medical applications such as noninvasive opthalmological imaging and endoscopic gastrointestinal tract imaging. It also has applications in other fields that require rapid, nondestructive imaging.

Two types of OCT technologies are available today: frequency domain OCT (FD-OCT) and time domain OCT (TD-OCT). TD-OCT is based on low coherence interferometry, with the depth resolution of the system determined by the coherence length of the light source. The basic setup resembles a Michelson interferometer, as shown in Fig. 1. Light from a broadband optical source is divided to illuminate both the sample and reference arms of the interferometer. The reflected light from both arms is recombined and sent to a detector. An interference pattern is created only when the path lengths in the two arms are matched to within the coherence length of the light source. Scanning the length of the reference arm over the range of interest using a fast delay line thus yields a one-dimensional reflectivity vs. depth profile of the sample. Adding x-y scanning optics in the sample arm enables the combination of depth scans from multiple points to create 2 or 3-dimensional images.

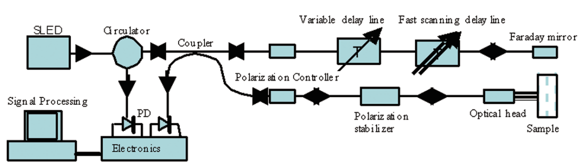


Fig. 1 Time Domain Optical Coherence Tomography (TD-OCT)

FD-OCT can be further divided into scanning laser-based FD-OCT and spectrometer-based FD-OCT, as shown in Fig. 2 and Fig. 3, respectively. Like TD-OCT, they are constructed with a Michelson interferometer, but they do not require a fast scanning delay line. For a scanning laser based FD-OCT, a fast scanning laser is used to replace the broadband source. The Fourier transform of the detected interferometric signal gives the reflectivity vs. depth information of the sample to be imaged. One problem associated with scanning laser FD-OCT is the high cost of the tunable laser. General Photonics has developed a new wide range, low ripple, high power wavelength swept laser for just this application.

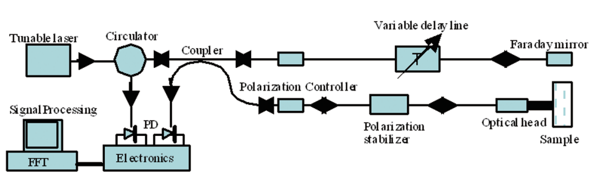


Fig. 2 Scanning Laser Based Frequency Domain OCT (FD-OCT)

Spectrometer based FD-OCT uses a broadband source as the input and a high speed spectrometer to receive and analyze the returned interferometric signal. The Fourier transform of the spectral information reveals the reflectivity vs. depth information. The drawback of this method is the small size of the achievable depth range, which is limited by the spectral resolution of the spectrometer.

Figures 1, 2, and 3 also show the key optical components used to construct an OCT system. Two primary issues for an OCT system are polarization control and optical delay balance. In order to produce a good interferometric signal, the state of polarization (SOP) of the two interfering arms should be aligned; therefore, polarization controllers must be used. For some applications, dynamic polarization control is required for tracking real time polarization changes. For a polarization sensitive OCT (PS-OCT) system, more sophisticated polarization control and analysis devices are required, such as a polarization switch or polarization state generator. General Photonics is proud to offer a complete array of polarization control and analysis solutions, ranging from manual polarization controllers to high speed dynamic polarization controllers and high speed polarimeters.

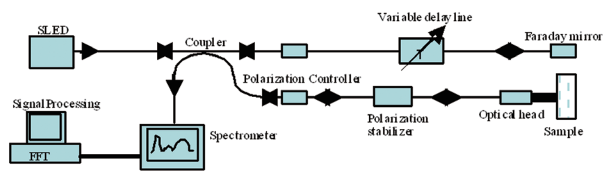


Fig. 3 Spectrometer based Frequency Domain Optical Coherence Tomography (FD-OCT)

Another factor necessary to achieve good interferometric signals in both TD-OCT and FD-OCT systems is the optical path length balance of the two interfering arms. General Photonics' manual variable delay lines (VDL) are perfect for this application. With a delay variation range up to 40 cm, these delay lines can quickly compensate for large delay imbalances between the two interfering arms.

A depth "zooming" function is desirable for some applications, such as opthalmological imaging of the front and back of an eye. General Photonics' motorized delay line (MDL-002) is ideal for such an application. With sub-micron resolution and a total delay of up to 40 cm, the MDL-002 enables the OCT system to "zoom" to any desired position.

The most important component for TD-OCT is a fast scanning delay line with a range of 3 to 5 mm and a speed of up to a few kHz. General Photonics provides fiber stretchers (FST) with varying speeds and delay ranges for this application

General Photonics also provides other components for OCT applications, such as wideband couplers, polarization maintaining couplers, circulators, and Faraday mirrors. Our bench-top SLED source is convenient for OCT related research. We are the one-stop shop for almost all optical components for OCT applications. Please contact us if you do not see the products you need in the catalog. We will be happy to listen to your requirements and modify or customize our products to meet your needs

Key OCT components from General Photonics

1. Wavelength swept laser source (WSL-001, p.68)

Function:

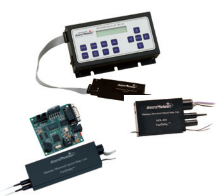
Scanning laser for resolution of depth information in frequency domain OCT (FD-OCT).

2. Manual variable delay lines (VDL-001/002, see pp. 61-63)

Function:

Manually adjust the optical path lengths of the interferometer arms.

3. Motorized variable delay lines (MDL-002/003 pp. 58-60)

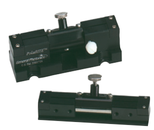


Functions:

a) Automatically adjust the optical path lengths of the interferometer arms.

b) Provide “zoom” function to look for details around a certain depth.

4. Manual polarization controller (PLC-003 & PLC-006, pp.56)



Function:

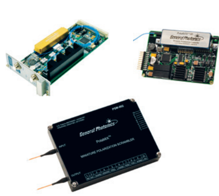
Manually adjust the polarization states of the interferometer arms.

5. Dynamic polarization controller (PCD-M02, p.50)

Function:

Dynamically tune the polarization states of the interferometer arms.

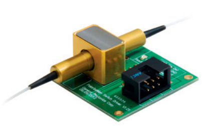
6. Polarization scrambler (PCD-005, PSM pp.41-46)



Function:

Randomize the polarization state to eliminate polarization effects.

7. Polarization switch (PSW-002, p.54)



Functions:

a) Switch polarization state by 90 degrees to decrease the polarization sensitivity of the OCT system.

b) Enables polarization sensitive OCT (PS-OCT)

8. Balanced photodetector (BPD, p.70-71)

Function:

Low noise balanced detector for accurate detection of small signals.

9. SLED source (SLD-101S, p.33)

Function:

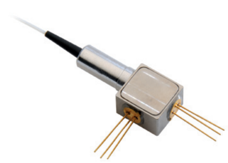
A wideband light source with Gaussian spectral distribution.

10. Fiber pigtailed free-space interferometer (MZI-001, p.76)

Function:

Acts as a frequency clock in frequency domain OCT (FD-OCT).

11. Polarization Diversity Detector (PDD, p.74)



Function:

Simultaneously detect the powers of the two orthogonal polarization states. Useful for PS-OCT.

12. Faraday mirror (FRM-001, p.88)

Functions:

a) Reflect light back to the coupler

b) Passively compensate for polarization fluctuations in the reference arm of the interferometer

13. Fiber couplers (NTC, PMC, pp.85-86)

Function:

Divide and combine optical beams for the interferometer.

14. Optical circulator (CIR, p.92)

Function:

Isolate back-reflected light and direct it to the detector.