



Axsun Technologies Inc.

Swept Laser Engines for OCT Imaging

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BioOpto Japan

September 26, 2012

Outline

- Axsun Overview
- Axsun Technology and Manufacturing
- Clinical Benefits of SSOCT
- Axsun Swept Laser Engine products
- SSOCT Future Directions
- Axsun OCT Images
- Conclusion
- Topcon Eye Care Presentation

Axsun Technologies Inc.



AXSUN MODULE ASSEMBLY FACILITY



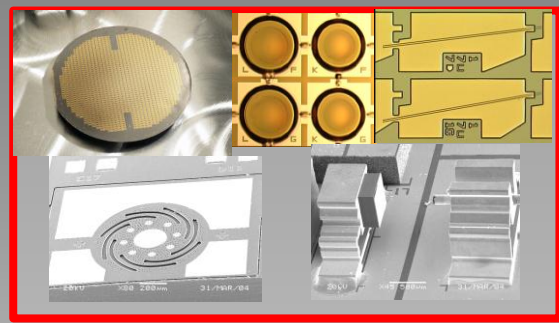
Optical Engine

- A wholly owned subsidiary of Volcano Corporation (Nasdaq: VOLC)
- Founded in 1998, located in Billerica, MA
- Producing more than ten thousand optical engines annually into Telecom, Industrial Spectroscopy and Medical Imaging applications
- Unique tunable MEMS and optical integration technology
- Telecom and Industrial products have strong synergy with Medical Imaging
- 115 employees
- 110 Issued Patents

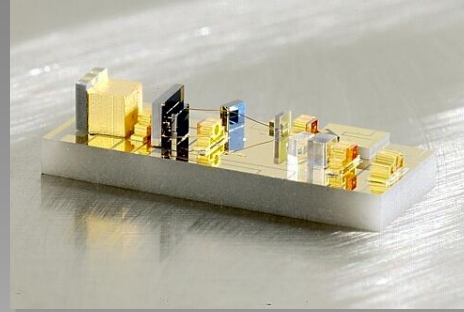
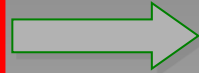
MEMs Technology and Manufacturing Platform

High Capacity, Automated
Manufacturing

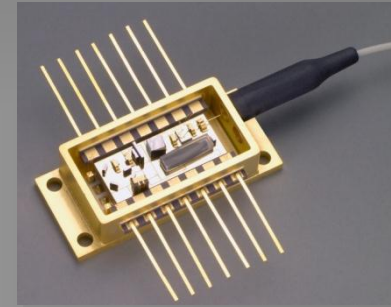
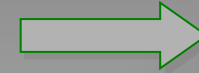
The Axsun Platform – Unique Devices, Assembly, and Products



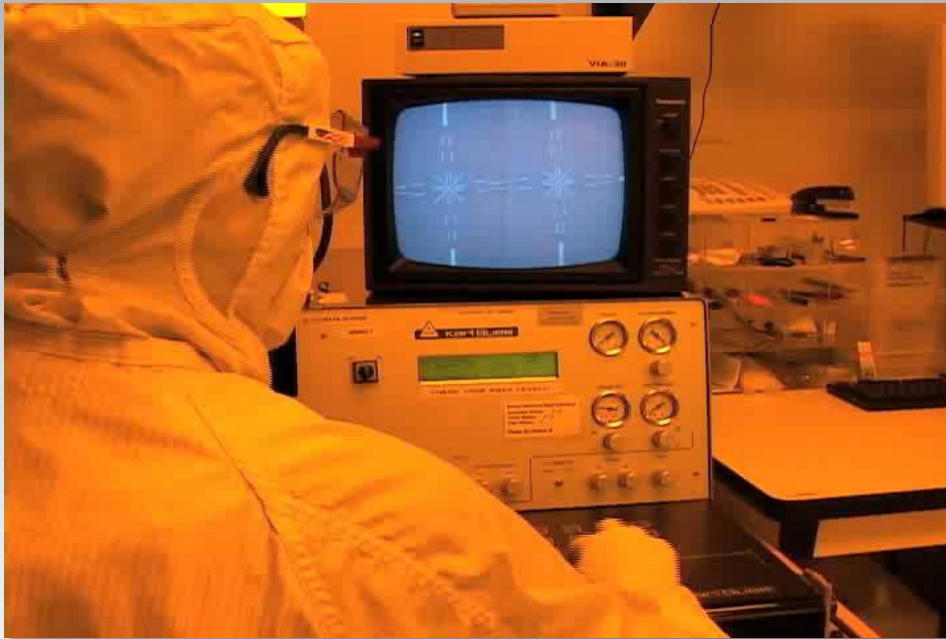
Unique Devices



Optical Bench

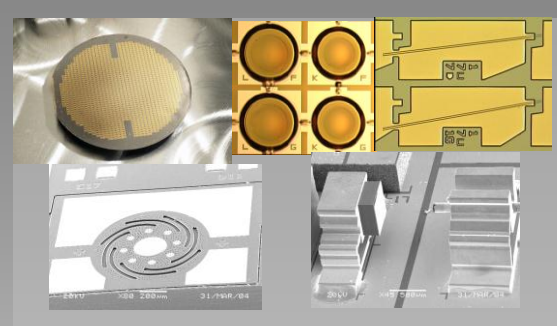


Optical Engine Module

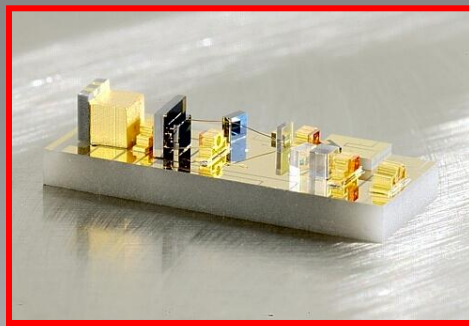
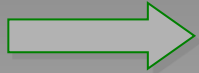


Complete Subsystem

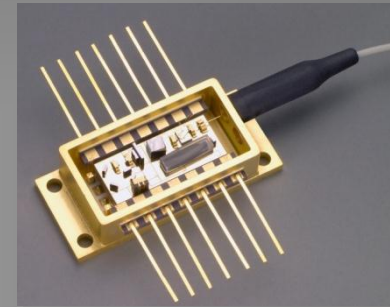
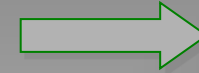
The Axsun Platform – Unique Devices, Assembly, and Products



Unique Devices



Optical Bench

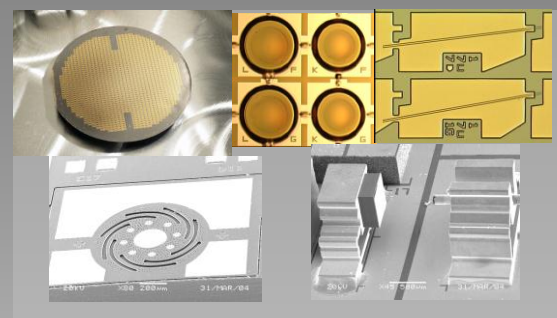


Optical Engine Module

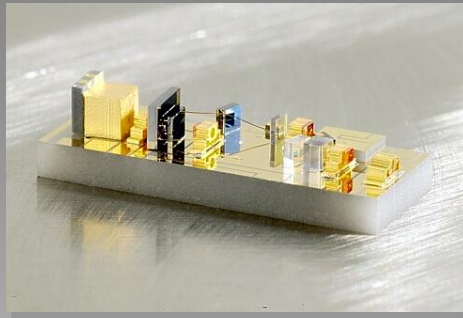
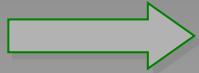


Complete Subsystem

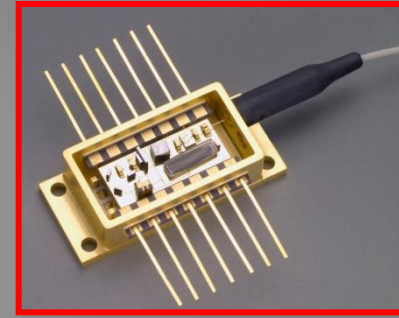
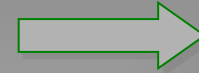
The Axsun Platform – Unique Devices, Assembly, and Products



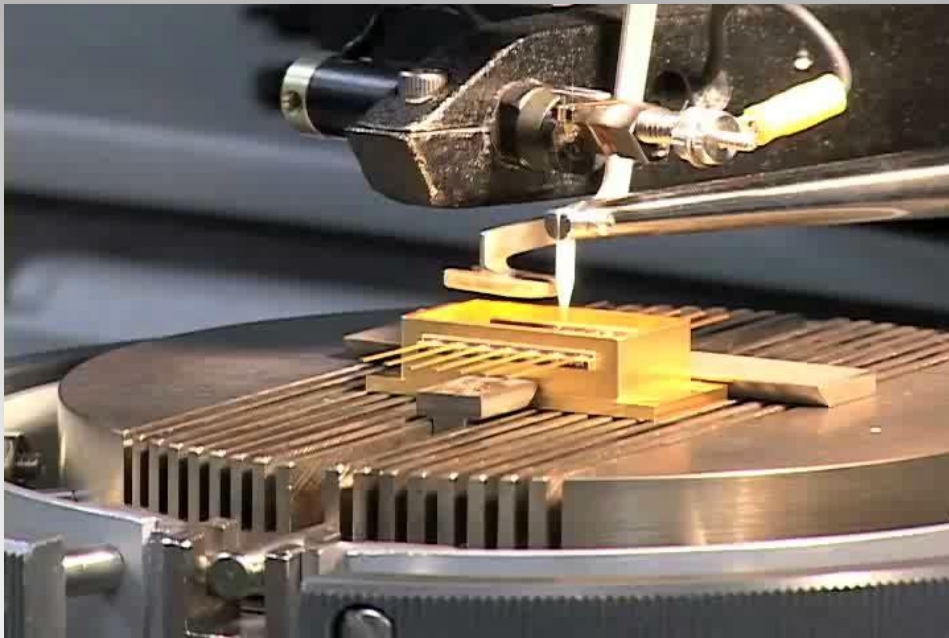
Unique Devices



Optical Bench

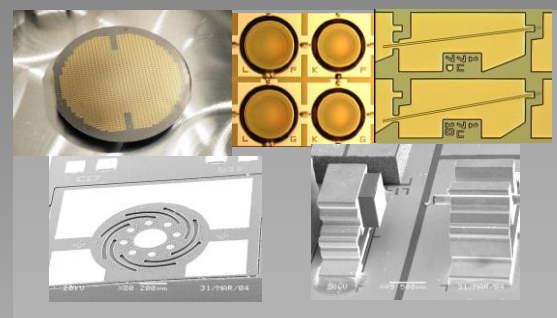


Optical Engine Module

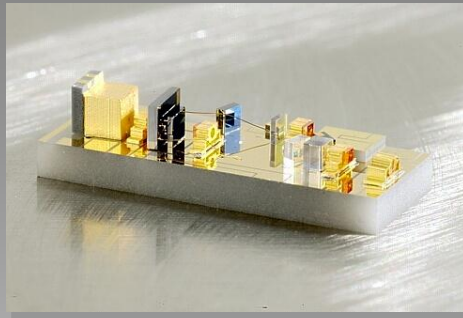
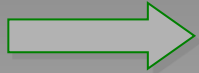


Complete Subsystem

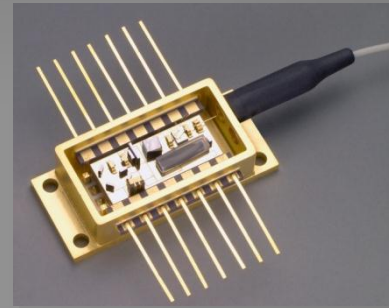
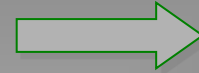
The Axsun Platform – Unique Devices, Assembly, and Products



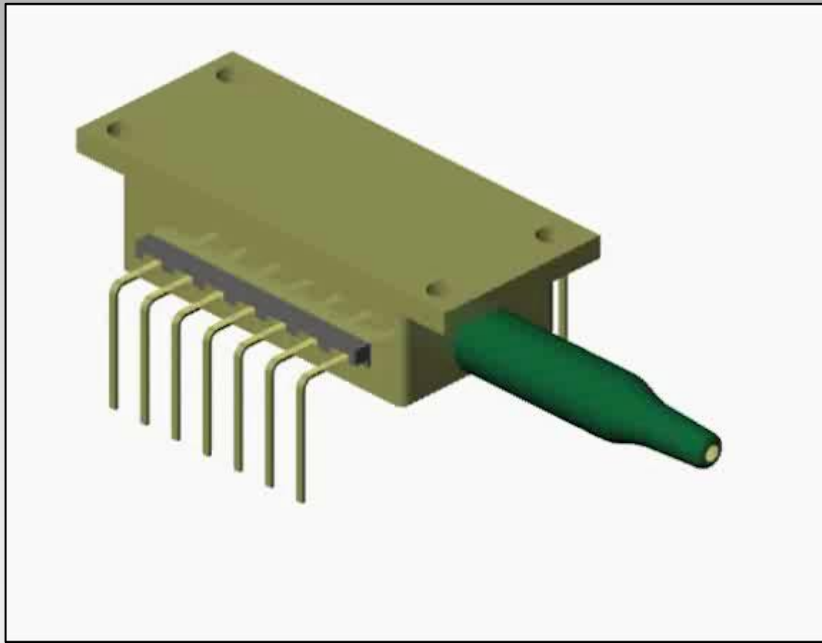
Unique Devices



Optical Bench



Optical Engine Module



Complete Subsystem

Swept Source OCT Advantages

Axsun Swept Laser Technology
and Performance

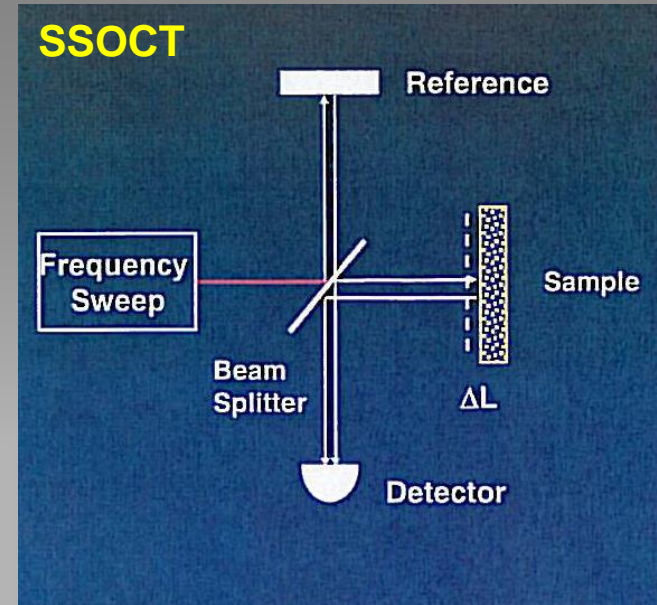
Optical Coherence Tomography

OCT Techniques

1. Time-domain OCT
2. Frequency-domain OCT
 - Spectral-domain OCT
 - **Swept-source OCT**

Swept-Source OCT advantages

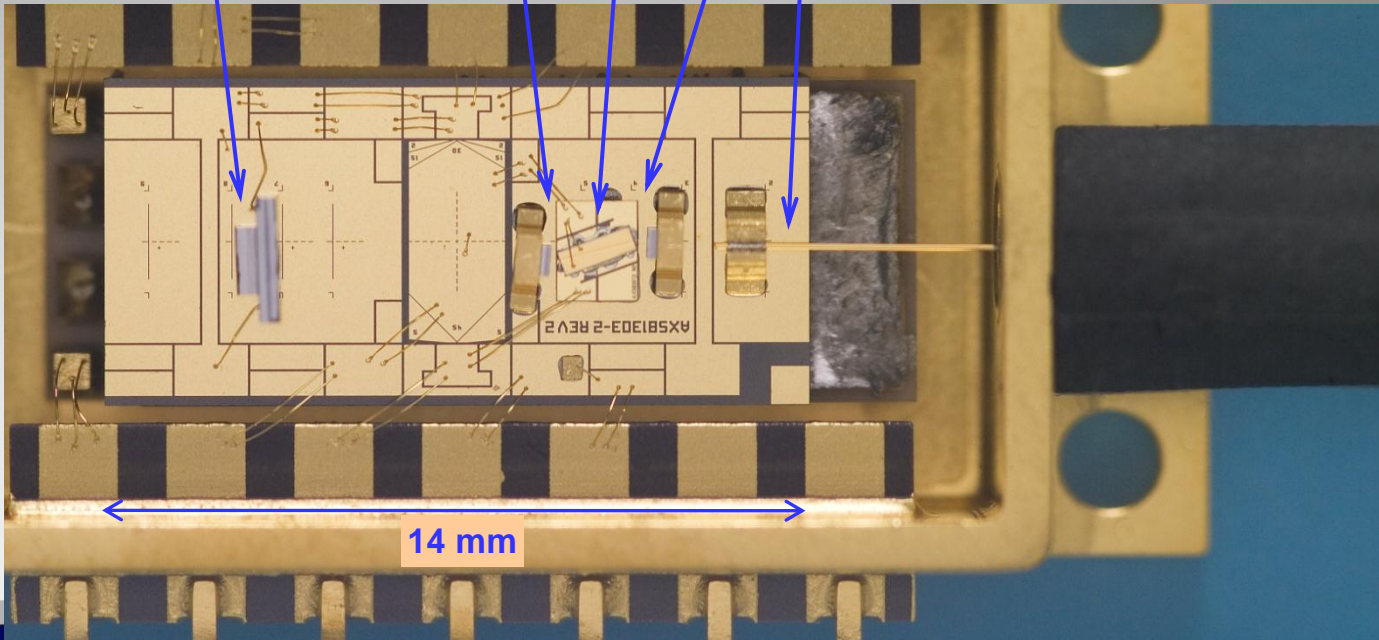
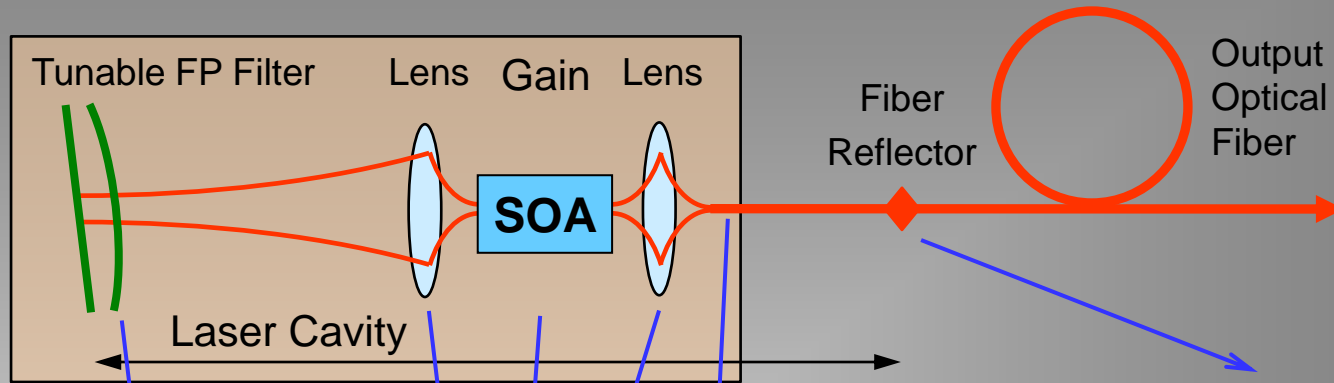
- Enables balanced and polarization diverse detection schemes
- Longer Wavelengths, such as 1060 and 1300 nm, enable deeper penetration into tissue
- Increased imaging depth range from slower signal roll-off
- High SNR and Resolution in a compact, rugged package



SSOCT Current and Future Capabilities enable dramatic benefits to patients

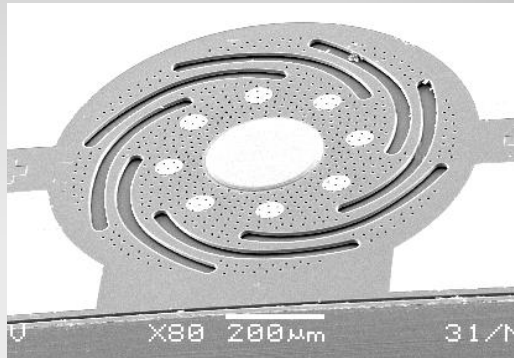
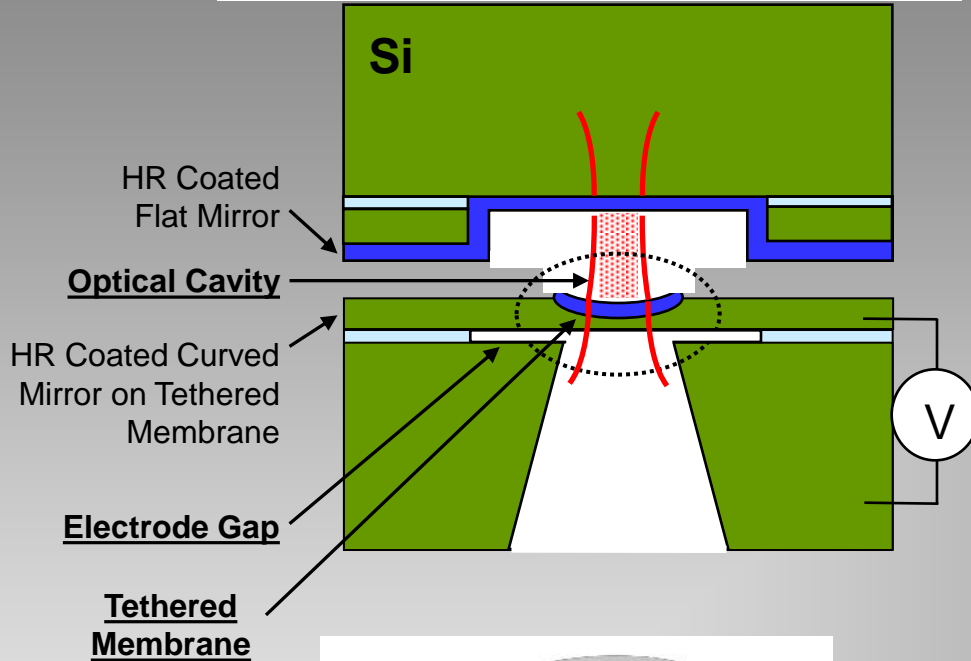
| Market Need | Clinical Benefits | SSOCT Current Capability | SSOCT Future Capability | Advance over current systems |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-----------------------------------------|--------------------------------------------------|
| Imaging Speed | Fewer movement artifacts, Larger # of averaged images Faster 3D imaging Better image quality in less time More accurate diagnosis | 100 kHz | 200kHz+ | 4X+ |
| Imaging Resolution | Ability to view sub retinal vasculature and individual blood vessels. Distinguish cancer from Dysplasia. More accurate diagnosis | 7-16 Microns | 5-10 Microns | Equivalent resolution at 4-8X speed |
| Imaging depth range | Increases the potential patient population and range of the instrument (able to image diseased eyes completely), possibility of whole eye imaging | 4 to 8mm | 4 to 40 mm | 2-8x at higher speed |
| Deeper Tissue Penetration | Makes the instrument more versatile, enabling choroidal thickness maps and quality retinal images in the presence of cataracts | Into Sclera | Into sclera with wider DOF | 2X |
| Size and cost | Enables widespread deployment of SSOCT at a reasonable system cost. Smaller size enables portable and handheld imaging instruments | Existing diagnostic system footprint | Volume drives smaller size and low cost | Smaller and lower cost for widespread deployment |

Axsun MEMs External Cavity Tunable Laser

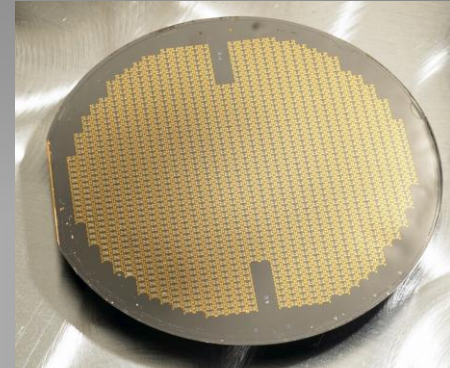


Micro-Electro-Mechanical System (MEMS) Tunable Filter

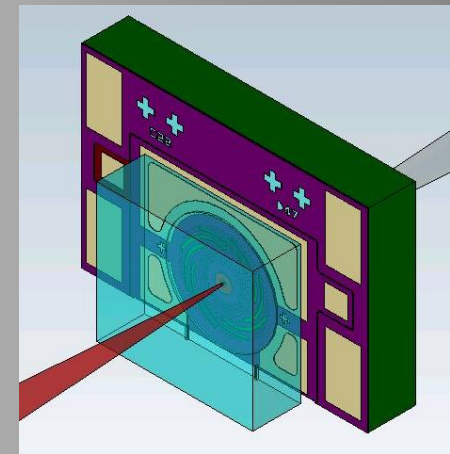
MEMS Fabry-Perot Filter Structure



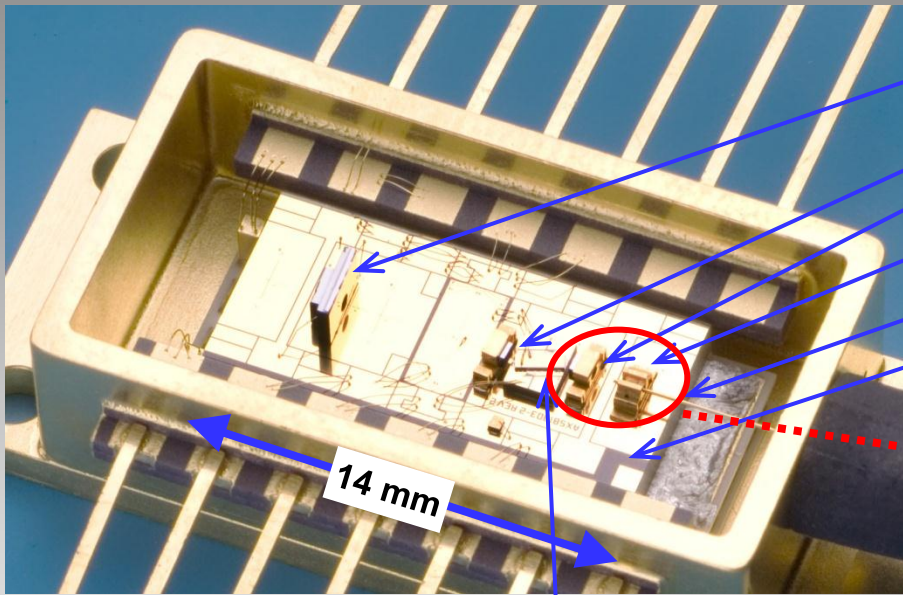
Wafer Scale Processing



Filter Assembly

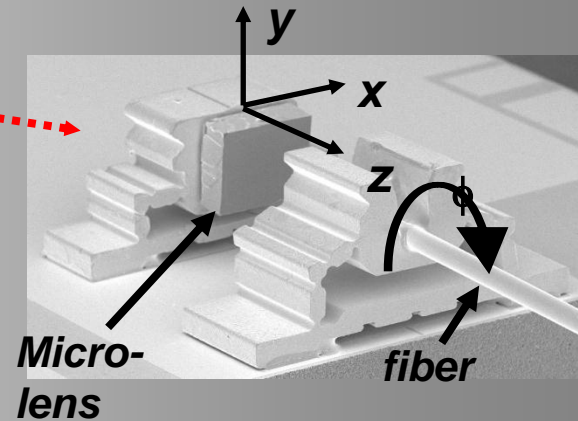


Micro-Optical Bench Packaging Platform



SOA gain chip

- MEMS tunable filter
- Si micro lens
- LIGA alignment structure
- Output Fiber pigtail
- Micro-optical bench

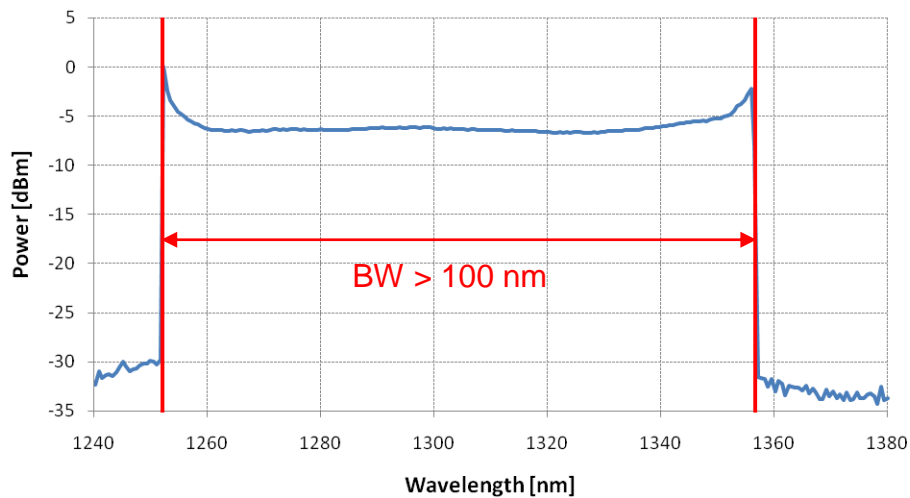


Enables the most compact, highest speed tunable laser for OCT

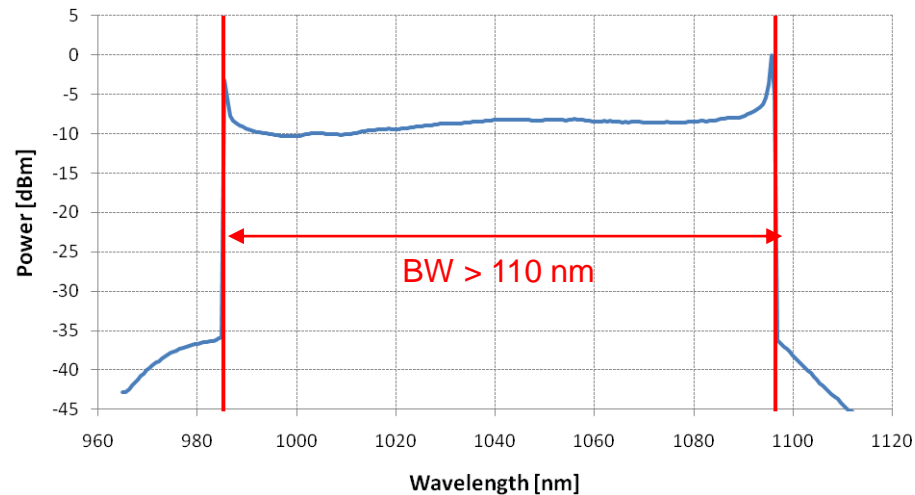
Axsun Swept Laser Performance

Axsun Laser Tuning Range (Bandwidth)

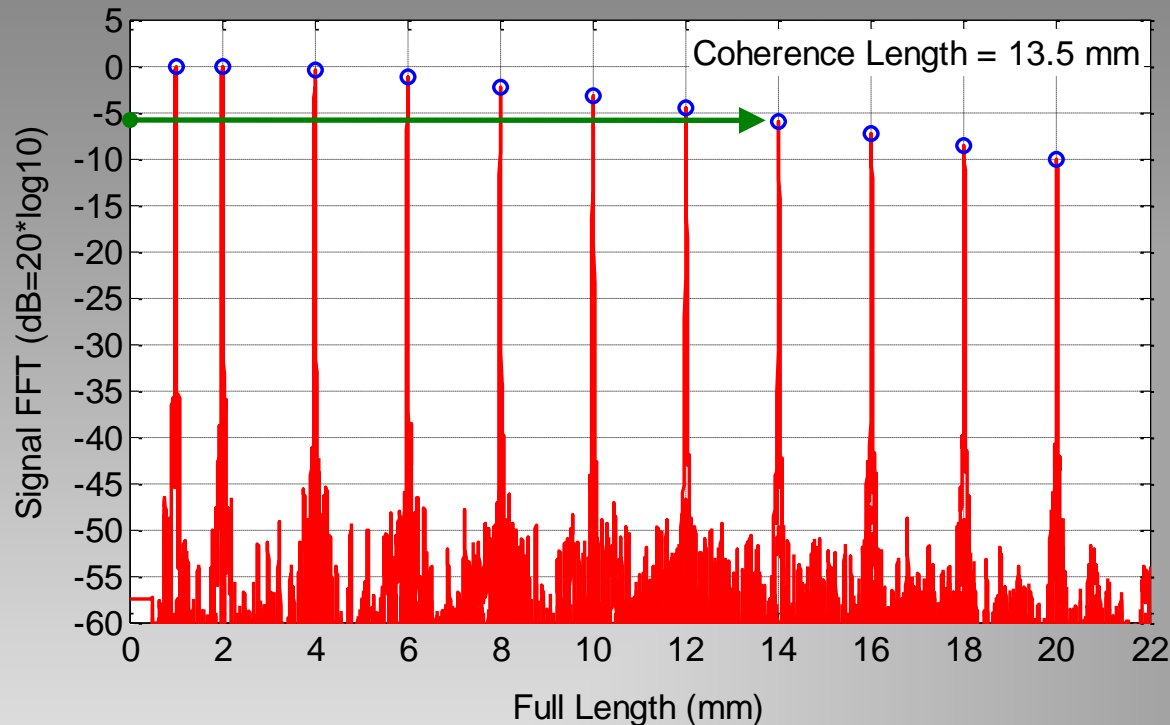
1310nm 50KHz Laser
Power Spectrum from OSA



1060nm 100KHz Laser
Power Spectrum from OSA



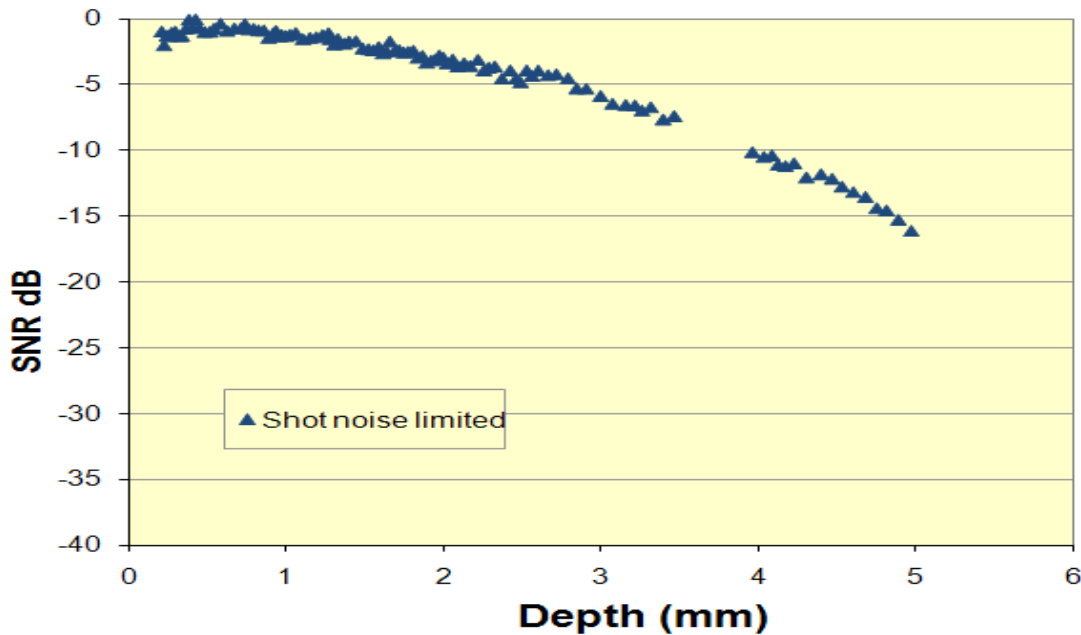
Axsun Laser Coherence Length



- Operating conditions:
- $\lambda \sim 1060$ nm
 - 110 nm tuning range
 - 100 kHz scan rate

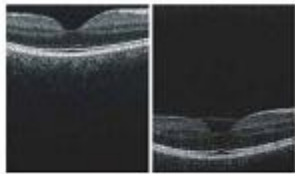
Axsun's slow signal rolloff enables longer imaging depth range than competitive swept lasers and Spectral Domain OCT systems

SNR over Imaging Depth



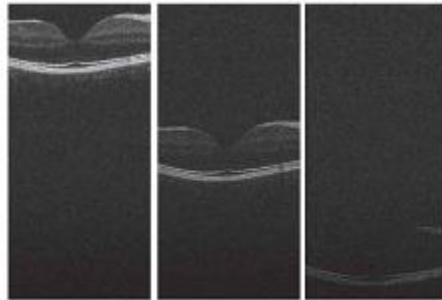
→ Slow SNR rolloff enables longer imaging depth range

(A) * 47kHz Spectral 1050nm



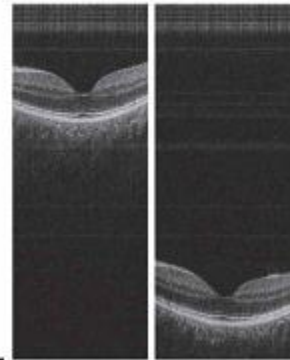
1.6mm

(B) □ 91kHz Spectral 850nm



2.2mm

(C) × 100kHz SS 1050nm



2.9mm

Ref:

Benjamin Potsaid, Bernhard Baumann, David Huang, Scott Barry, Alex E. Cable, Joel S. Schuman, Jay S. Duker, and James G. Fujimoto, "Ultrahigh speed 1050nm swept source / Fourier domain OCT retinal and anterior segment imaging at 100,000 to 400,000 axial scans per second," *Opt. Express* 18, 20029-20048 (2010)

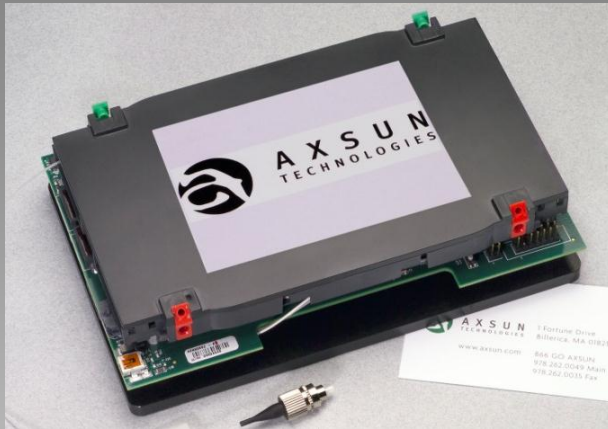
1060 47kHz
InGaAs Camera

850nm 91kHz
CMOS Camera

Axsun 1060nm
100kHz Engine

Axsun OCT Engine products

Axsun OCT products



Axsun Swept Laser OEM Engine



Axsun Camera Link DAQ Board

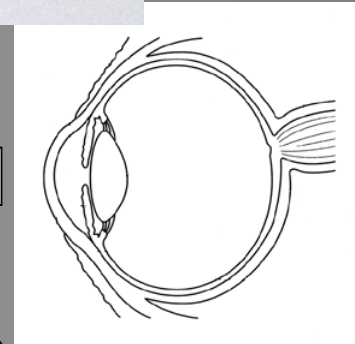
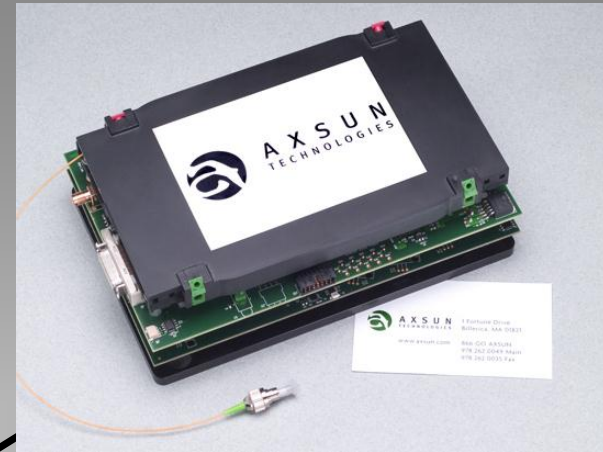
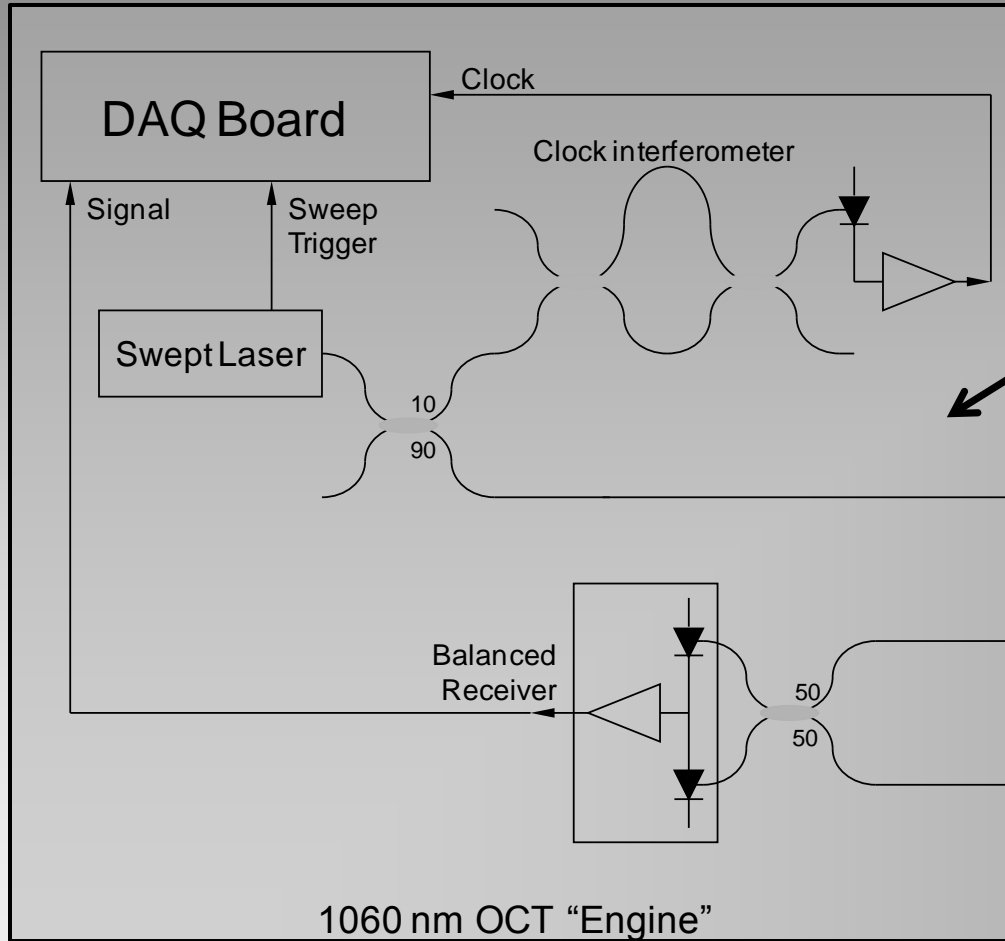


Axsun Swept Laser Benchtop Engine



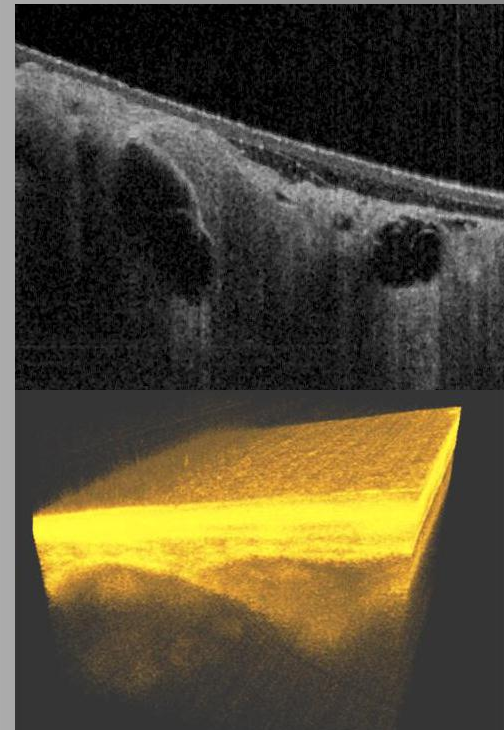
Axsun Swept Laser Engine with integrated DAQ

OCT system with Axsun SS Laser + Axsun Data Acquisition Board



OCT System (Systems Engineering)

- Based on Axsun 1310nm SSOCT Engine
 - Includes stage mount or handheld probe
 - Reference and sample interferometers
 - High Speed Data acquisition card
 - 2 axis scanning for 2D or optional 3D OCT imaging
 - Integrated control and image display software



Axsun OCT Future Directions

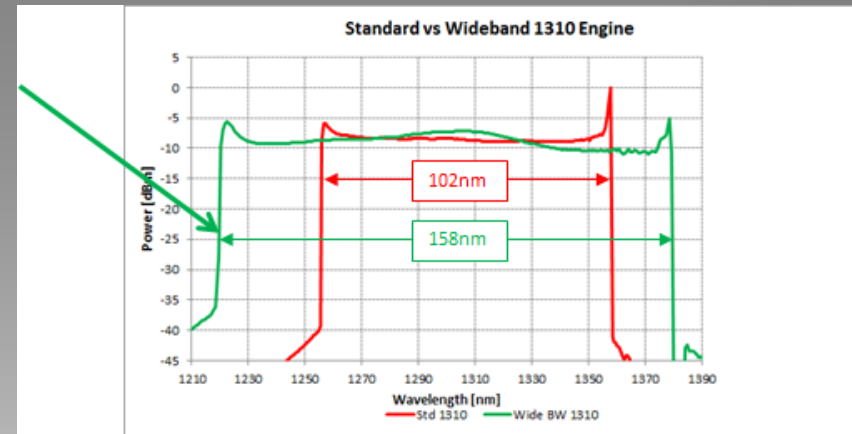
Product Plans

- Axsun's Core Technology provides distinct advantages in size, speed, imaging depth range and reliability for our OCT Engine Products
- In 2012 and beyond, Axsun will build on our technology lead in Swept Laser Subsystems
 - Higher speed, wider bandwidth Swept Laser Engines
 - Data Acquisition/Image Processing
- Our value added subsystem products will speed TTM and allow our OEM customers to focus on their applications

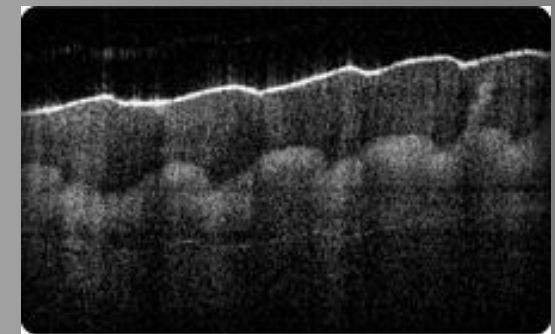
OCT Product Roadmap – Next Gen Lasers

- 140nm 100kHz 1310nm Engine

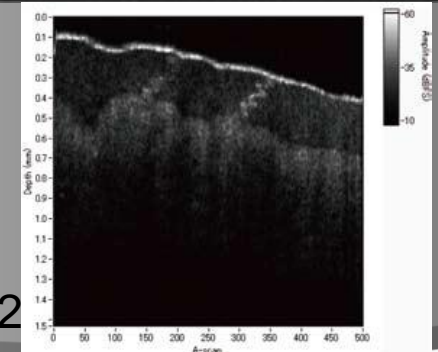
- High resolution Anterior segment imaging
- Endoscopic cancer detection
- Enables higher resolution and speed
- Targeting similar coherence length to our 100nm 50kHz 1310 laser (12-15mm)
 - We can provide equivalent resolution at 4X speed and 3x Imaging depth of our competitors
- Available early 2013



Wider Tuning BW



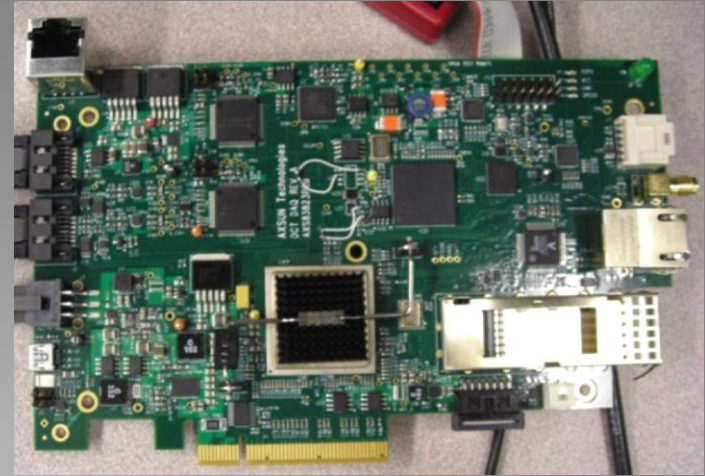
150nm



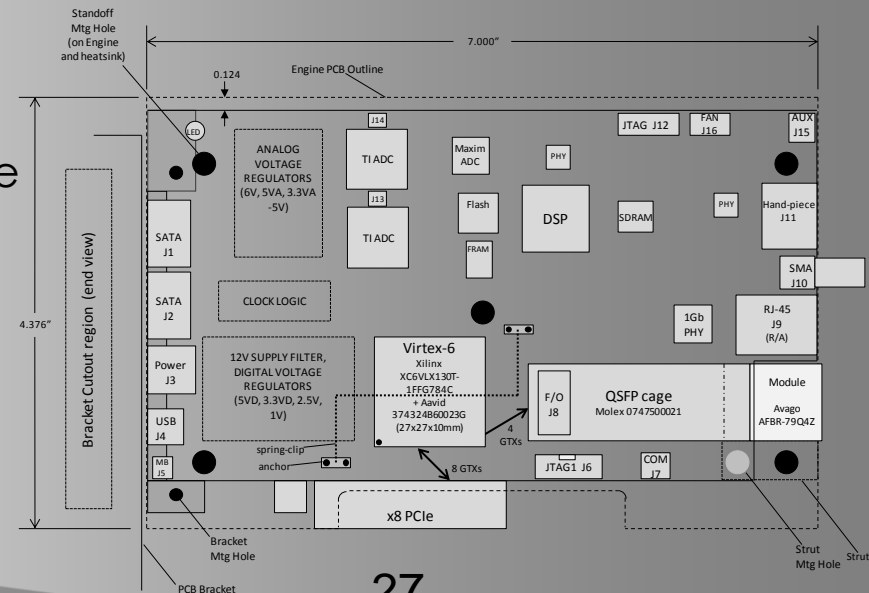
OCT Product Roadmap- System Capabilities

- 2 Channel PCIe based DAQ Board

- Specifically designed to work seamlessly with Axsun 100 and future 200kHz sources
- 2 Channel 500MSPS 12-bit DAQ
 - 1024-2048 samples per A scan
- Xilinx Virtex 6 FPGA gives added signal processing capability
 - Image processing (FFT, Pol. Mixing Windowing)
 - Image compression
- Multiple high speed data interfaces
 - Ethernet, GBE, RS232, PCI
- In house expertise to provide custom algorithms
- Quick turn customization capability will be a differentiator and speed TTM for our customers



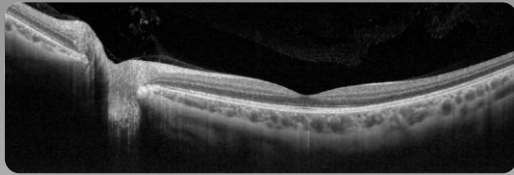
500MSPS PCI DAQ



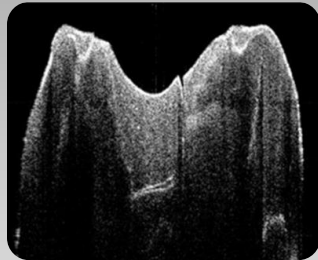
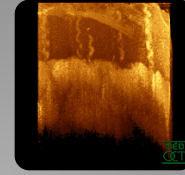
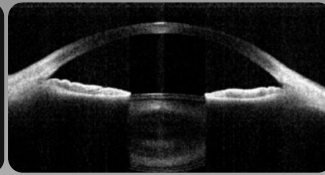
Axsun OCT Markets and Real World Imaging Examples

Expanding Axsun Opportunities

Image Guided Therapy, Diagnosis & Guidance



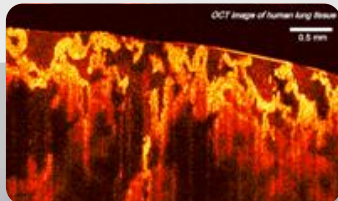
Retinal Image Courtesy of Topcon



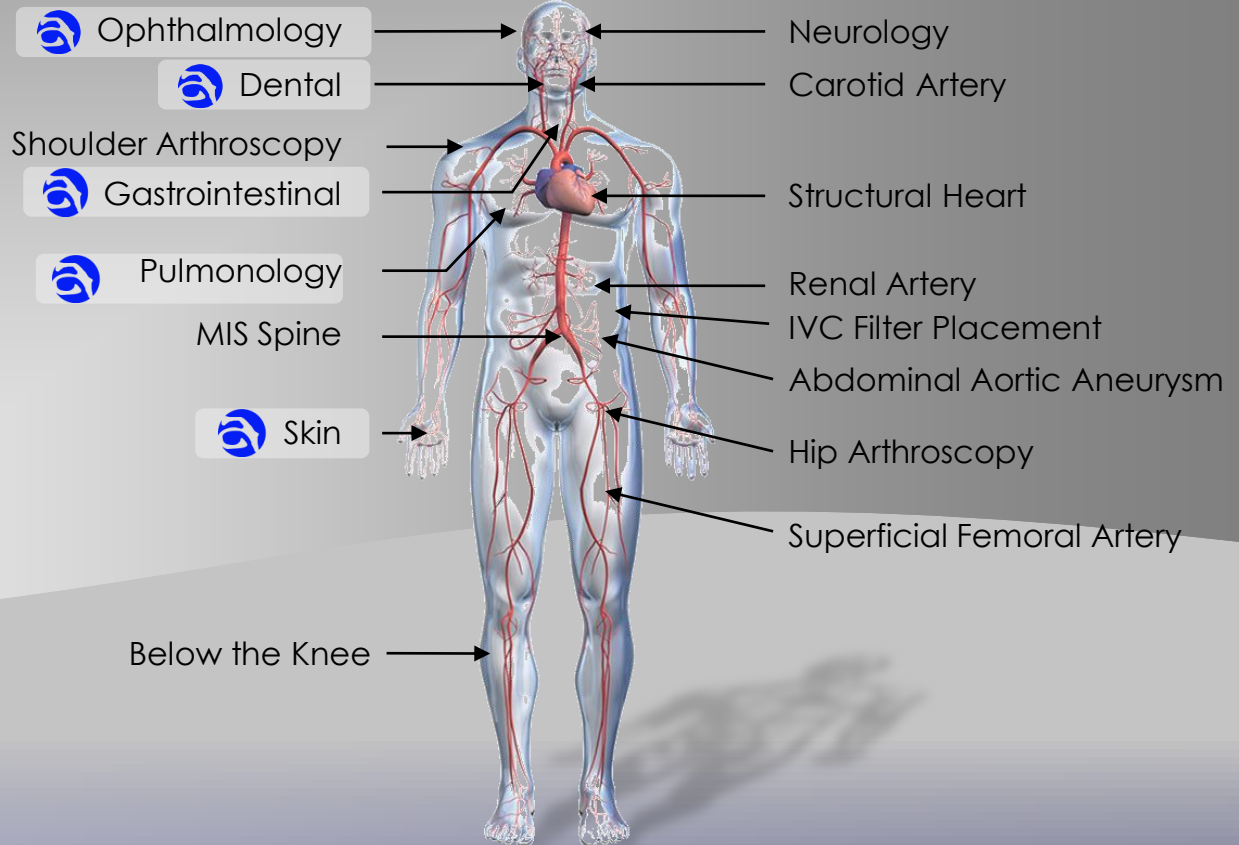
Molar with Composite Filling



GI Image Source – Nature Medicine



Lung Image Source U. Illinois Urbana



Ophthalmic OCT Today – Diagnostic

OCT is primarily used today to diagnose age related eye disease

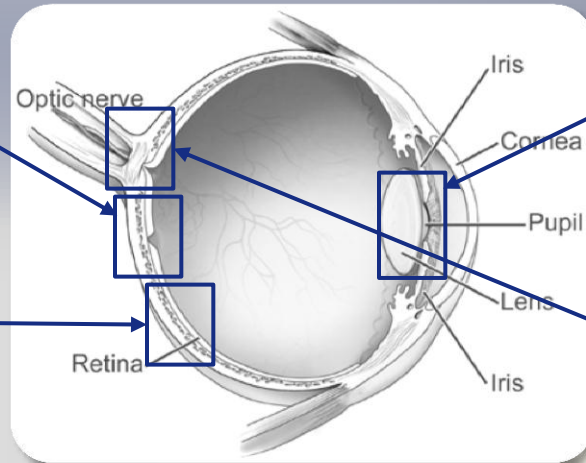
Age Related Macular Degeneration (AMD)

Causes 9% of blindness WW



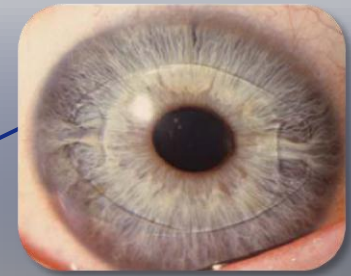
Diabetic Retinopathy

Causes 5% of blindness WW



Cataracts

Causes 47% of blindness WW



Glaucoma

Causes 12% of blindness WW

Ophthalmic OCT – Future Directions

OCT will be used to guide sight-restoring laser surgery

- **18 Million cataract surgeries performed in 2010**
- **Current method for Cataract Surgery**
 - Manual scalpel incisions
 - Outcome is highly dependent on the surgeon's skill
 - Not precise enough for new IOL technology
- **Laser Cataract Surgery with OCT guidance**
 - More precise self-healing incisions
 - Faster patient recovery
 - Lower risk of adverse events
 - Consistently better surgical outcomes
- **OCT Expected to penetrate the \$800M Cataract Surgery Equipment market rapidly over the next several years**

Source: Marketscope 2009 Cataract Surgical Market Report

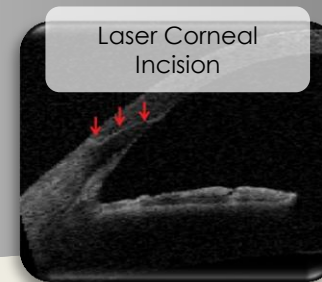
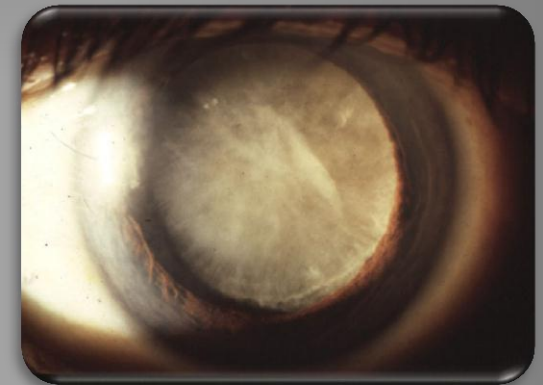
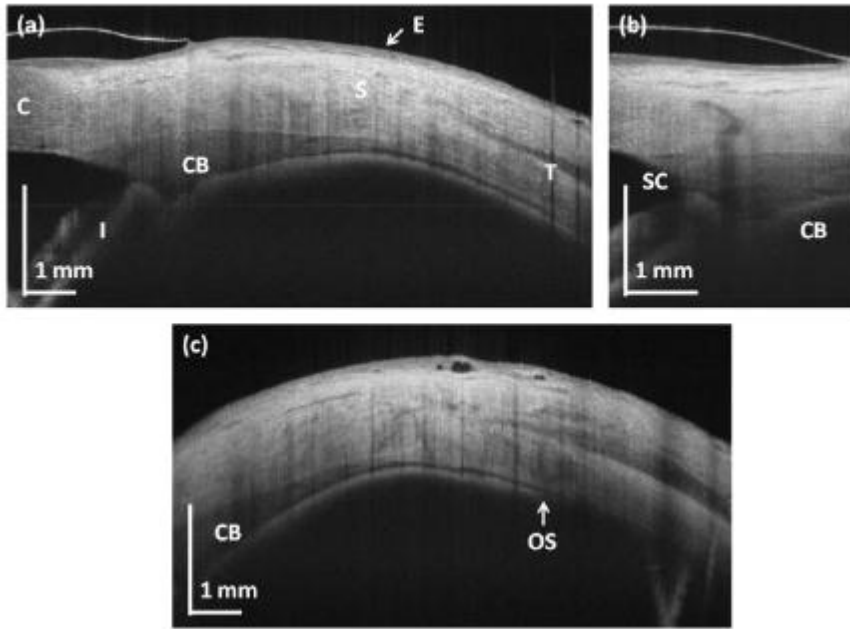


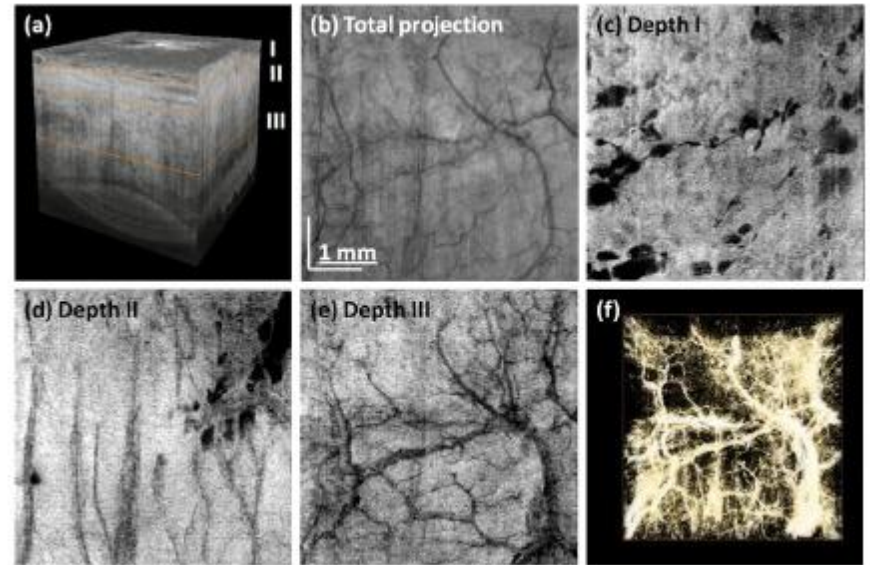
Image Source: Optimedica

Anterior Segment Imaging at 1050 nm



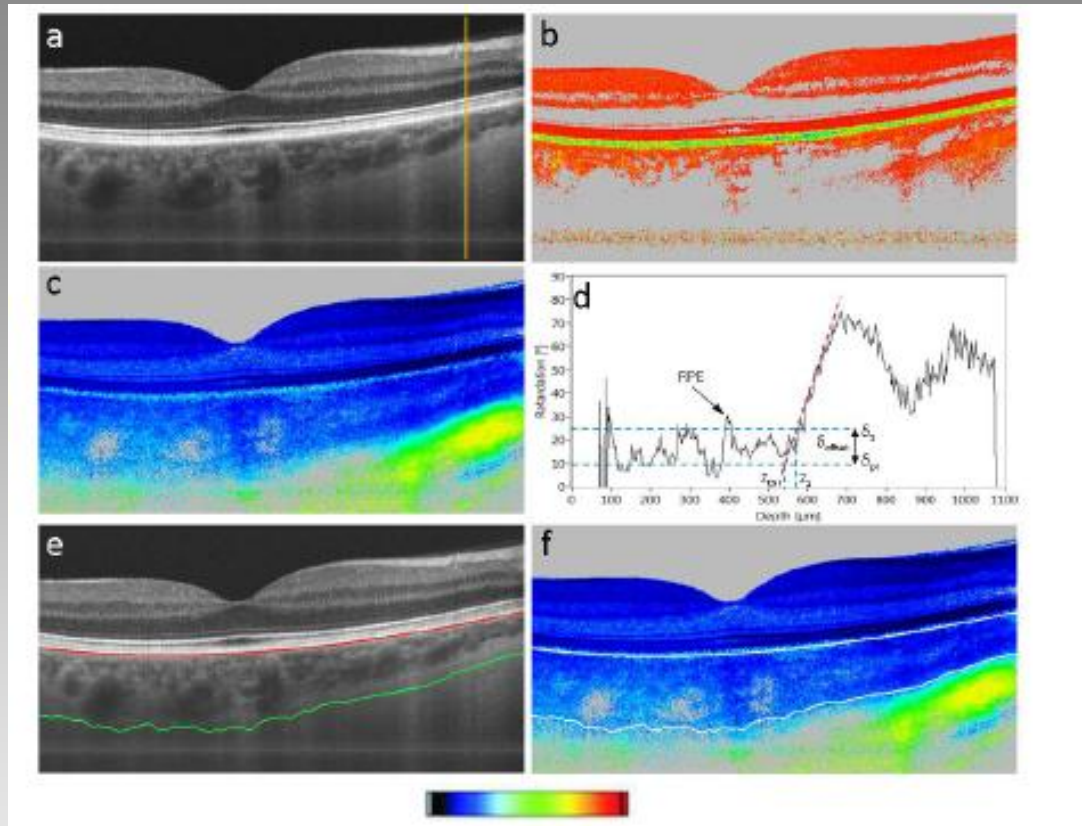
High resolution images of Corneo-Scleral Region showing Cornea, Iris, Schlemm's Canal, Ciliary Body and Ora Serrata

3D Reconstruction of Limbus, En Face projections of Scleral Vasculature



I. Grulkowski et al PHOTONICS LETTERS OF POLAND, VOL. 3 (4), 132-134 (2011)

Retinal Measurements with 1060nm Axsun Swept Laser Engine

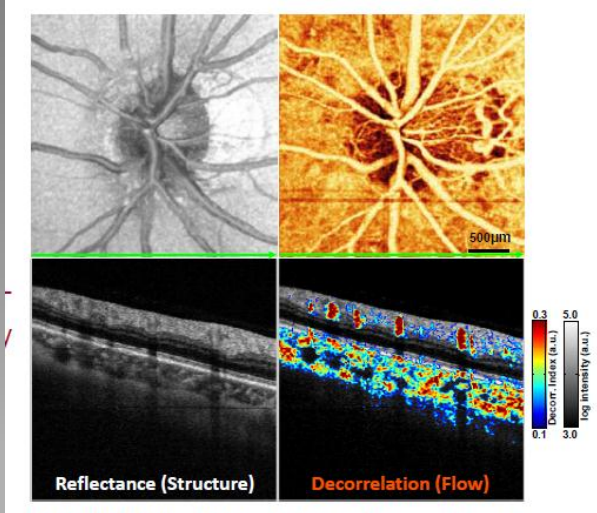


Automated measurement
of choroidal thickness in
the Human Eye with
PSOCT- Medical
University of Vienna

Torzicky et al 26 March 2012 / Vol. 20, No. 7 / OPTICS EXPRESS 7565

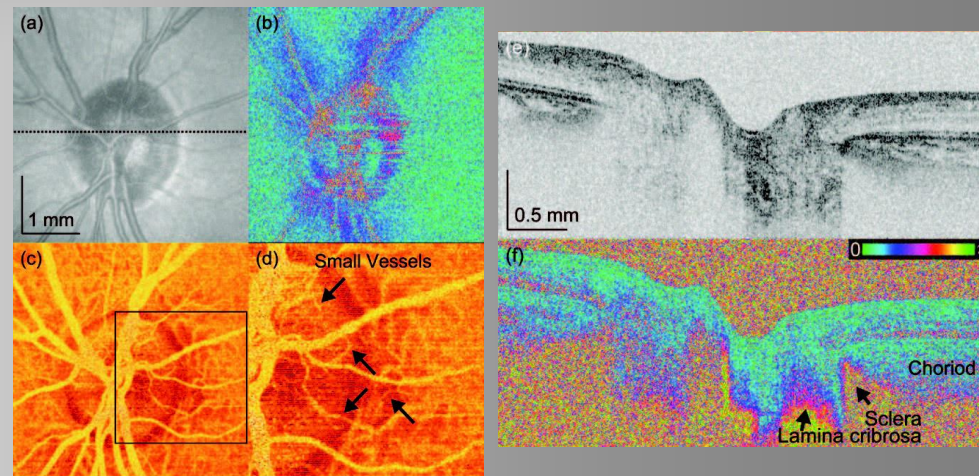
Blood Flow Measurement with SSOCT

- ONH blood flow with OCT Eye Angiography(1)
 - Uses an amplitude decorrelation method as an alternative to Doppler OCT



Huang SSOCT Angiography in the Eye – ARVO 2012

- Doppler and PSOCT measurement of ONH flow(2)



Yasuno et al – Doppler and PSOCT Measurement of ONH Blood flow

1. ARVO Presentation May 2012
2. OPTICS LETTERS / Vol. 37, No. 11 / June 1, 2012

Speed of SSOCT Enables Dynamic Measurement

- OCT Doppler Imaging of Vibrating porcine Vocal Chords – UC Irvine (1)

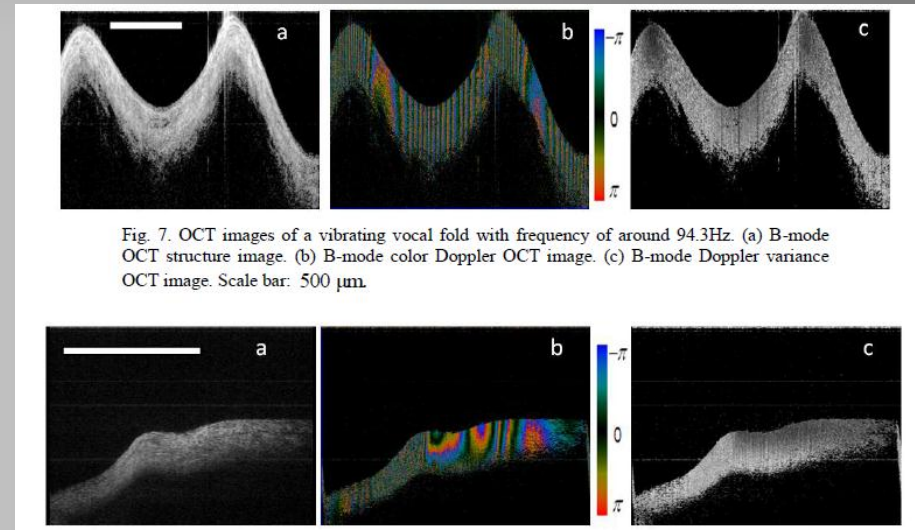
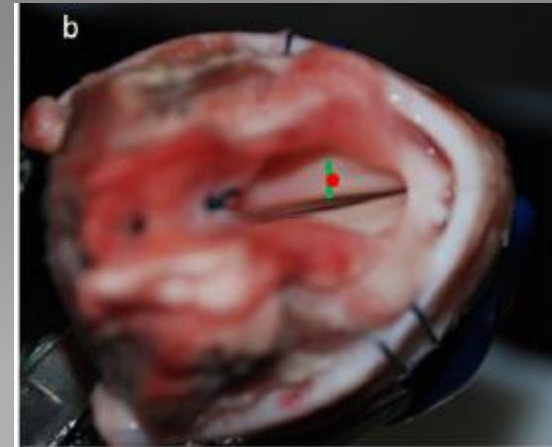
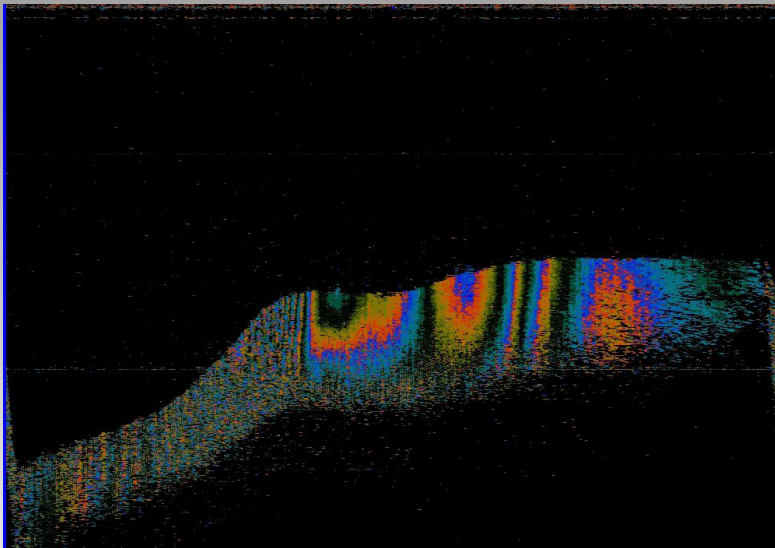
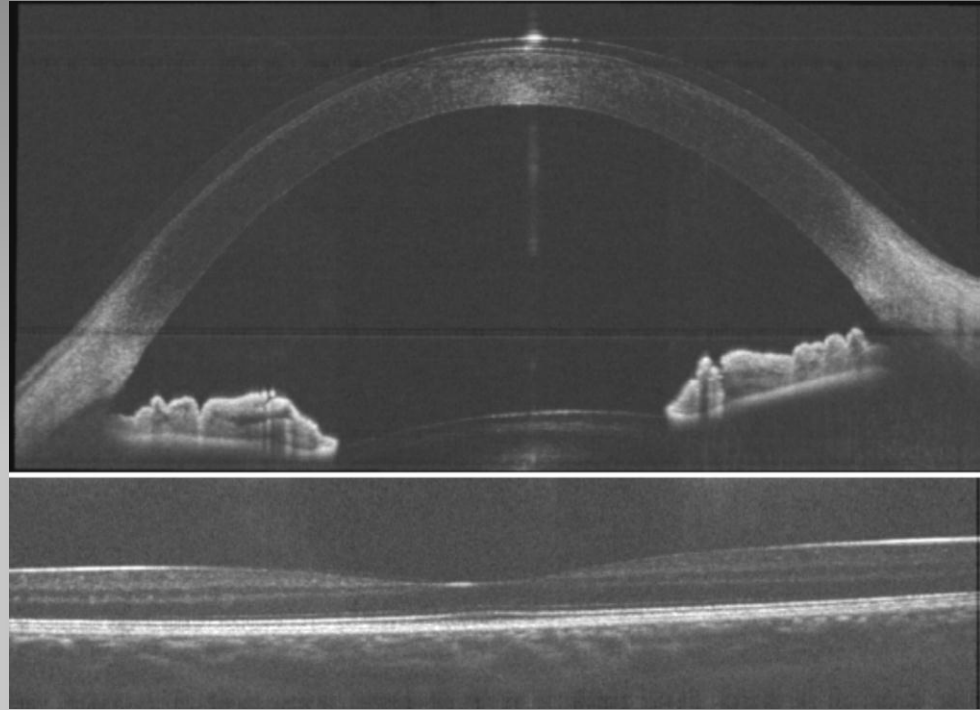


Fig. 7. OCT images of a vibrating vocal fold with frequency of around 94.3Hz. (a) B-mode OCT structure image. (b) B-mode color Doppler OCT image. (c) B-mode Doppler variance OCT image. Scale bar: 500 μm .

- June 2011 / Vol. 19, No. 12 / OPTICS EXPRESS 2010

Novel imaging using properties of SSOCT

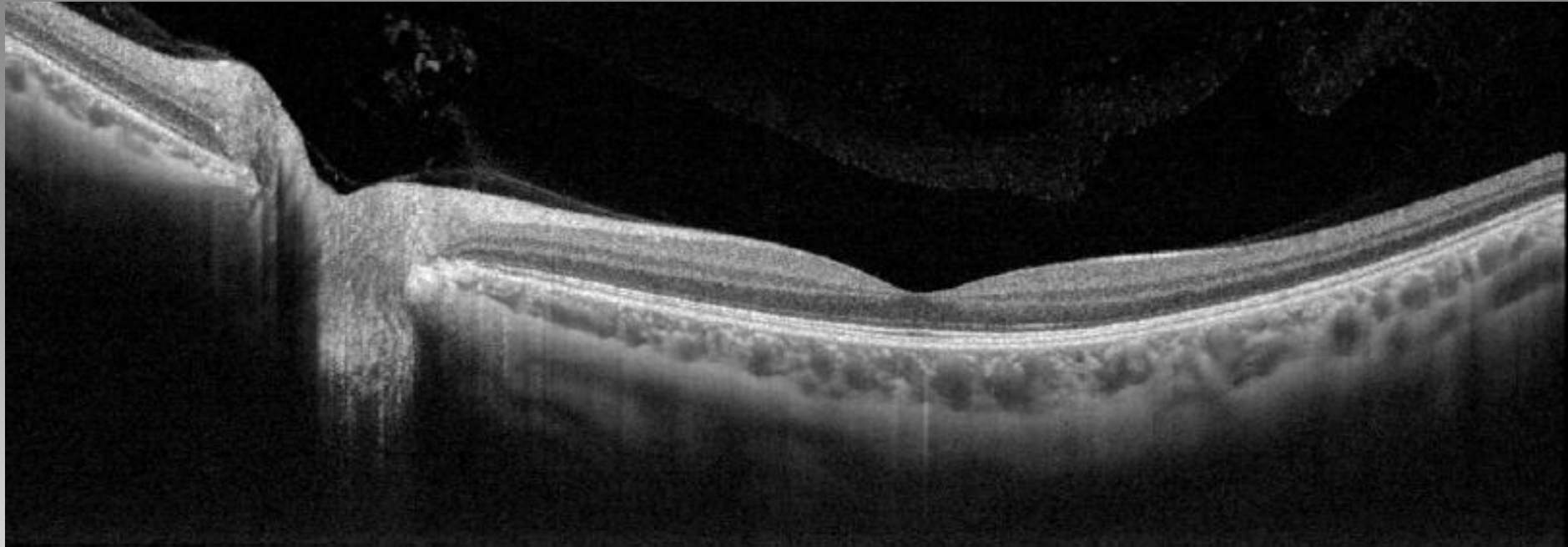
- Simultaneous imaging of Anterior and Posterior Eye Segments with SSOCT
 - Dhalla et al at Duke University



Both images obtained in 200mSec with Axsun 1060 Swept source

1. SPIE 2012 Conference Proceedings

World Class Retinal Imaging



*Image Courtesy of
Topcon
(Healthy Subject)*



Summary

- Axsun's Core Technology provides distinct advantages in size, speed, imaging depth range and reliability for our OCT Engine Products
- Swept Laser OCT provides many clinical benefits to patients and will grow quickly over the next several years
- Researchers and OEMs are building a large body of impressive clinical data showing advantages from the use of Swept Laser OCT
- Axsun's Swept Laser OCT Engine products are leading the way in the next generation of OCT imaging systems



Thank you for your Attention

Systems Engineering Stand B-192