

VCSEL-driven ToF Applications and its Market Trend

Presenter: Andy Seo, Sr. PLM

October 18, 2019



Agenda

- Corporate Overview
- 3D Sensing Market Trend
- Understanding of Technologies for 3D Sensing Applications
- ToF Applications
- Q&A





Corporate Overview



Lumentum: How We Got Here



Complementary Chip Leadership Drives Sustainable Product Differentiation



Our Key Locations

North America

Milpitas, California USA - Corporate headquarters

San Jose, California USA

Ottawa, Ontario Canada

EMEA

San Donato, Italy

Škofljica, Slovenia

Zurich, Switzerland

Caswell, UK

Paignton, UK

APAC

Shenzhen, China Sagamihara, Japan Tokyo, Japan Pangyo, Korea

New Taipei City, Taiwan

Pathumthani, Thailand

Best-in-class manufacturing partners

Global presence – close to our customers R&D and operations excellence centers across the globe





3D Sensing Market Trend



Diode Laser Options for 3D Sensing

DFB edge emitters	Fabry-Perot edge emitters	VCSEL arrays
 Narrow bandwidth: <1 nm 	 Narrow bandwidth: >1 nm 	 Narrow bandwidth: <1 nm

- inanow pandwidun. < i nin
- Power range: 200 mW scalable to • 10s of watts
- Output beam: Elliptical ٠
- Wavelength locking with ٠ temperature

- inanow pandwidth. >1 hm
- Power range: 200mW scalable to ٠ 10s of watts
- Output beam: Elliptical ٠
- Higher wall plug efficiency ٠

- inanow pandwidun. < i nin
- Power range: 200 mW scalable to ٠ 10s of watts
- Output beam: Circular ٠
- Wavelength locking with ٠ temperature

3D Sensing: Past, Present, and Near-Future Applications



Lumentum is the largest supplier of laser illuminators in 3D sensing

Automotive 3D Sensing: 90M Cars Sold Annually



10

Strengths and Challenges of ToF for Automotive

ToF

- 1D Tx array w/ 1D scan, 1D/2D Rx array
- Larger collection aperture
- "Less" complex photonics

Comfort Zone

Strengths

Challenges





Understanding of Technologies for 3D Sensing Applications



3D Sensing Architectures for Mobile Applications



* Credit: Nalan Karunanayake, University of Kentucky (Laser Focus World)

LUMENTUM

© 2019 Lumentum Operations LLC 13

Comparison of Structured Light (SL) and Time-of-Flight (ToF)

Method	SL	ТоҒ
Principle	3D point cloud pattern is projected on an object. Each point depth is calculated by analyzing the deformation of the pattern.	IR illuminator sends out IR signal and IR sensor measures time or phase difference to calculate depth.
Hardware	Dot projector + Flood illumination	IR illuminator
Pros	High depth accuracy Low power consumption	No baseline Compact size Low cost
Cons	Baseline required Heavy processing Big module size High cost	High power consumption Weak on ambient noise Eye-safety concern
Applications	Biometric scanning	AR, VR
Working distance	Poor linearity	Depending on light source power



Comparison of Indirect TOF vs Direct TOF

	Indirect ToF	Direct ToF
Mechanism	phase delay	Received pulse Time delay
Measurement	Phase shift	A round trip time of light
Range	5 meters (indoor), 3 meters (outdoor)	Tens-to-hundreds of meters
Resolution	VGA	< HQVGA
Detector type	IR CMOS image sensor	APD / SiPM / SPAD
Outdoor noise immunity	Low	High
Packaging complexity	Low	High
Manufacturability	Established	Emerging

* APD: Avalanche Photo-Diode, SiPM: Silicon Photo-Multiplier, SPAD: Single-Photon Avalanche Diode

LUMENTUM

VCSEL Coverage and Trend

- Market is moving towards longer distance coverage (5~10 m) with ToF.
- Well covered 1A ~ 6A for mobile and consumer markets
- Also extended VCSEL catalog of high power for new markets



LUMENTUM

Triple Junction

D-TOF LIDAR

Flash LiDAR

•

Requirement of Eye Safety Function

Diffuser is required for eye safety (IEC 60825-1)



How to ensure diffuser is intact on package

Eye safety function	Detection mechanism
Optical detection (Photodiode)	To measure PD current which is created by reflected light by diffuser and to control laser power automatically (APC function)
Electrical detection (ITO or metal coating)	To check electrical connection between substrate pads and ITO layer on diffuser before driving laser
Hybrid detection (ITO + Photodiode)	To check diffuser existence before laser driving and to measure PD current after laser driving

ToF Focus Area

- Extend Range/Improve SNR
 - Narrow Pulse
 - Higher Peak Power
 - Narrower Rx Optical Filter







ToF Applications



Applications for 3D Sensing Face ID



Animojis



Credit: Apple

Portrait Mode Selfies



Credit: Snapchat Ultra realistic Snapchat Lenses



Credit: Apple

Background substitution video

Front Facing 3D Sensing – Native Support with Android Q!!!

- 3D facial recognition function is a standard feature with Google Android Q(10).
- This feature will allow users to unlock the phone, to authorize payments and to sign into apps.





Credit: arstechnica

World Facing 3D Sensing – Killer Apps Coming



22

Various Kinds of Applications with 3D Sensing Functions



Credit: All3DP Room scanning and real time distance measurement



Credit: Pngfly People identification and behavior analysis



Credit: Magic Leap Interactive application with augmented reality



3D reconstruction and realtime object scanning









Credit: iSense



Credit: Asus





Thank you



This presentation was presented at EPIC Meeting on VCSELs Technology and Applications 2019

HOSTED BY

SONY **GOLD SPONSOR** SILVER SPONSOR PIXAPP Photonic Packaging **Pilot Line BRONZE SPONSOR** PHOTONICS²¹ EU initiatives funded by www.photonics21.org