



BANDWIDTH10

EPIC OTM ON VCSELS TECHNOLOGY AND APPLICATIONS

TUNABLE MEMS HCG-VCSEL SOLUTIONS



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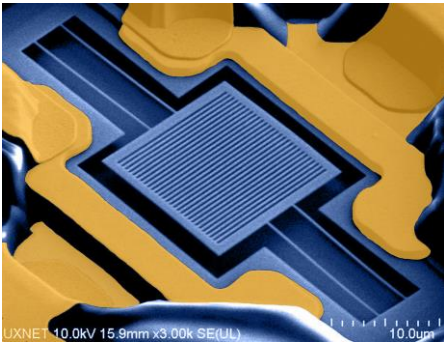
COMPANY PROFILE

- Founded in February 2011 from a team out of Berkeley and industry veterans
- Design center in Berkeley - CA
- Operations in Berkeley and San Jose (CA), and Zhongli (Taiwan)
- Manufacturing in North America and Asia
- New fabrication and packaging facility in Taiwan
- 67 employees worldwide
 - 30% of them with 10+ years in optoelectronics/semiconductors
 - Core team: 11 PhDs from top US, EU and Chinese universities
- VCSEL wafer capacity ~100 million lasers per year
- Sales team on the ground in Germany, China and USA

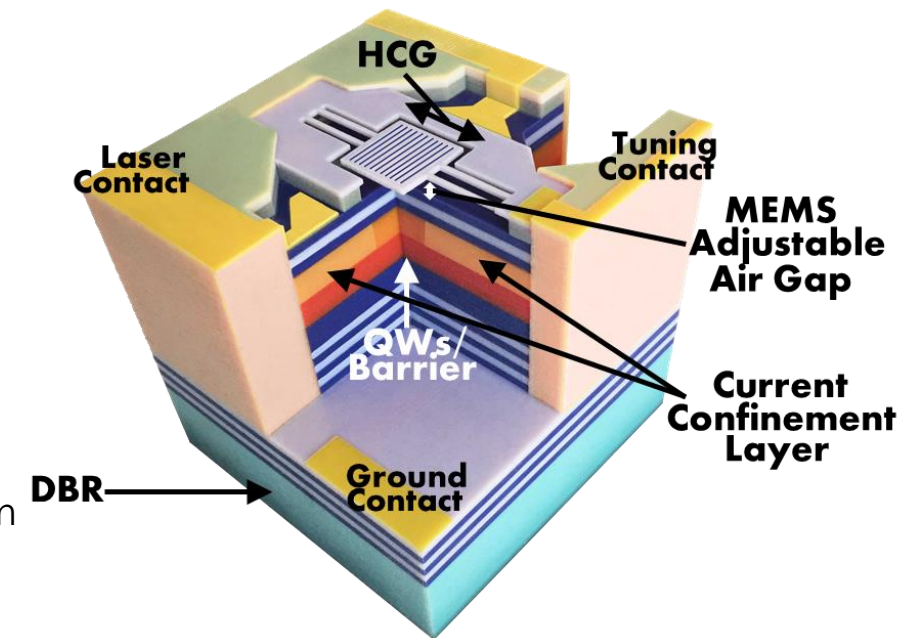


PATENTED HCG-VCSEL TECHNOLOGY

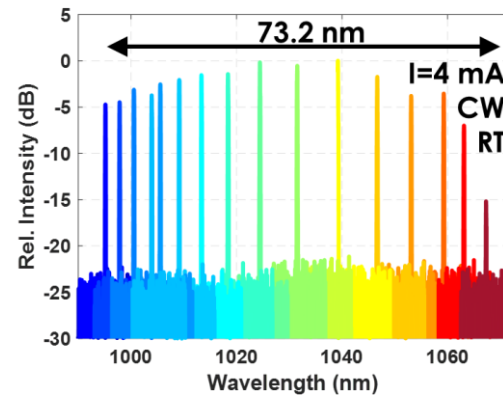
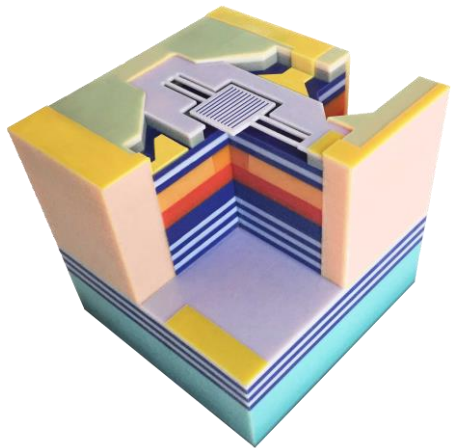
Bandwidth 10 is bringing revolutionary wavelength tunable Vertical Cavity Surface Emitting Laser (VCSEL) technology to the market, delivering cost-effective tunable solutions that are out of reach with conventional technologies



- HCG = High Contrast Grating
- Monolithic growth and integrated fabrication process
- Electrostatic MEMS tuning controlled by voltage
- Fast and continuous wavelength tuning (sweep)
- GaAs and InP-based lasers available
- Flexible platform for all wavelengths from 720nm to 1700nm

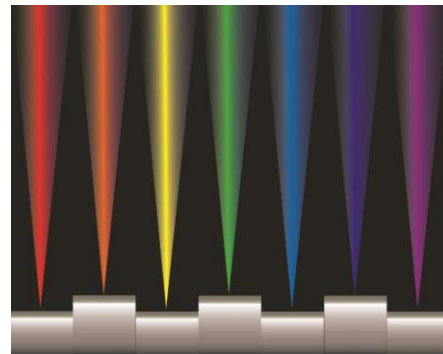


BW10 HCG SWEPT SOURCE VCSEL



Fast Tunable Swept Source

- 500 kHz sweep rate (bidirectional)
- 50 nm tuning range at 1050 nm
- 10 nm tuning range at 1550 nm
- 4 nm tuning range at 1654 nm



Multiple wavelengths 720nm to 1700nm

- 1654 nm product available
- 1550 nm product available
- 1060 nm product available
- 13xx nm forthcoming
- Fine selection of center wavelength
- More wavelengths possible



VCSEL chip



TO-can



TOSA



Pigtailed TOSA

Tunable
TransceiversDrive and Control
electronics



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TYPICAL APPLICATIONS FOR SWEPT TUNABLE VCSEL





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APPLICATIONS BY WAVELENGTH

WAVELENGTH (nm)

900	→	990 – 1080	<ul style="list-style-type: none"> OCT - Optical Coherence Tomography <ul style="list-style-type: none"> Medical (Ophthalmology, ocular diagnosis) Industrial (real time process control, quality check, additive manufacturing) Consumer Electronics Augmented Reality /AR Biosensors Glucose Monitoring (CGM) Brain computing interface
1000			
1100	→		
1200	→	1310	<ul style="list-style-type: none"> OCT - Optical Coherence Tomography (Ophthalmology Anterior eye segment) Vascular diagnosis Skin cancer diagnosis
1300	→	1397	<ul style="list-style-type: none"> Atomic Clock Redundant wavelengths for short range LiDAR and range finders
1400	→	1410	
1500	→	1500 – 1590	<ul style="list-style-type: none"> FBG (Fiber Bragg Grating) Sensing, distributed fiber sensing (Strain, temperature, vibration) <ul style="list-style-type: none"> Infrastructure Wind turbine blades Railways Mining, fracking Industrial production lines Environmental Gas Sensing (Hospitals, communities, ...) FMCW LiDAR and short distance range finders (robotics, drones, ...) Blood VO2 (oxygen saturation) Glucose monitoring (CGM) Fiber optical communications
1600	→		
1700	→		
1800	→		
		1654	

1512 NH₃
 1442 C₂H₂
 1576 H₂S
 1579 CO₂


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MAINSTREAM APPLICATIONS

Features by wavelength			Applications																
Wavelength (BW10 standard product)	Tuning range	non amplified VCSEL source CW Pout at 20°C TEC Temperature	FBG Sensors	Gas Sensors	SS-OCT	Optical seed lasers	FMCW LIDAR / range finder	consumer electronics	AR/VR	Biosensors	Glucose monitoring	Brain computing interface	Vascular diagnosis	Skin cancer diagnosis	Blood VO2	Optical communications	atomic clock	OTDR (telecom)	
1060nm	50 nm	0.5 mW			•	•		•	•	•	•	•							
1310nm	10nm	1.0 mW											•	•					
1410nm	10nm	1.0 mW					•										•		
1550nm	10 nm	1.0 mW	•	•		•	•				•				•	•			
1654nm	4 nm	1.0 mW		•												•			•

BW10 VCSEL Common features

- Single mode VCSEL
- High modulation bandwidth 10G
- Mode-hop free
- Swept-tuning up to 500 kHz TO
- TOSA with integrated TEC and isolator
- Pigtailed TOSA with PM or SM fiber



VCSEL chip



TO-can



TOSA



Pigtailed TOSA

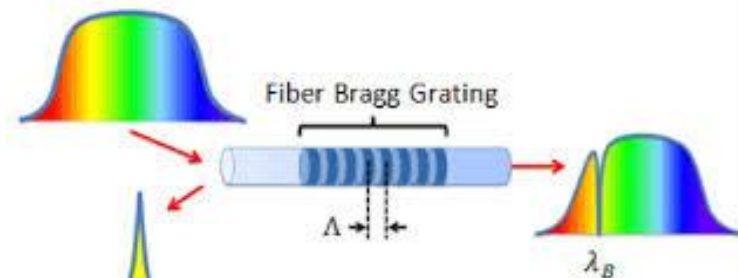

 Tunable
Transceivers

 Drive and Control
electronics



FIBER BRAGG SENSING

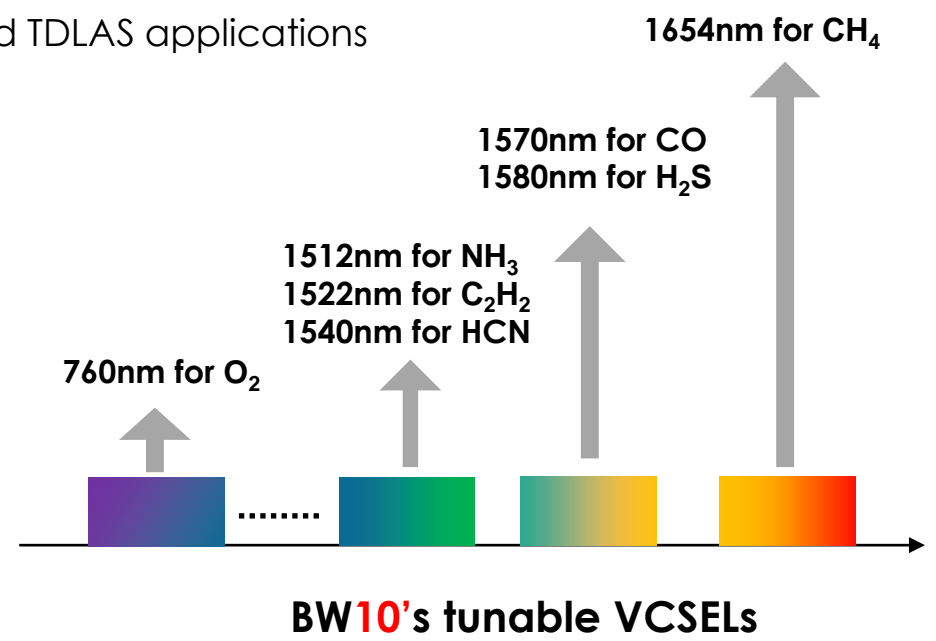
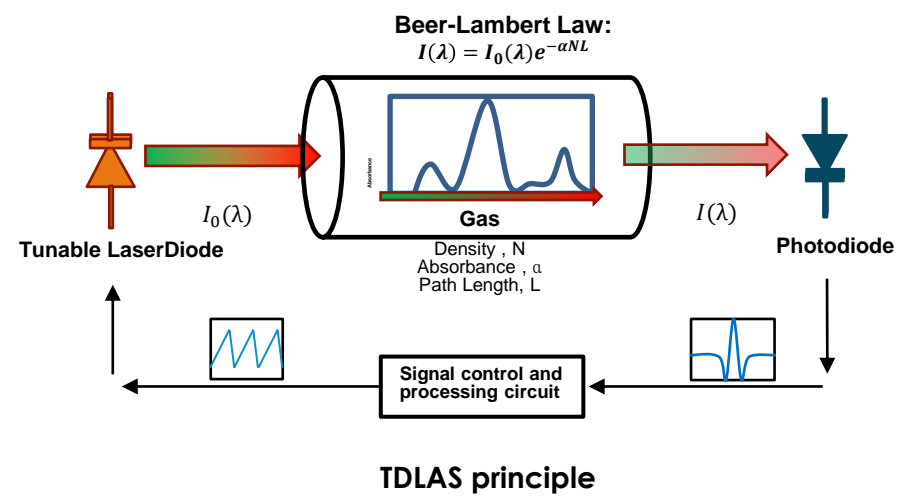
- Tunable VCSELs can be used for various fiber sensing applications i.e. using **Fiber Bragg Gratings (FBG)** for strain and temperature monitoring.
- Typical monitoring applications are:
 - Strain sensing of wind turbine blades
 - Gas pipeline expansion
 - Bridge expansion
 - Expansion of railroad tracks



Sensing principle: using FBGs temperature changes or strain expands the grating and changes the wavelength of the incoming light that gets reflected.

TDLAS

- Tunable VCSELs are cost effective light sources for **Tunable Diode Laser Absorption Spectroscopy (TDLAS)** gas sensors
 - BW10's HCG-VCSELs provide wide tuning range
 - Low power consumption enables next generation and handheld TDLAS applications
 - Fast tuning speed benefits real time monitoring



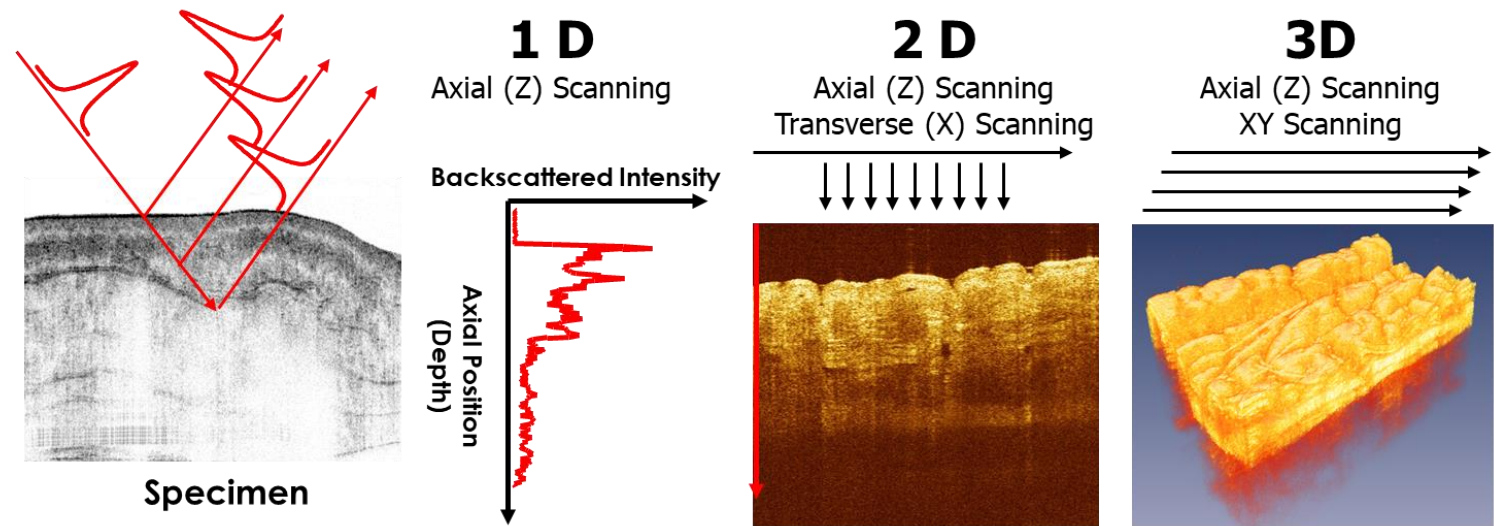
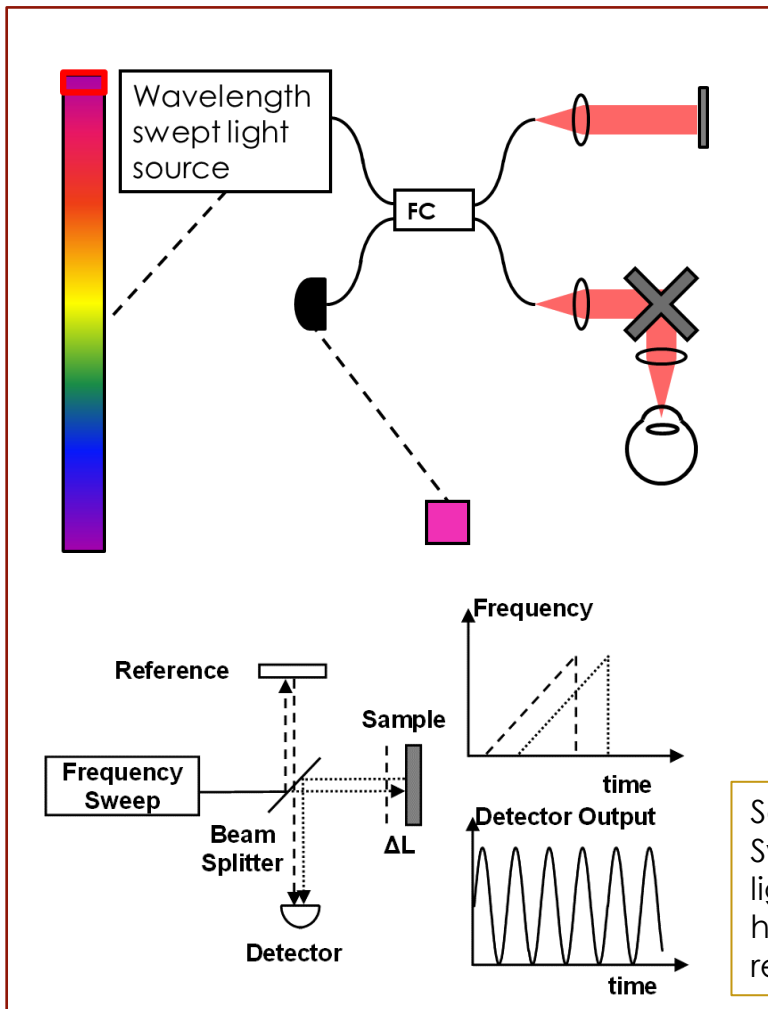


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SS-OCT

Swept-Source-Optical Coherence Tomography

Optical coherence tomography (OCT) supports micrometer-scale, cross-sectional imaging of the sample architectures in real time.



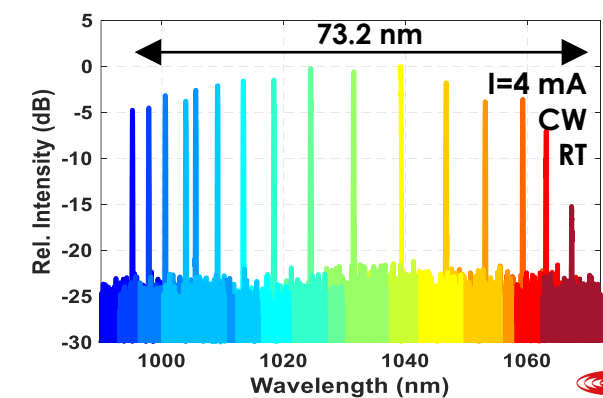
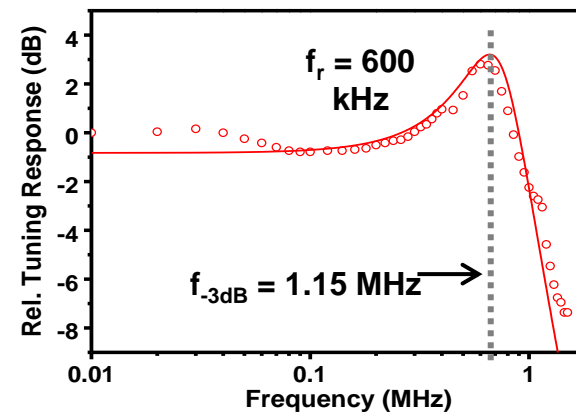
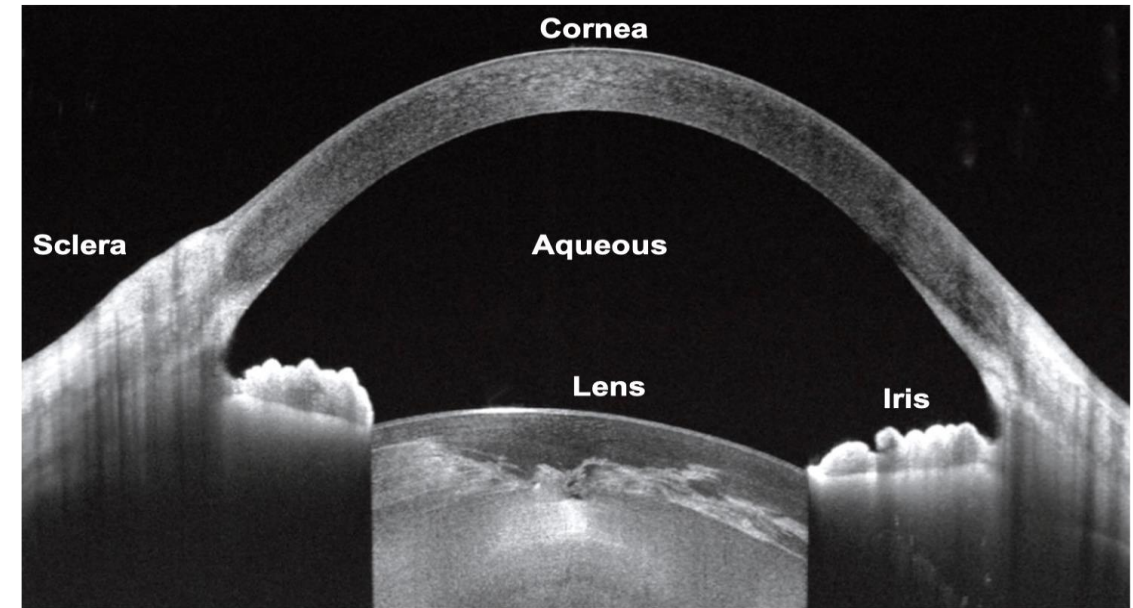
Schematic diagram of the swept source OCT, also termed as optical frequency domain imaging (OFDI). Swept-source OCT is based on optical frequency domain reflectometry, featuring a wavelength swept light source. SS-OCT exhibits several advantages over the conventional time domain OCT system such as high imaging speed, high detection sensitivity and signal to noise ratio. However, the imaging resolution is relatively lower due to the limited bandwidth of the light source.


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1060 NM HCG-VCSEL

1060 nm GaAs HCG-VCSEL swept source for next generation **optical coherence tomography (OCT)**

- Bandwidth10's BW10-1060-T-PxFA is a family of pigtailed TOSAs based on the innovative MEMS-High Contrast Grating (HCG) Single-Mode Tunable VCSEL.
- BW10-1060-T-PxFA, the Swept-tunable VCSEL pigtailed-TOSA at 1060nm with PM fiber, the ideal swept source for Optical Coherence Tomography (OCT), Medical Imaging, Optical Sensing, Biosensing.
- BW10-1060-T-PxFA is available with HI1060 or PM980 fiber pigtail and an FC/APC connector. It includes an integrated TEC for temperature stabilization, and an internal optical isolator. The standard product features a wavelength tuning range up to 50nm, and fast sweep tuning >200 kHz.




BANDWIDTH10
NEW

1060 NM SWEPT-SOURCE OCT-BOX

- BW10's first **Swept Source-OCT Box (40mW)**: first Live Demo at BiOS 2022
- based on Bandwidth10's BW10-1060-T-P9FA, the Swept-tunable VCSEL pigtailed-TOSA at 1060nm with PM fiber

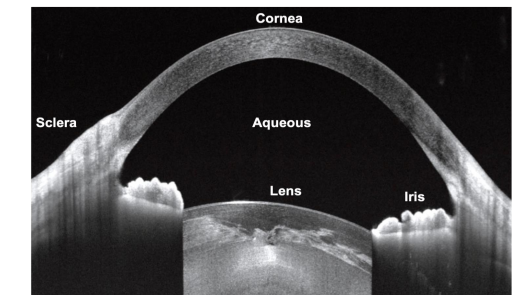
Main Features

- Tunable 1060 VCSEL
- Sine-wave 100/200 kHz
- 50nm AC sweeping tuning range
- PM or HI1060 pigtail
- 20mW ~ 40mW
- SOA
- Output port
- K-clock and A-trigger

For more information, visit <https://www.bandwidth10.com/product/1060nm-vcsel-products/> or contact Sales in your region



Example of application:
medical OCT



1060 nm GaAs VCSEL swept source for next generation **optical coherence tomography (OCT)**

Demonstrated performance (in cooperation with a partner company and a research institute):

Swept source: Bandwidth10 1060nm tunable VCSEL (Product model number: BW10-1060-T-PxFA),

Tuning range 60nm

Optical amplifier: SOA with 15dB gain

Scan speed: 200KHz A-Scan

Image depth: 12mm



BANDWIDTH10, LTD.

BW10 TEAM





BANDWIDTH10

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20 years in optoelectronics & photovoltaic devices



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THANK YOU

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