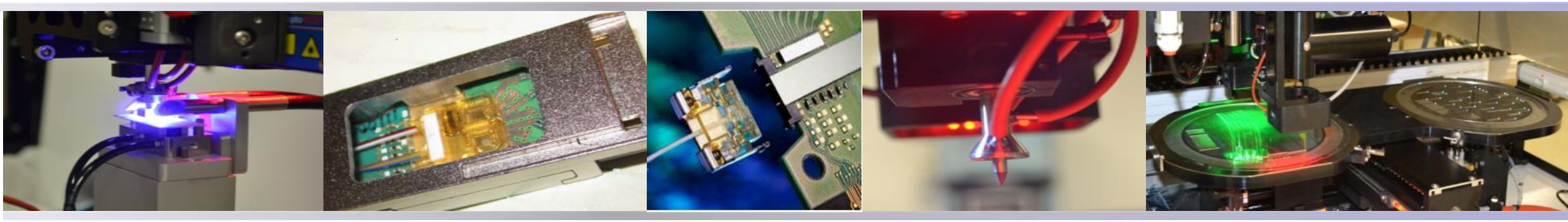
The Challenges in High Volume Manufacturing of Photonic Devices



Dr. Yi Qian
Vice President, Product Management
MRSI Systems

Your Standard in Precision Automation®

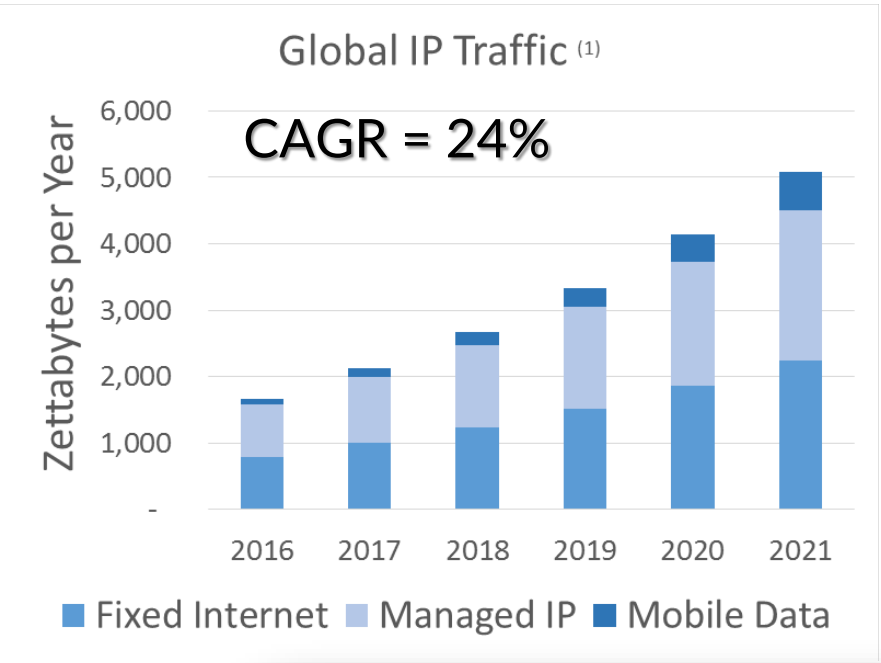
About the Talk

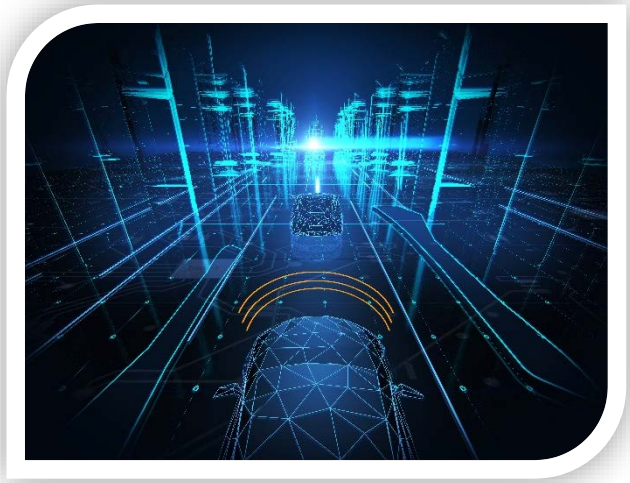
The Trends

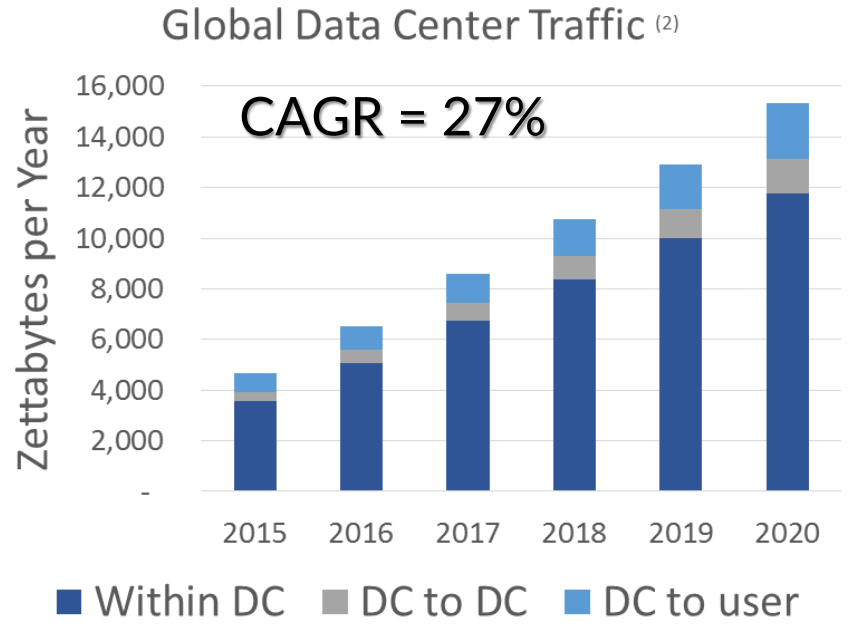
The Challenges

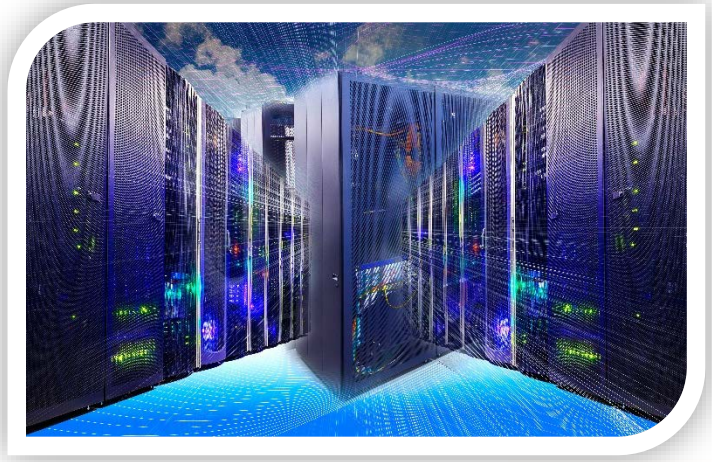
The Opportunities

High Growth Internet and Data Traffic Drive Bandwidth Demand









(1) Cisco Visual Networking Index: Forecast and Methodology, 2016-2021
(2) Cisco Global Cloud Index: Forecast and Methodology, 2015-2020

www.mrsisystems.com

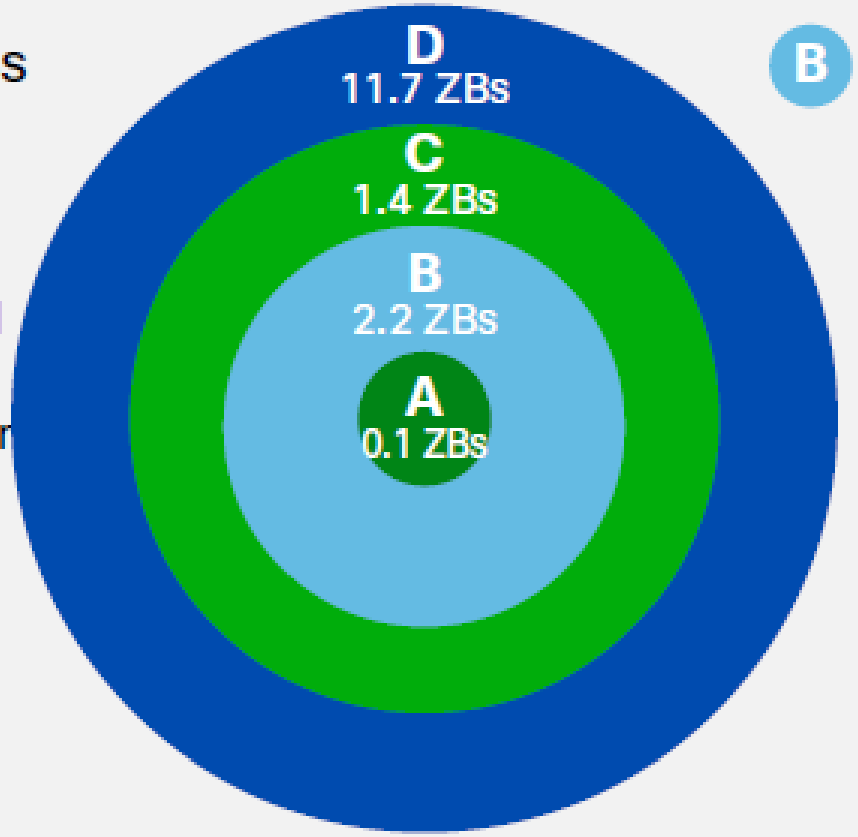
Global Data Center Traffic >5X of Non-Data Center Traffic

Visual Networking Index (VNI)

A + B = 2.3 ZBs

A Non-Data Center Traffic
NOT included in GCI

B Data Center-to-User Traffic
This is the overlap between VNI and GCI



Global Cloud Index (GCI)

B + C + D = 15.3 ZBs

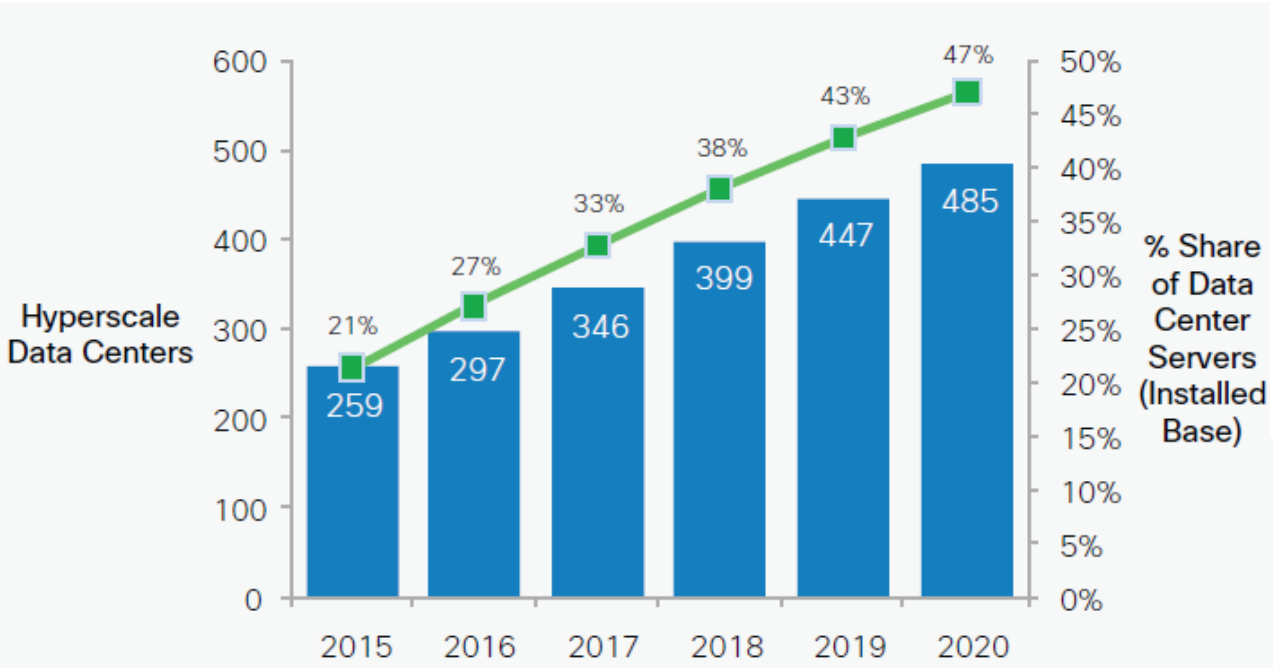
B Data Center-to-User Traffic (14%)
This is the overlap between VNI and GCI

C Data Center-to-Data Center Traffic (9%)
Traffic that flows from data center to data center

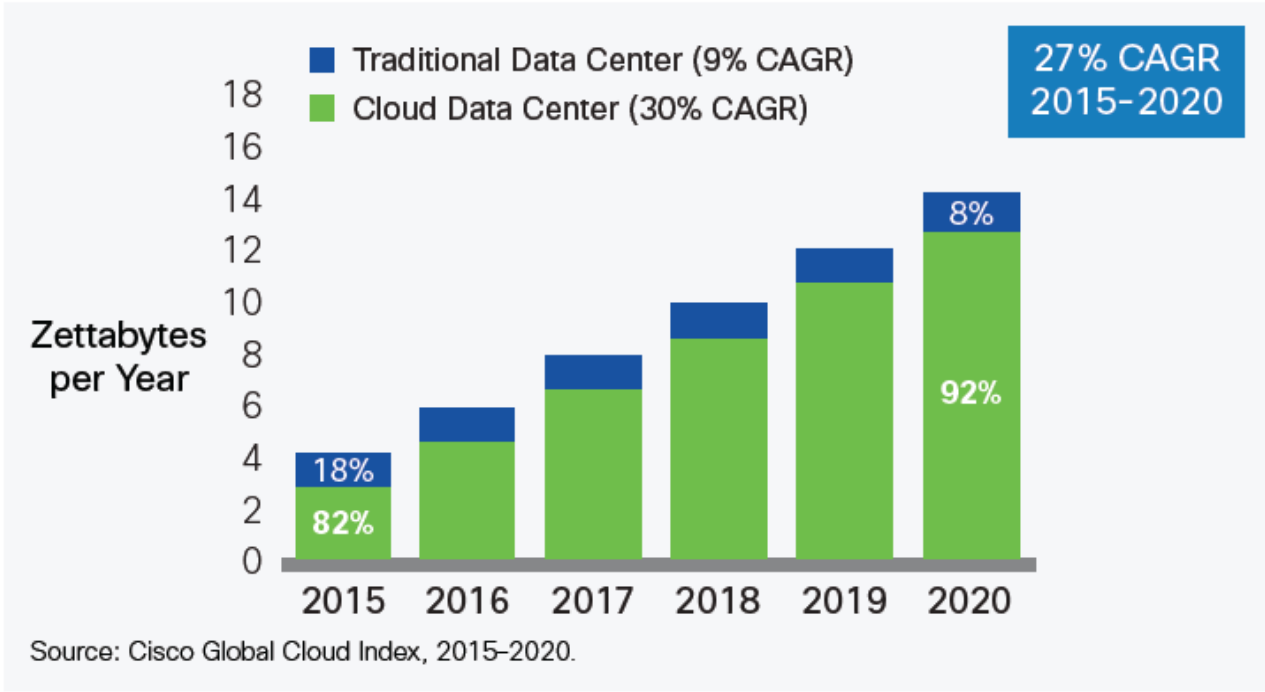
D Within Data Center (77%)
Traffic that remains within the data center

Source: Cisco Global Cloud Index, 2015–2020.

Hyperscale / Cloud Data Centers Drive Growth



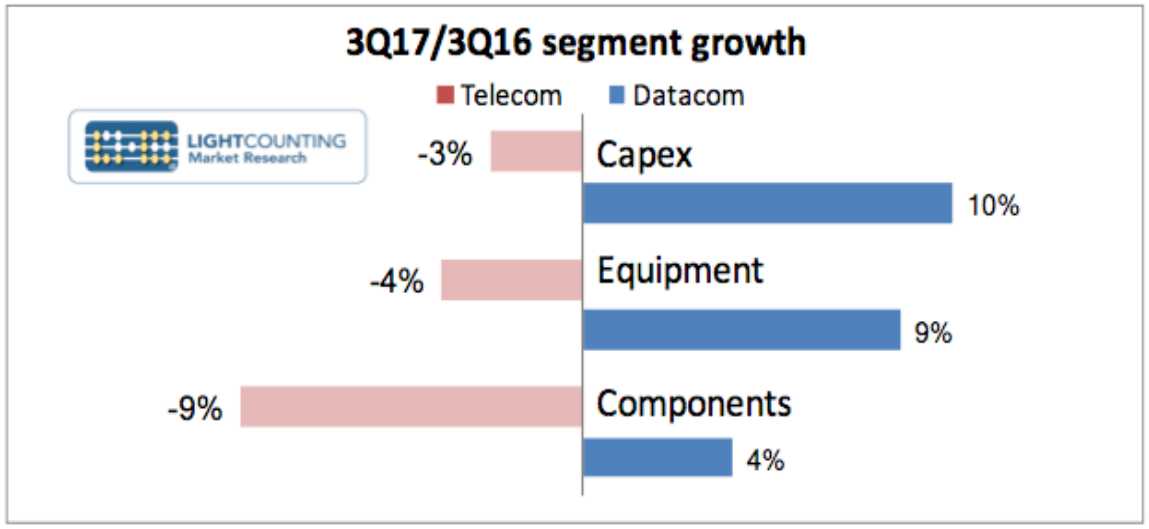
Source: Cisco Global Cloud Index, 2015–2020; Synergy Research.



Source: Cisco Global Cloud Index, 2015–2020.

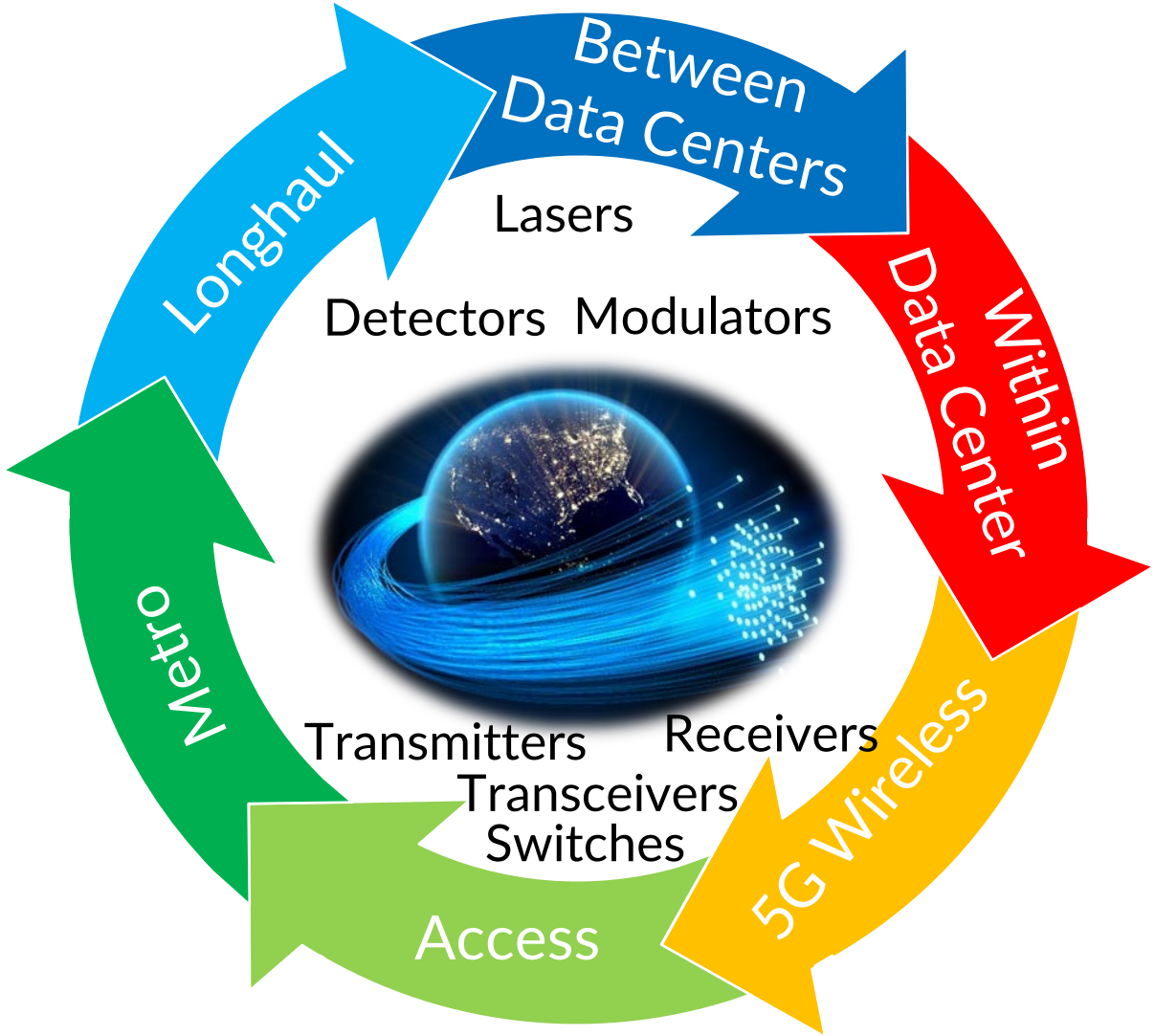
“Deep Pocket” Cloud Providers Sustain Spending on Data Centers

Group average	2Q17 result	Trend
Revenues	Up 16%	Growth accelerating again
Spending	Up 20%	Double 1Q17 growth rate
Operating margin	20%	Flat vs. year ago quarter
Net income	26%	Up sharply, well above long term average of 20%
Cash & equiv.	$491 billion	Up 23% y-o-y, record high

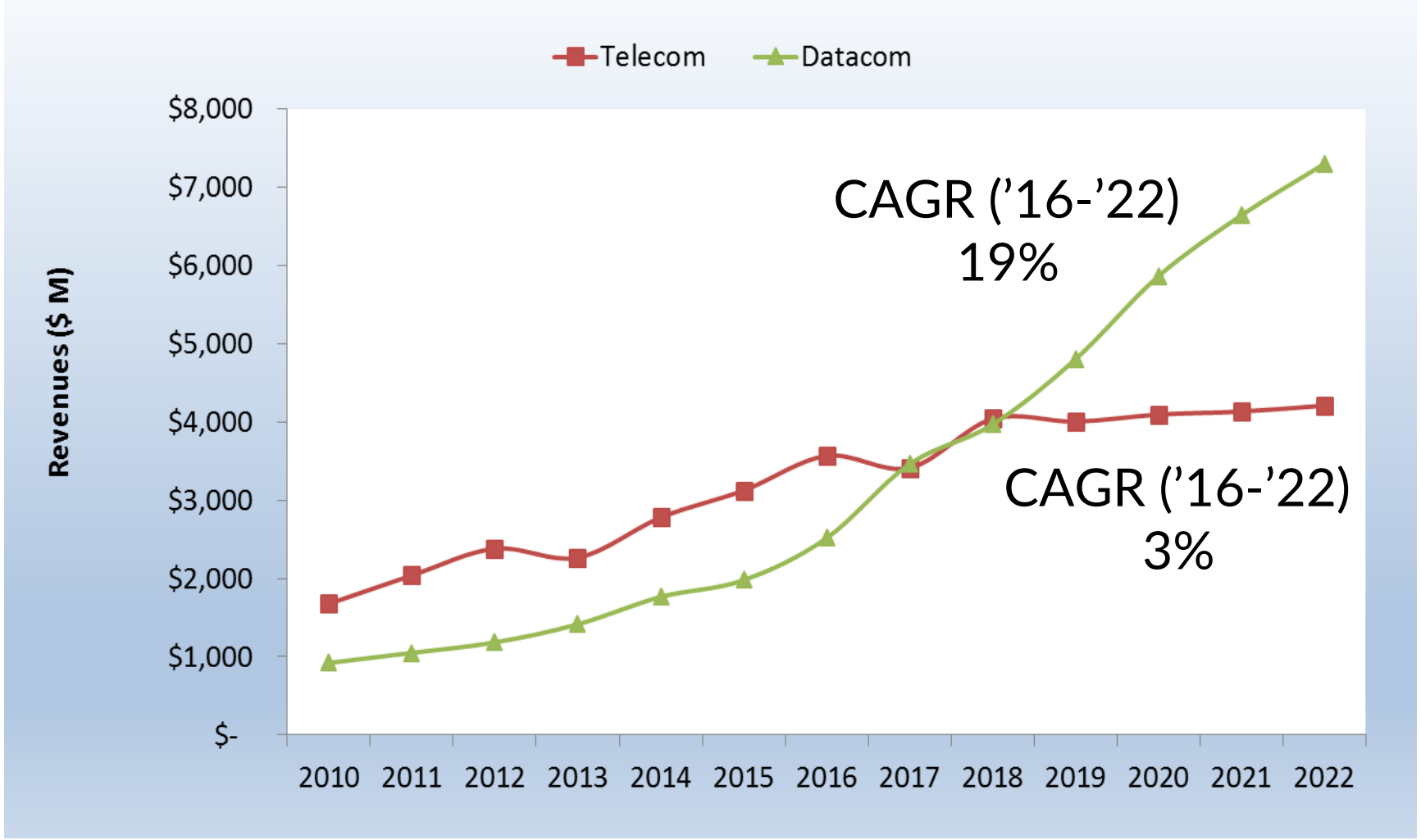


* Includes Alibaba, Alphabet, Amazon, Apple, Baidu, eBay, Facebook, Microsoft, Oracle, PayPal, Sohu, Tencent, Twitter,

Photonics is Essential for Bandwidth Growth



Datacom / Data Center Drives Future Optical Transceiver Growth



LightCounting April-2017

About the Talk

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The Opportunities

New Cloud-based Business Model Demands Rapid Innovations and Ramps

New Cloud-based DC Model

- Controlled operating climate
- Upgrade every 3-5 years
- Low photonics installation costs

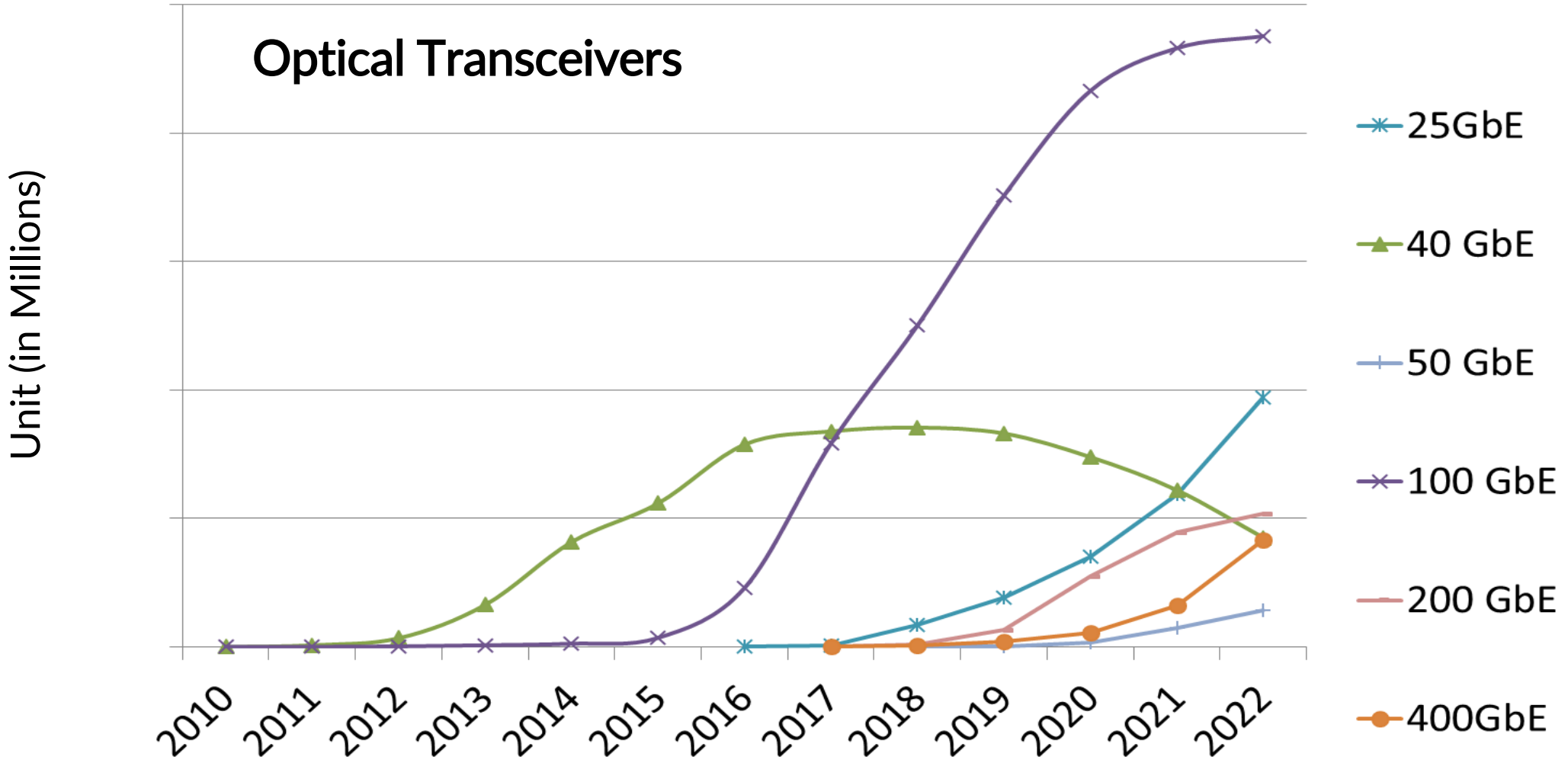
- High volume
- Poor forecast visibility
- Fast project ramp up and tailing down
- Fast pace of innovation
- Extremely sensitive to photonics cost (<$1/Gbps)

Traditional Telecom-Centric Model

- Stringent operating environments
- Device life time for 20+ years
- High photonics installation costs

- Medium-low level of volume
- Good forecast visibility
- Slow project ramp and tailing down
- Slow pace of innovation
- Reduced sensitivity to photonics cost (field service is #1 cost now)

Photonics Manufacturing Needs to Handle High Volume and High Mix



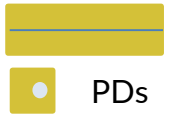
LightCounting April-2017

Large Varieties of Parts through Manufacturing Assembly Lines

Chip & Die


FB/DFB/EML lasers

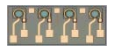

Pump lasers


PDs

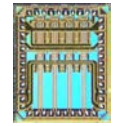
Capacitance
Thermistor

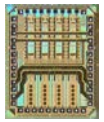
AWG (1/4 scale)

Lens Isolator (1/2 scale)


PD array

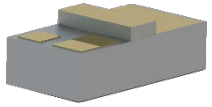

VCSEL arrays

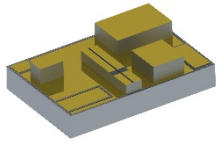

LD Driver

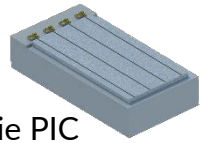

TIA

LiNbO3 modulator chip (1/10th to actual)

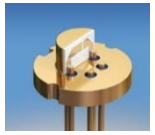
Chip on Carrier (CoC)

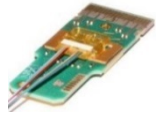

Single die CoC


Multi-die CoC

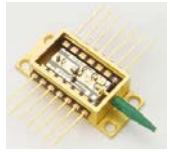

Multi-die PIC (SiPh, Glass, etc.)


Laser CoC, lens on Baseplate


Laser or PD on TO

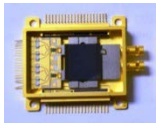

VCSELs-Drivers/PDs-TIAs /Lens on AOC PCB

Open Package Assembly

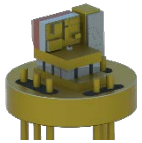

Laser


TOSA


ROSA

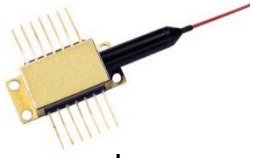

Receiver


Modulator

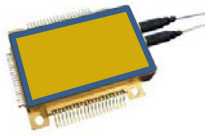

Complex TO


AOC

Final Module

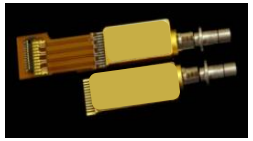

Laser


Transceiver


Receiver


Modulator

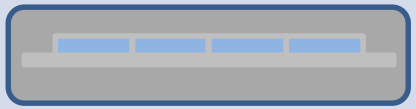

BOSA


TOSA, ROSA

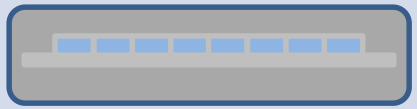

AOC

Advanced Products Require Increasingly High Precision Assembly

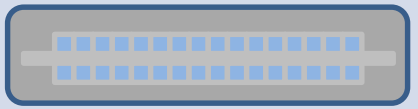
Higher Density
Smaller Size



CFP
4x100Gbps



CFP2
8x100Gbps



CFP4/QSFP28
32x100Gbps

Higher Speed
Higher Precision

10G (1x10G)

40G (4x10G)

100G (4x25G)

100G (50G x2)

200G (8x25G)

200G (4x50G)

400G (8x25Gx2)

400G (4x50Gx2)

Need to assemble more parts on smaller carriers/boards and into smaller packages.
Need to manage smaller gaps between parts for low impendence and thus higher speed.
Need to align more precisely between parts on light path for higher power and better yield.

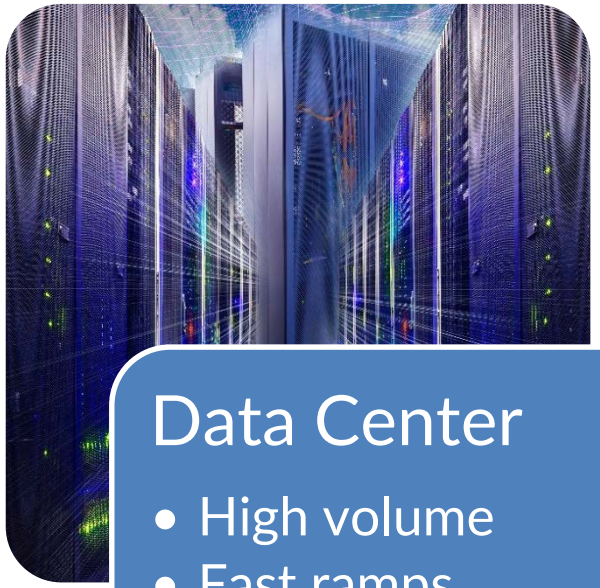
About the Talk

The Trends

The Challenges

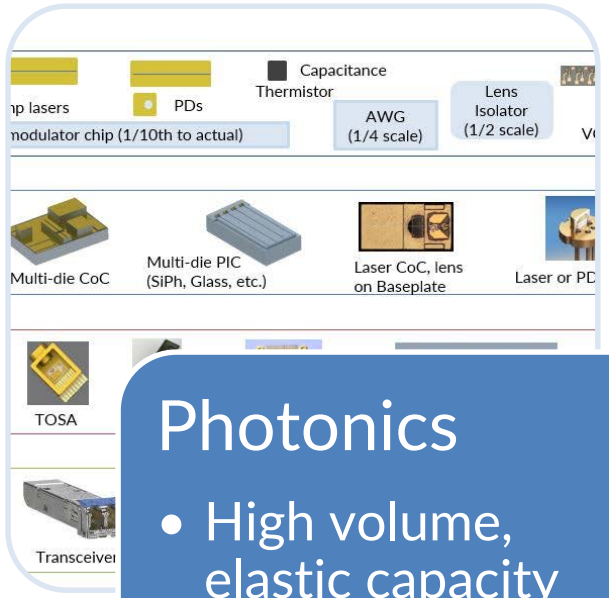
The Opportunities

Opportunities Exist with Challenges



Data Center

- High volume
- Fast ramps
- Poor forecast
- Rapid innovation
- Cost sensitive



Photonics

- High volume, elastic capacity
- Advanced products
- Accelerated NPD
- Risk free NPI
- Cost efficient SCM

Automation

- High speed
- High flexibility
- High precision
- High reliability
- ROI on Capex and Opex

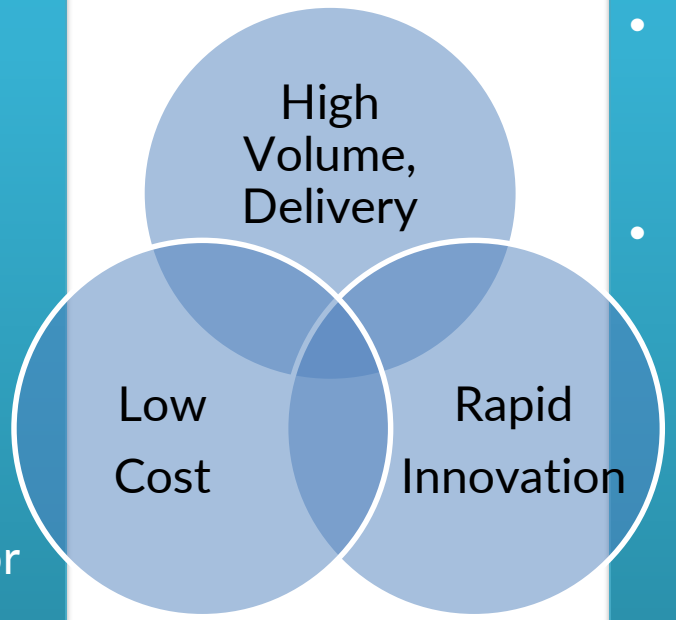
Automation Improves Photonics Supplier's Response to Data Center Demand

Data Center Provider's cloud-based business model

- Project based, Just-In-Time Procurement
- Qualified suppliers compete for the best delivery and lowest cost

Challenges for photonic device suppliers

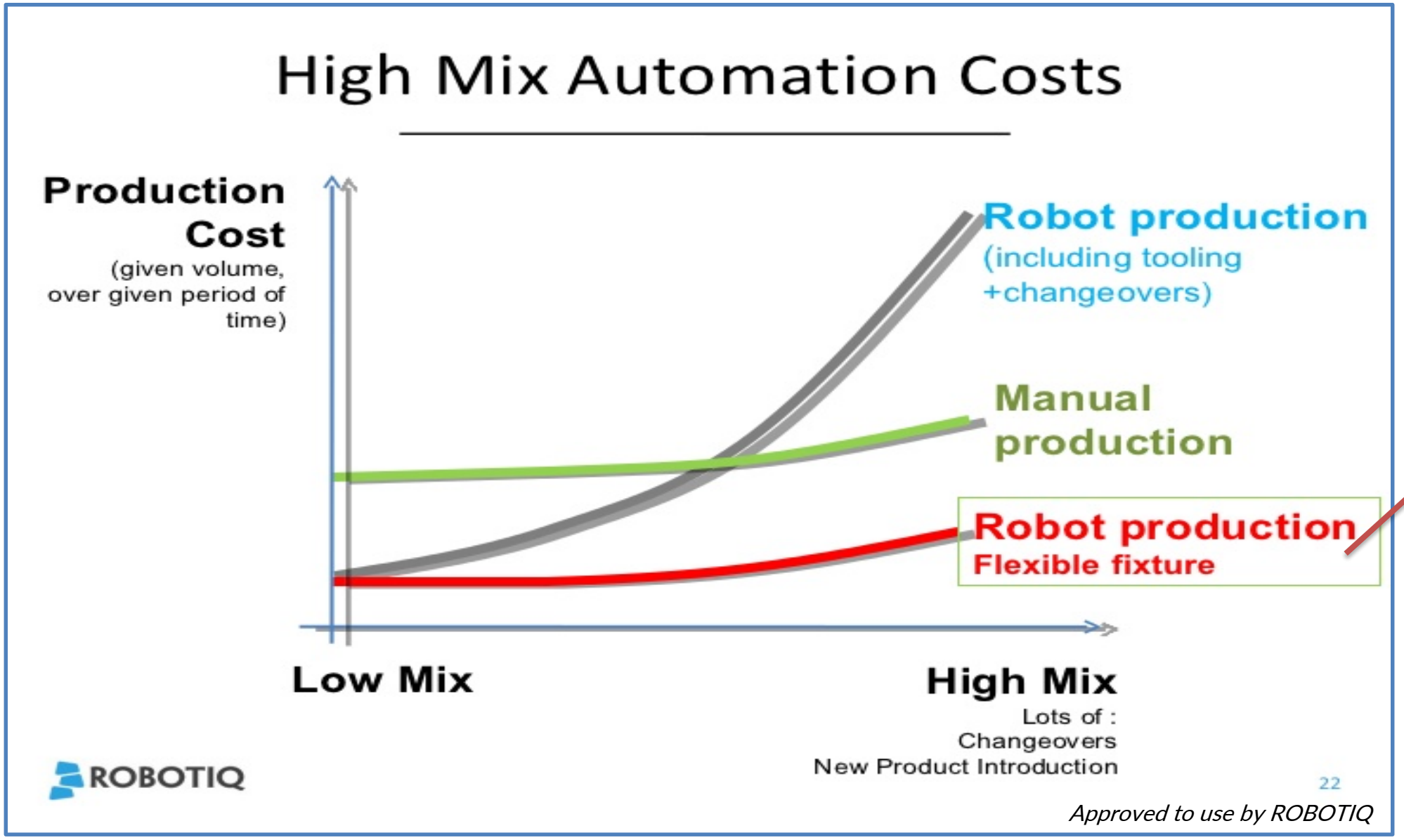
- Need reasonably large manufacturing base for the size of each order
- Can't ramp fast enough for short lead time when getting an order
- Can't reduce labor cost fast enough when missing an order
- CM model is sometimes challenged to respond due to capacity competition for the same projects from multiple photonics customers at one time



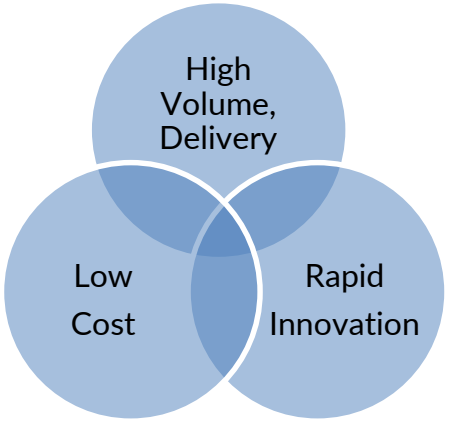
Response of photonic device suppliers

- "Elastic" capacity model for
  - High Quality, Low Cost manufacturing with Fast Switch on-and-off of capacity
- More automation for R&D&E and Manufacturing
  - Lower dependence of labors to reduce variable cost (labor hiring, training, and retention)
  - Minimize risks for NPI by using the same automation platform and processes
  - High precision automation enables processes and thus advanced products that could not be achieved manually

Flexible Automation for High Volume and High Mix Manufacturing



Approved to use by ROBOTIQ



For Photonics HVM

MRSI-HVM3

A New Class of Automatic Die Bonding Machine for Photonics High Volume Manufacturing

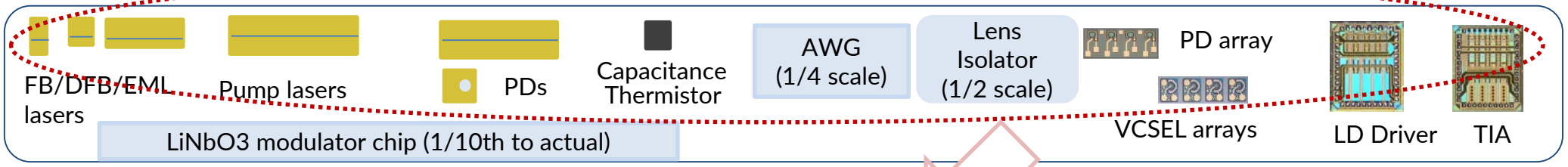
Target the Highest Volume Applications – Multi-CoS per Transceiver

Chip & Die

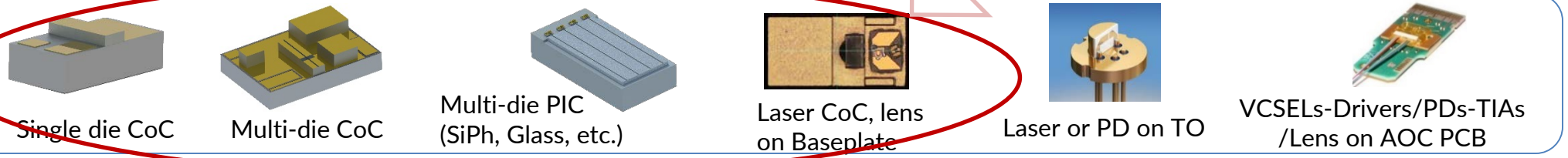
Chip on Carrier (CoC)

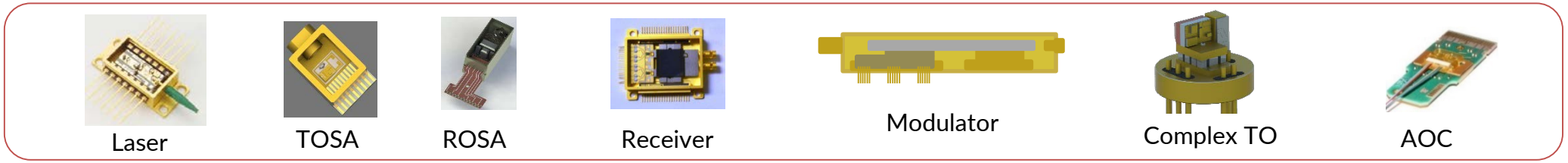
Open Package Assembly

Final Module

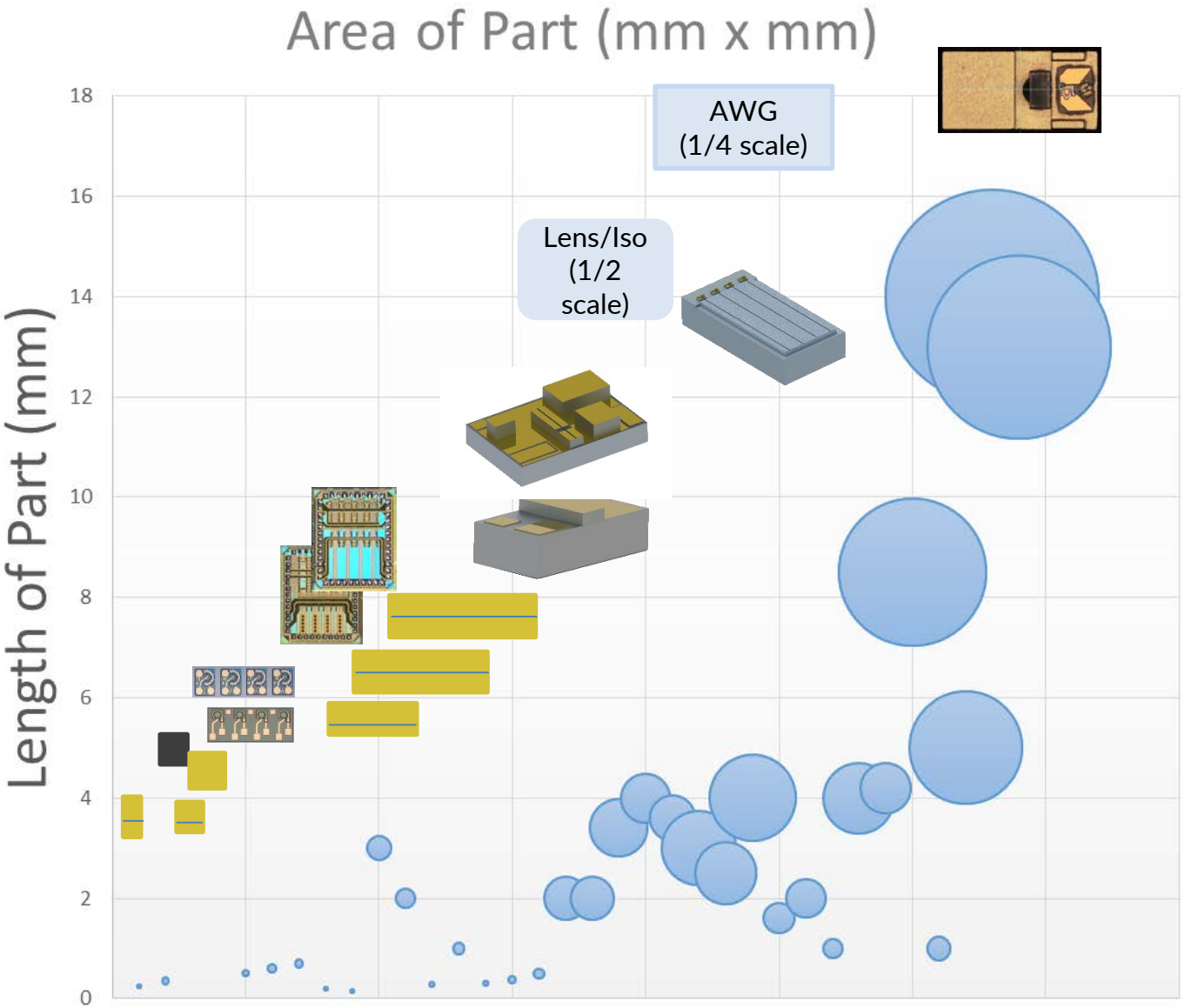


Solder or epoxy joint





High Flexibility
Enables Multi-Chip Multi-Process CoS Assembly In One Machine

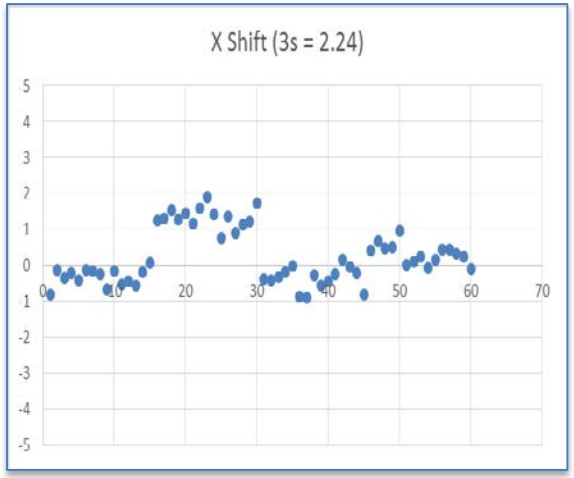


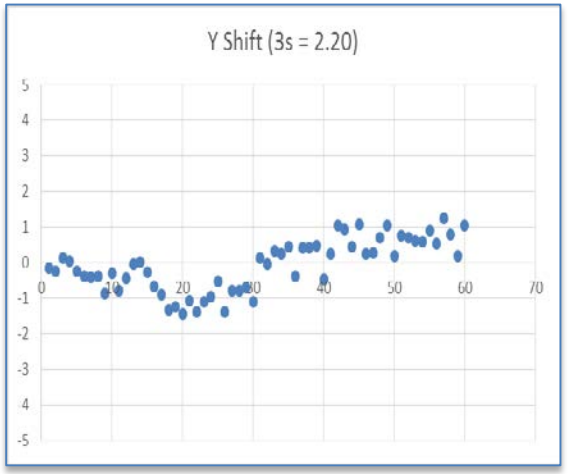
- Photonics CoS assembly involves lots of different types of parts (size, geometry) that can't not be picked/placed by single fixed tool

- MRSI-HVM3
  - Integrated "On-the-fly" tool change module with up to 13 vacuum tips/collets
  - Spacious working areas for large variety of materials handling (up to 30x 2" Waffle-Pak/Gel-Pak, and 2x 4"or 6" wafer tape)

High Precision Improves Manufacturing Yield and Enables Advanced Products

- Photonics HVM needs high precision for higher yield, higher speed and more complex products
- MRSI-HVM3 provides future-proof assembly with ±3μm@3σ die bonding precision
  - Built based upon long proven MRSI-M3 (±3μm@3σ)
  - Current photonics HVM tightens front end (e.g. CoS) packaging tolerance to have better yield in later packaging steps to reduce total assembly cost
  - Next generation photonic packaging designs require 3μm die bonding precision for 5μm post-processing accuracy
  - Some of silicon photonics assembly steps need 3μm die bonding precision to work with self-alignment mechanics built on parts using semiconductor nanofabrication in order to achieve submicron post-processing accuracy

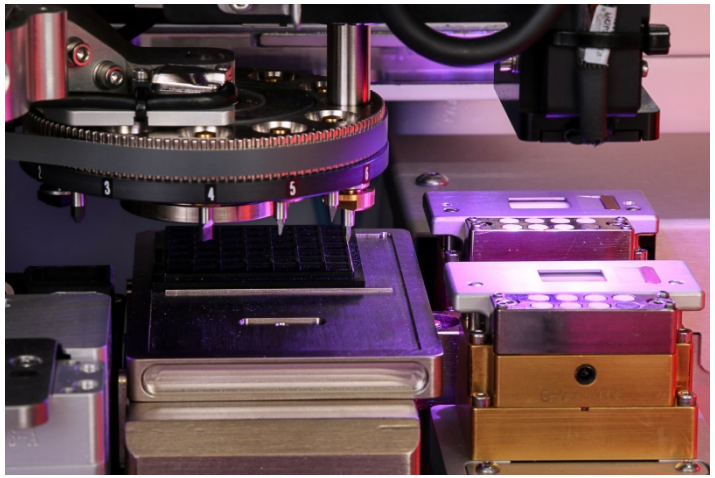




High Speed without Sacrificing Flexibility or Precision

- Photonics HVM needs high speed equipment to be flexible and precise

- MRSI-HVM3's speed is the fastest in class (<7μm) for photonic CoS HVM, without sacrificing precision or flexibility, realized by optimizing assembly steps
  - "on-the-fly" tool change
  - Parallel material handling and final bonding steps using dual head/gantry/stage
  - Ultrafast temperature ramping & cooling of eutectic hot stage



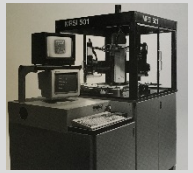
High Reliability Proven by MRSI's Long Track Record Serving Manufacturing

1984

MRSI

MRSI founded.
Newport acquisition-2002.
MRSI MBO-2014.

1986



Industry 1st Automatic,
Flexible Die Bonder
MRSI-501

1990

Ultra-Flexible, High Speed
MRSI-505
(12μm)

2002

Ultra-Flexible, High Speed
MRSI-605
(10μm)

2012

Ultra-Flexible, High Speed
MRSI-705
(5μm)

2013

Ultra-Flexible, High Speed
MRSI-M3
(3μm)

2017

Ultra-Fast, High Flexibility
MRSI-HVM3
(3μm)
Industry fastest!

Proven Proprietary Design, Deep Process Knowledge, State-of-Art Manufacturing, World-Class Global Customer Service

Recap

The Trends
Data Center Drive; High Volume; High Mixes; JIT

The Challenges for Photonics
High volume high mix; Quick delivery; Rapid innovation; Make profit

The Opportunities in Automation
Speed; Flexibility; Precision; Reliability

A Case Study with MRSI-HVM3
The fastest in class (< 7μm) fully automated die bonder
with 3μm high precision, superior flexibility and long proven reliability
for high volume manufacturing of photonic chip-on-submount

Thank You!

MRSI SYSTEMS

SCALE WITH US

- Photonics
- Sensors
- Medical
- Semiconductors

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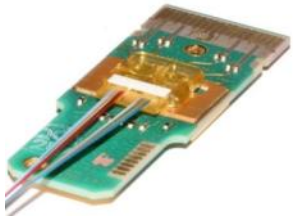
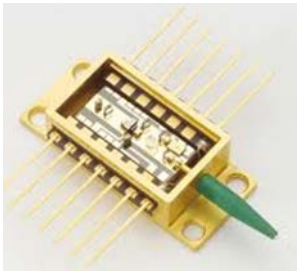
Sales@mrsisystems.com

MRSI SYSTEMS

History – 33+ Years of Precision Automation Solutions

MRSI was founded in Massachusetts in 1984. We are the leading provider of automated solutions for dispense and assembly of microelectronic and optoelectronic devices.



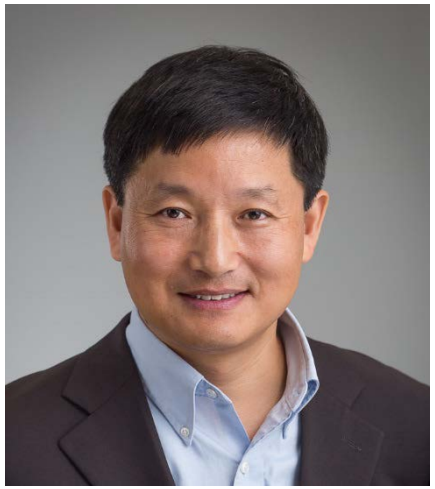


1984 – 2002
Micro Robotics Systems, Inc. (MRSI)

2002-2014
Newport Corporation

2014 –
MRSI Systems

About the Speaker: Dr. Yi Qian



- VP Product Management, MRSI Systems
  - Automating photonics manufacturing
  - Ph.D. in Physics + B.S.E.E.
- A veteran of lasers and photonics for multi-markets
  - Developed high power pump lasers and high speed EML/DFB lasers for optical communications
  - Managed 40G/100G transceiver product lines for optical communications
  - Managed high speed laser scanner product lines for multiple industries (medical, industrial, etc)
  - Led a startup's engineering and developed 3D laser sensors for medical and industrial

CORNING

OCLARO

Novanta
(formerly GSI Group)

MRSI SYSTEMS