

The meeting was the second in a tutorial series on Optical Diagnostic Technologies. Brett Bouma, PhD, discussed new technological developments for OCT. Four areas were discussed: Doppler imaging, measurement and use of tissue birefringence, techniques for obtaining higher resolution and the incorporation of spectroscopic information. Doppler imaging is based on the shift of the optical frequency of light when reflected from a moving object, such as blood flowing in a vessel. With appropriate signal processing this effect on the OCT signal can be quantified and used to obtain radial velocity gradients of laminar flow through a tube. Birefringence is a property of some materials in which the speed of light varies with orientation of the polarization of the light, resulting in slow and fast propagation axes. A number of tissues, including collagen, muscle, tendon and retinal nerves, exhibit birefringence; thermal tissue damage, such as that caused by a burn, can destroy birefringence. The use of a polarization-sensitive OCT (Pol-OCT) system, such as the one recently built at Wellman Labs by Dr. Johannes de Boer, allows regions of differing birefringence to be spatially resolved. Pol-OCT has been used to image burn depth and so may be useful clinically in burn-depth determination to determine treatment.

The depth resolution of OCT increases with the bandwidth of the light source; a conventional superluminescent diode source provides about 10-micron depth resolution. A femtosecond (fs) titanium-sapphire laser source, which has much greater spectral bandwidth than the usual diode source, has been demonstrated by the MIT group to provide about 1.5 micron depth resolution. The MIT group also demonstrated the use of spectrally-resolved OCT to demonstrate spatial variations of the combined scattering and absorption of cells. Such spectroscopy is best carried out with broadband sources. In addition to the fs laser sources described broad continuum radiation can be generated using nonlinear effects in optical fibers. A tapered optical fiber, which produces high fields in the tapered region, is being studied as a source.

Gary Tearney, MD, PhD, discussed Confocal Microscopy in Thick Tissue. Optical Biopsy has many attractive features, such as sampling of regions where physical biopsy is hazardous, screening, increasing the yield of conventional random biopsy and perhaps primary diagnosis. However optical biopsy has not been fully implemented to date. OCT, with its 10 micron resolution, yields information about tissue architecture while confocal microscopy has sufficient resolution to provide cellular information. Both techniques need to reject scattering by tissue surrounding the region of interest and require a source of contrast to provide images. Penetration depth and speed of imaging are issues for both techniques. OCT rejects multiply-scattered light by time gating; confocal does so by spatially confining the region imaged using a pinhole or equivalent to reject out-of-focus light. Confocal systems typically have transverse resolutions of about 1 micron and axial resolutions of < 5 microns. In contrast to OCT, which provides transverse sections, confocal provides an "en face" view which is unfamiliar to pathologists. Transferring confocal microscopy, originally a relatively bulky laboratory tool, to in vivo use requires the elimination of motion artifacts. This in turn requires rapid scan rates, from 5-30 frames/second. An in vivo confocal system was developed at Wellman and commercialized. A number of applications to dermatology as well as to the oral mucosa have been studied. A further refinement, endoscopic confocal microscopy,

would require both rapid scanning and a small diameter probe. A technique to eliminate rapid scanning of the probe has been developed at Wellman and demonstrated with a test grid. The technique uses a diffraction grating at the distal end of a fiber to spatially separate different wavelengths and produce a number of spots in the focal plane. Fourier Transform Spectroscopy is used to spectrally analyze the reflected signal and signal processing allows the reflection from the focal plane to be reconstructed.

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