
***Optoelectronics:
Successfully penetrating many
new markets***

Michael Lebbby



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

Overview

- n **Opto**mism in the marketplace

- ÿ Market evolution over the next decade

- n Optoelectronic Markets

- ÿ OIDA global forecast

- Displays, HBLEDs, Image Sensors, Medical Photonics, Solar Cells

- n International Roadmaps

- ÿ Global snapshot across the industry

- n Summary

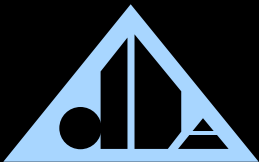
- ÿ DARPA matching program



Michael Leiby (leiby@oida.org)

Optomism is back again!

Next decade in Optoelectronics

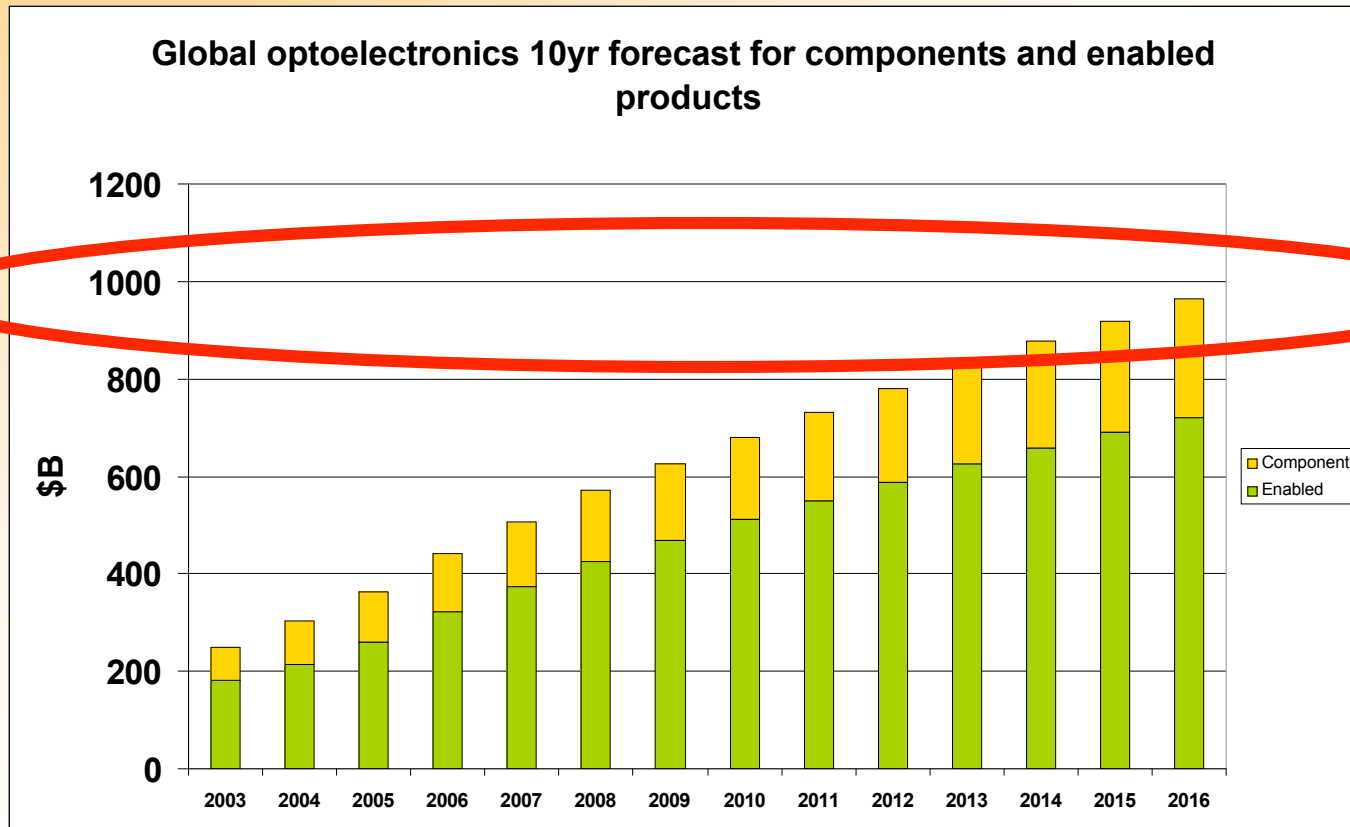


OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

Next decade in optoelectronics

n Combined OE components and enabled products

ÿ 2004-16 CAGR 11%

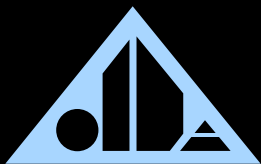
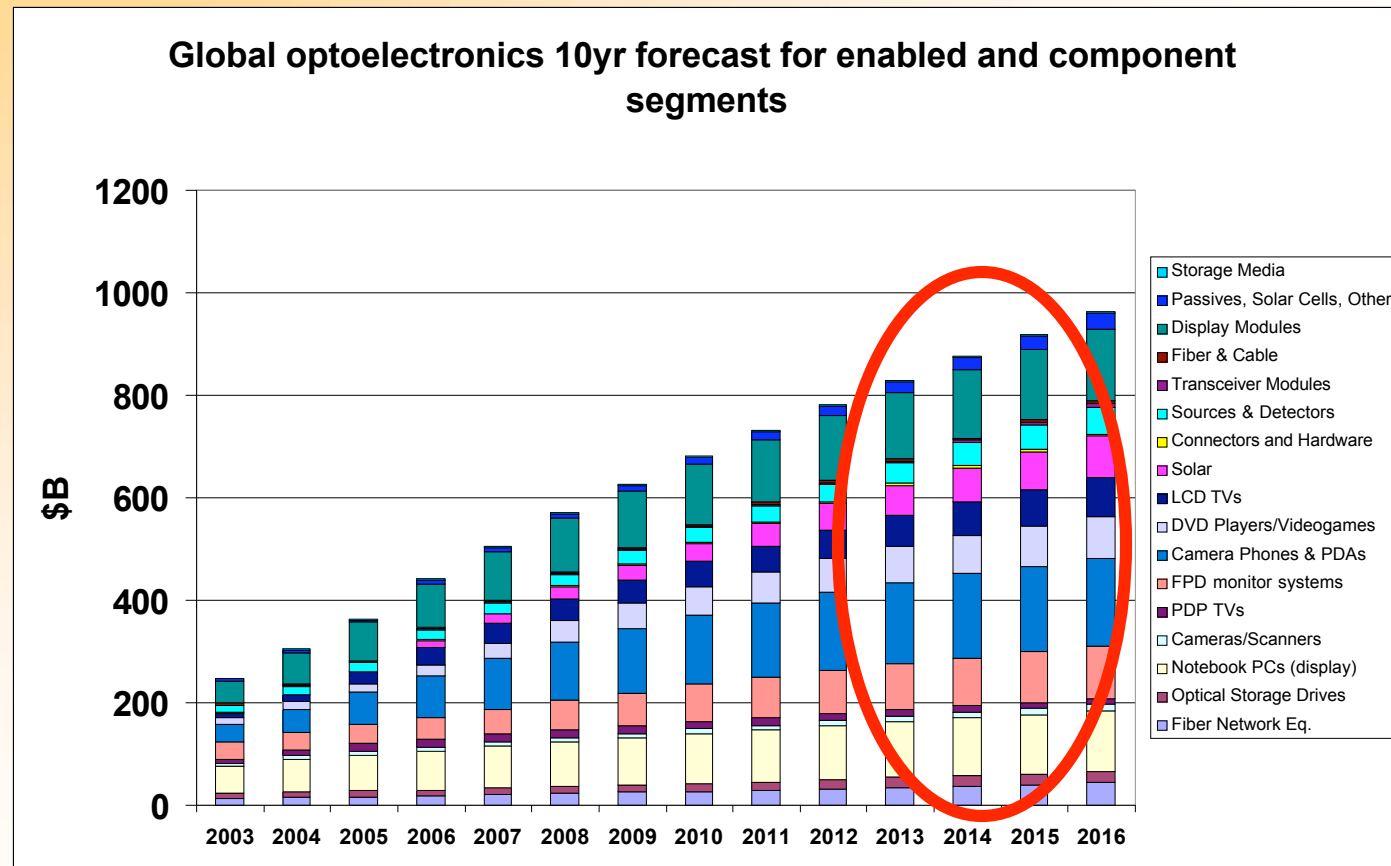


Michael Leby (leby@oida.org)

Is this a \$T industry?

Next decade optoelectronics segments

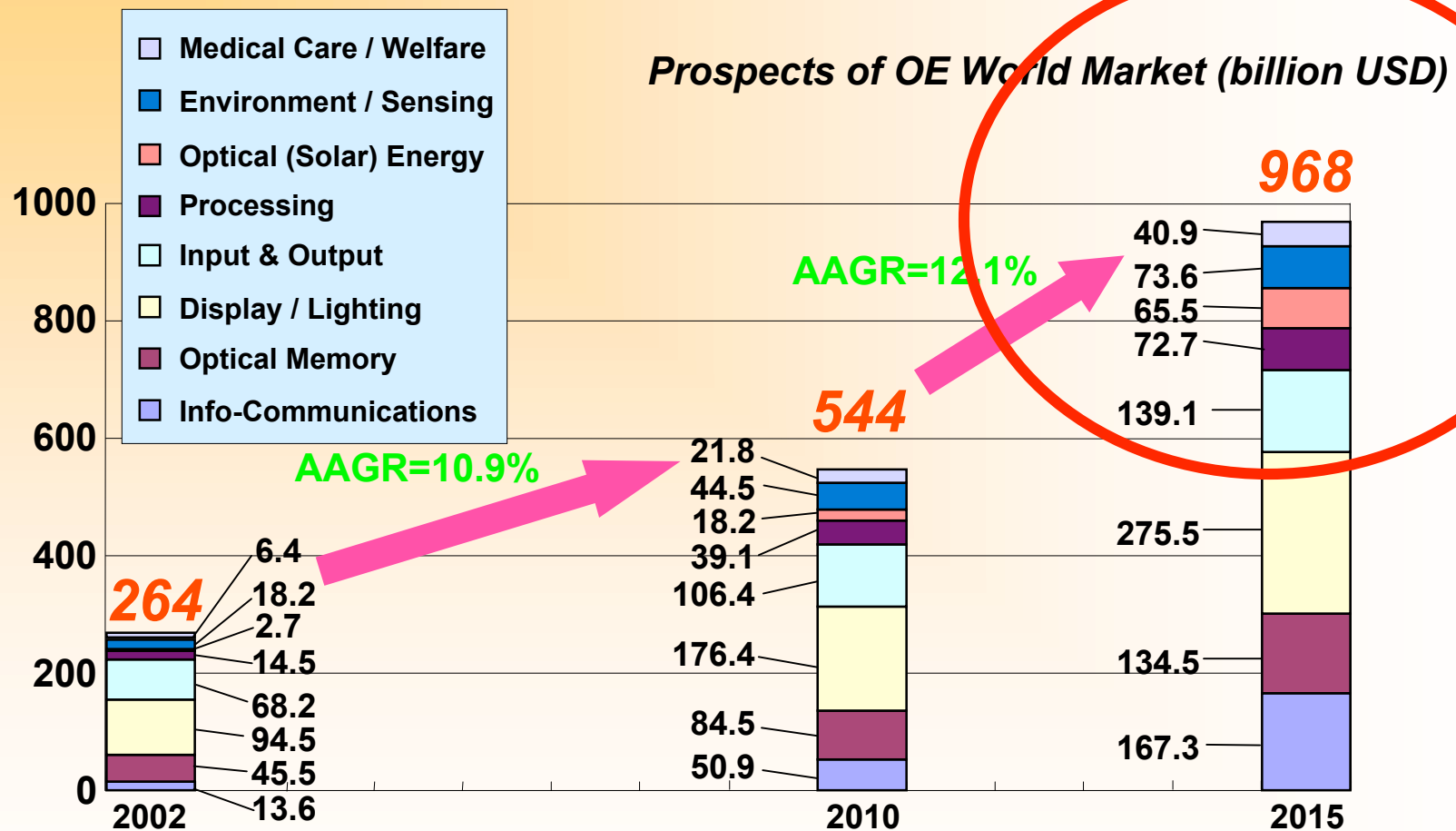
n Strong consumer/entertainment drivers



Michael Lebbly (lebbly@oida.org)

Displays grow more slowly

Japanese future vision



Source: <http://www.oida.or.jp/main/syourai04-j.html>

[1 USD=110 JPY]

AAGR: average annual growth rate

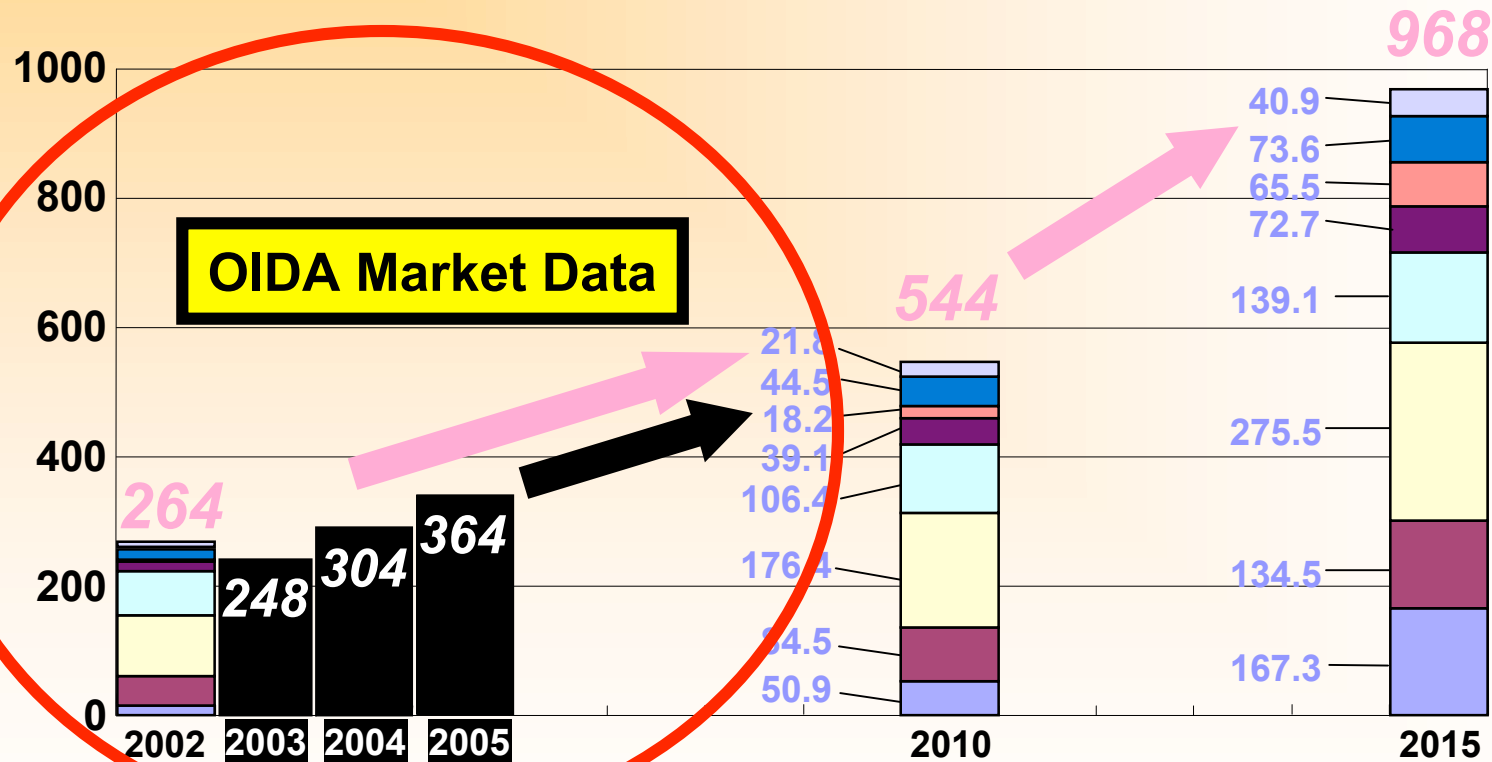


Michael Lebby (lebby@oida.org)

OITDA expects \$1T OE business

Japanese Future with OIDA data

Prospects of OE World Market (billion USD)



Source: <http://www.oida.or.jp/main/syourai04-j.html>

[1 USD=110 JPY]

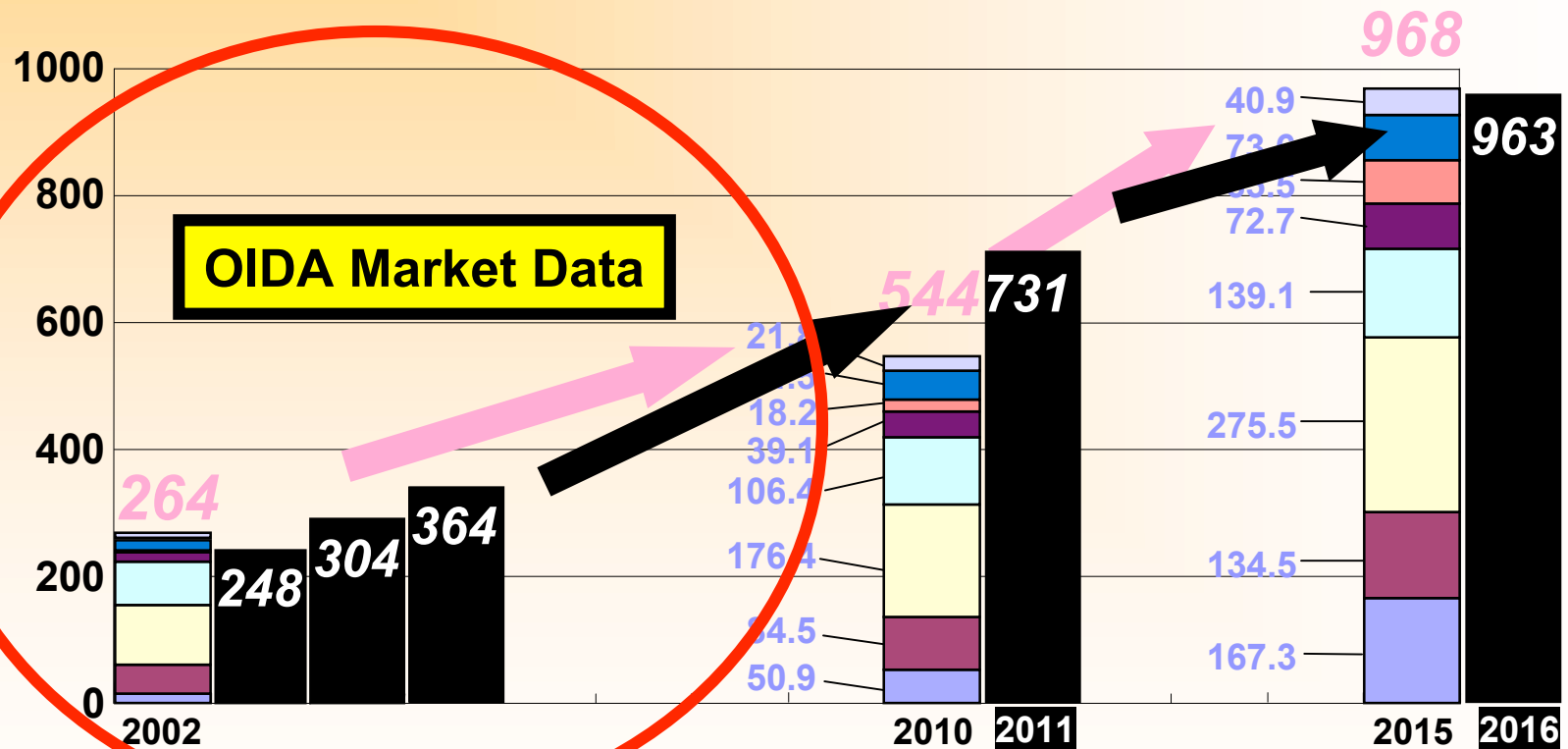
Michael Lebby (lebby@oida.org)



OE market growing well today

OIDA and OITDA next decade data

Prospects of OE World Market (billion USD)



Source: <http://www.oitda.or.jp/main/syourai04-j.html>

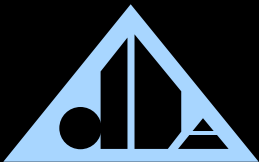
[1 USD=110 JPY]

Michael Lebby (lebby@oida.org)



Maturing towards \$1T business

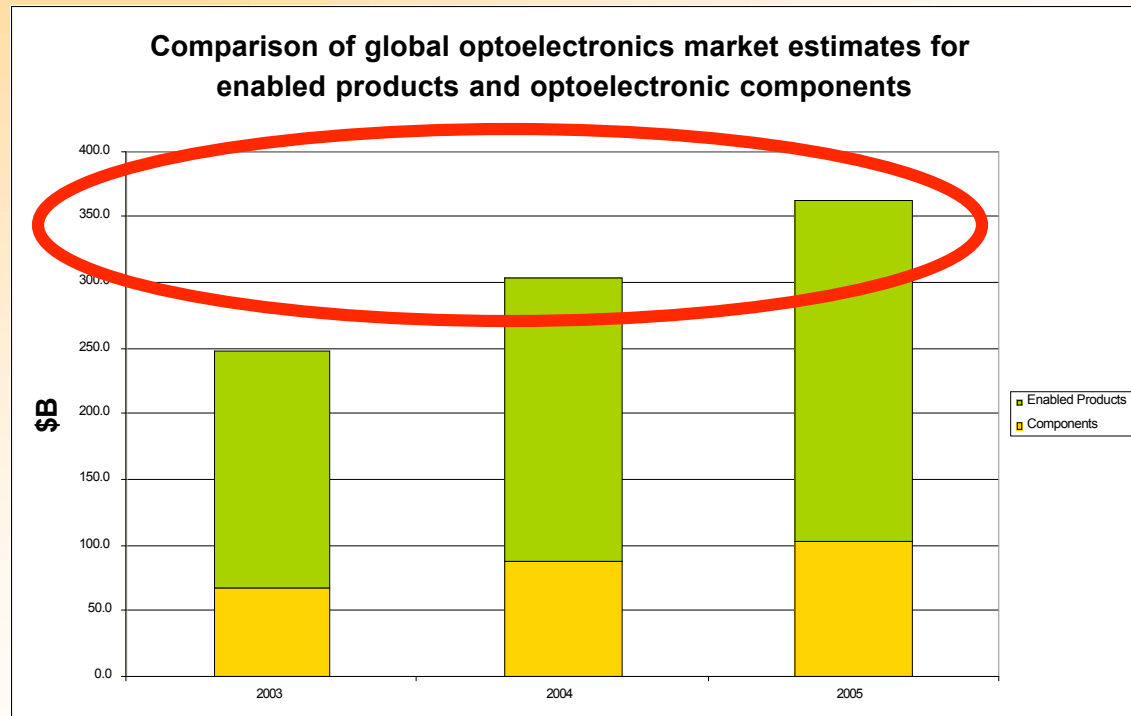
Optoelectronics Markets



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

Global OE markets for enabled products

n FPD displays big driver for enabled products (\$364B)



Sources: OIDA member companies, OIDA estimates, KMI, Infonetics, Ovum-RHK, TIA, IDC, CIR, Gartner, Dell'Oro, Aventis, Prudential Equity, Strategies Unlimited, CTIA, PIDA, OITDA, KAPID, Display Search, ISupply, MIC Japan

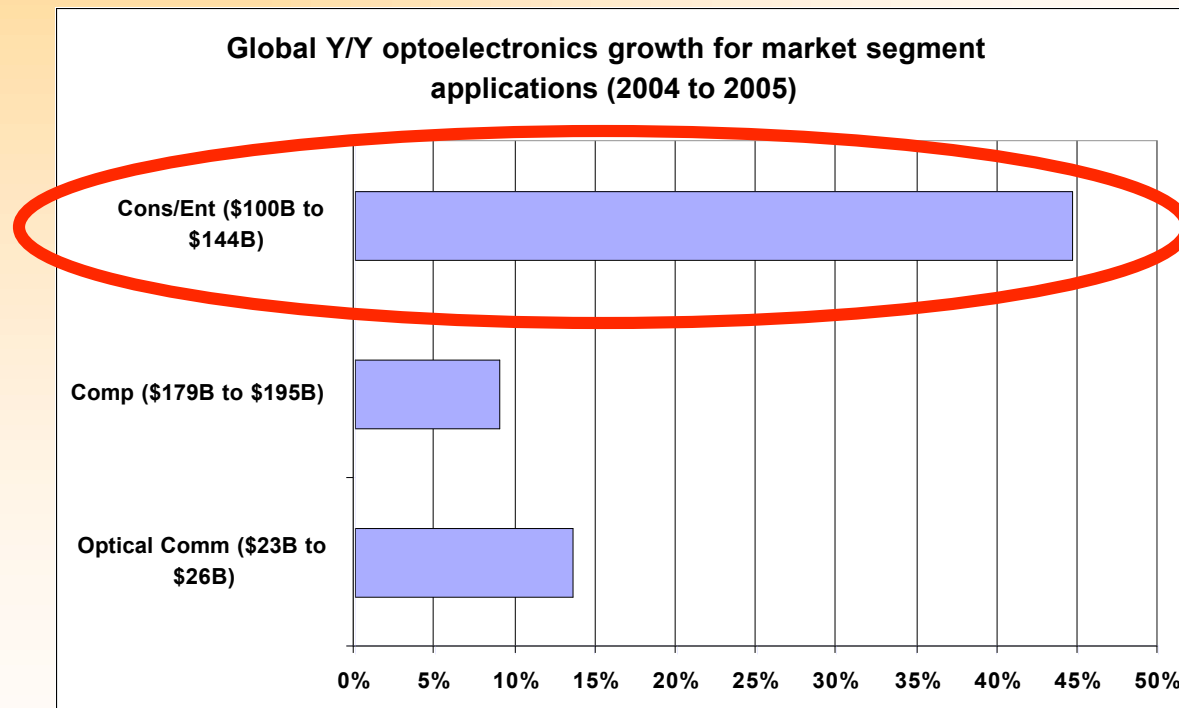


Michael Leby (leby@oida.org)

Strong growth in OE enabled products

Global optoelectronics market growth

- n Consumer/Entertainment driving optoelectronics
 - ÿ Liquid crystal display becoming ubiquitous



Sources: OIDA member companies, Display Search, ISupply, OIDA estimates

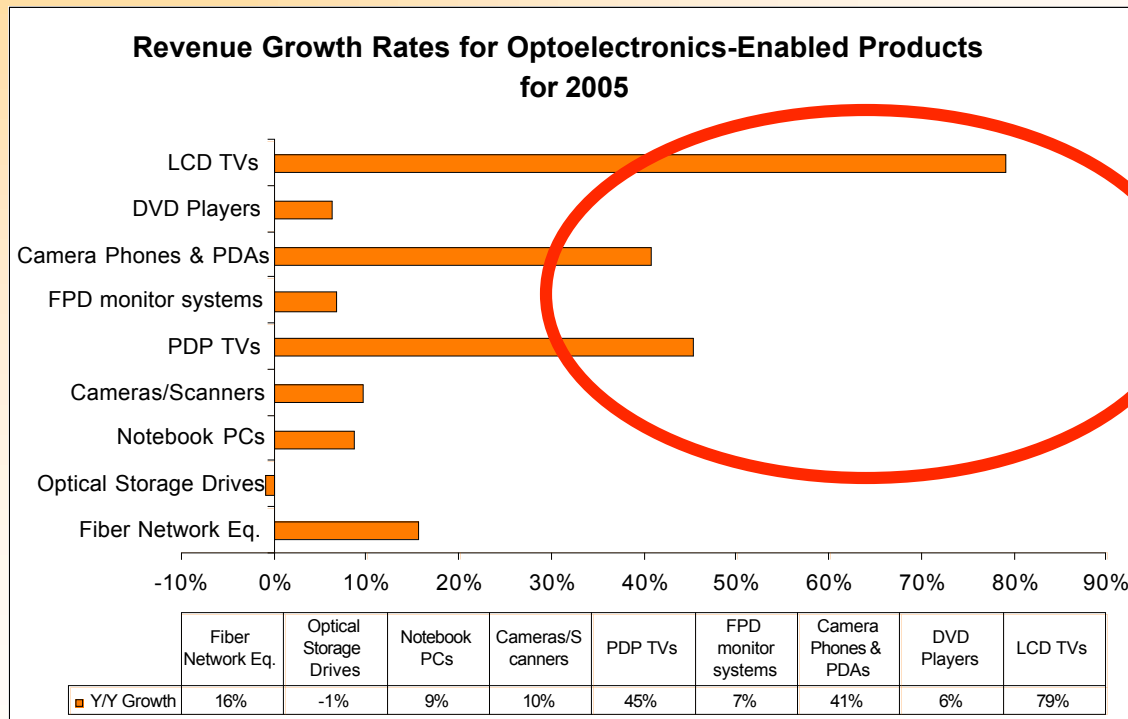


Michael Leby (leby@oida.org)

No surprise !

Growth for OE enabled products

n Consumer products are jazzing the market in 2005



Sources: OIDA member companies, KMI, Infonetics, Ovum-RHK, TIA, IDC, CIR, Gartner, Dell'Oro, Aventis, Prudential Equity, OIDA estimates

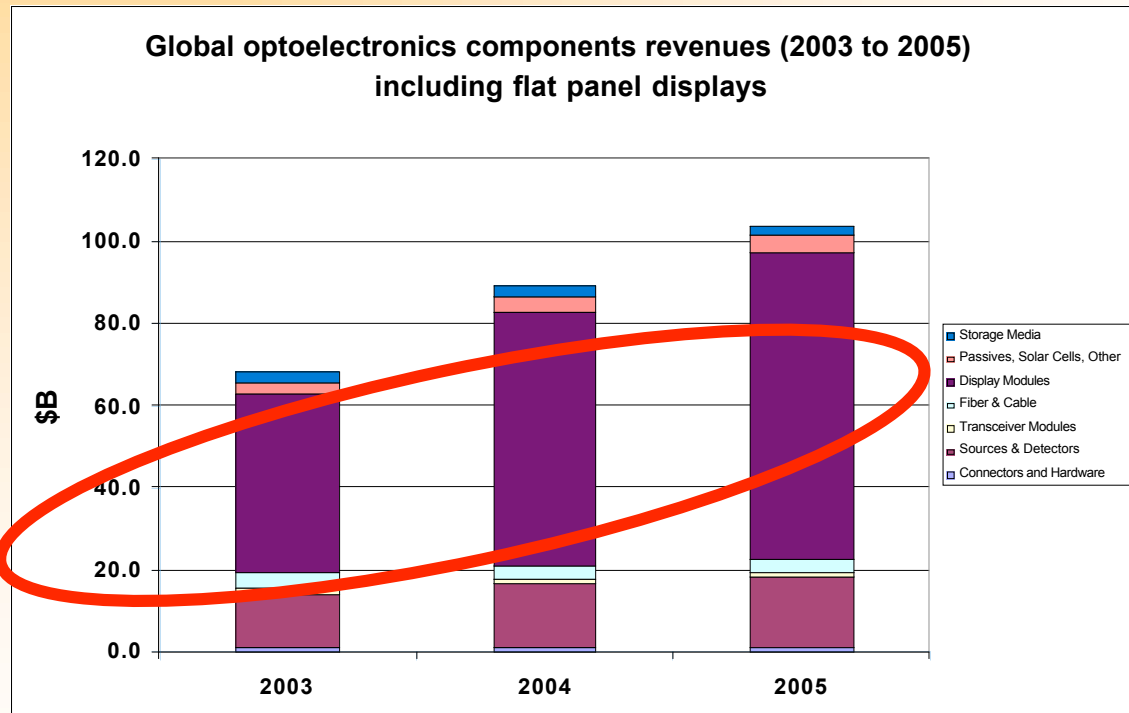


Michael Leby (leby@oida.org)

Flat panel displays are everywhere

Global OE components markets

n Displays dominate components



Sources: OIDA member companies, KMI, Infonetics, Ovum-RHK, TIA, IDC, CIR, Gartner, Dell'Oro, Aventis, Prudential Equity, OIDA estimates

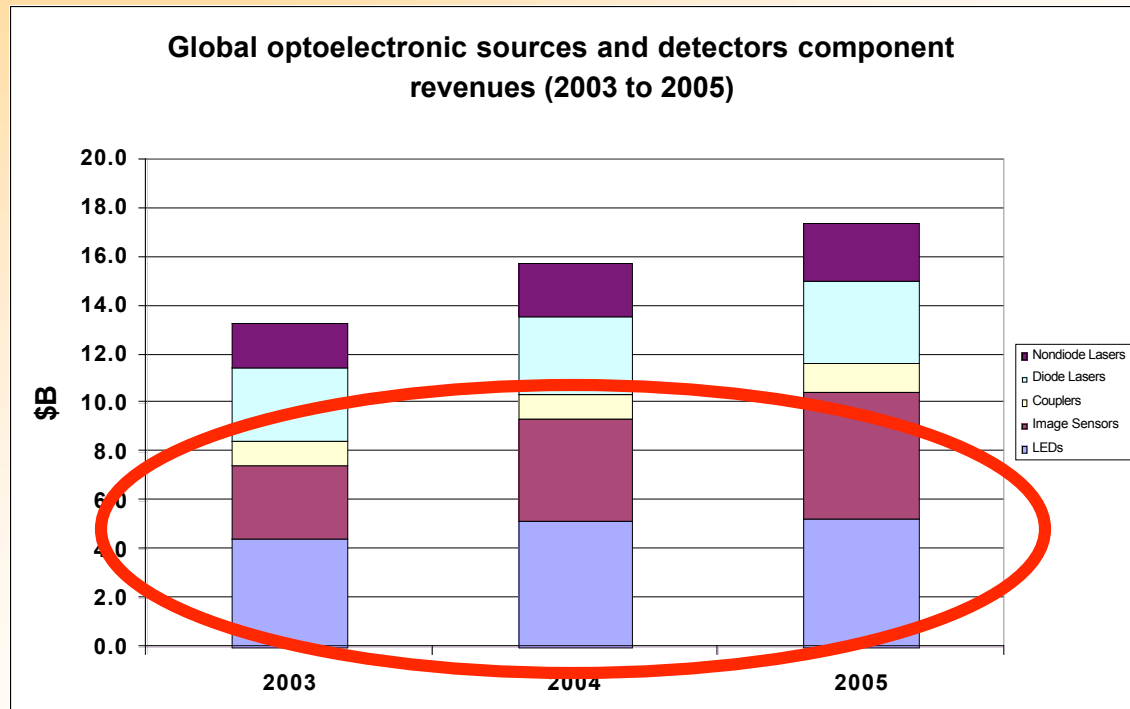


Michael Leby (leby@oida.org)

Displays dwarf traditional OE components

Global OE sources and detectors

- n Image sensors strong growth due to camera phones
- n HBLEDs now penetrating many consumer markets



Sources: OIDA member companies, OIDA estimates, KMI, Infonetics, Ovum-RHK, TIA, IDC, CIR, Gartner, Dell'Oro, Aventis, Prudential Equity, Strategies Unlimited, CTIA, PIDA, OITDA, KAPID, Display Search, ISupply, MIC Japan

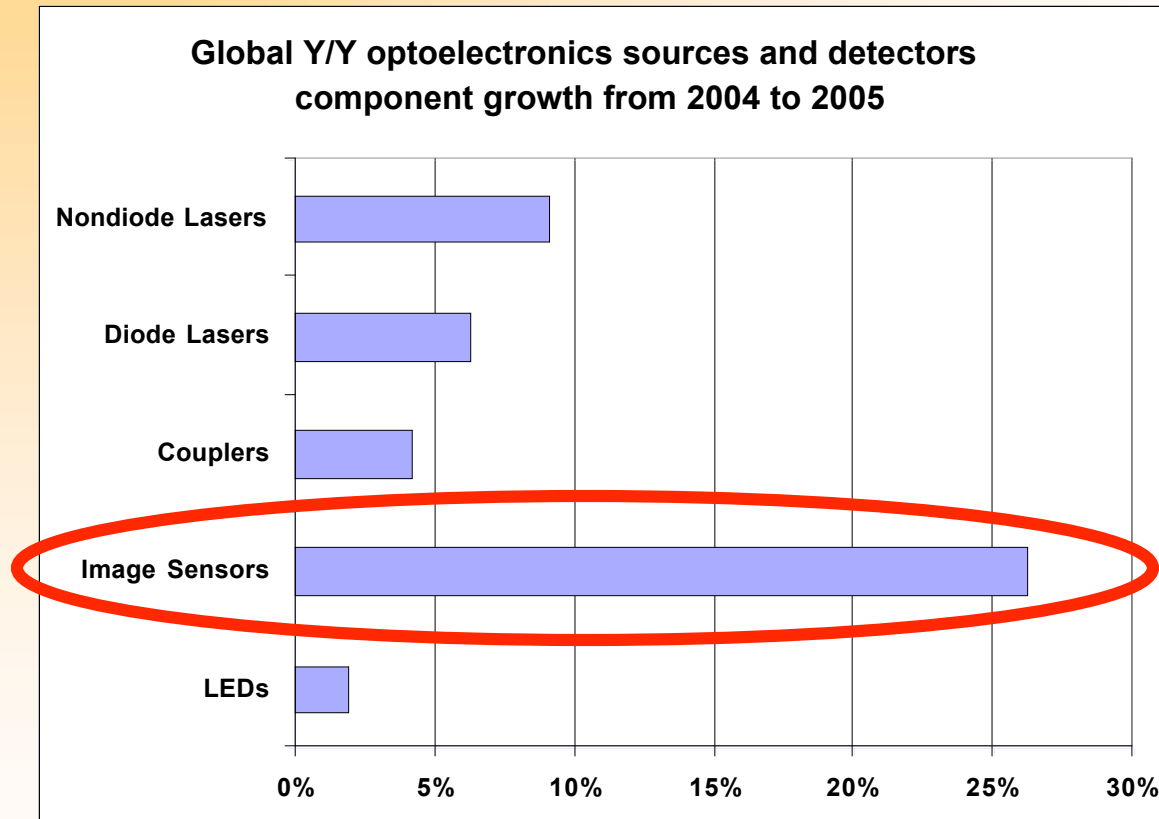


Michael Leby (leby@oida.org)

Growth driven by consumer markets

Growth in OE sources and detectors

n Image sensors driving the component growth in 2005



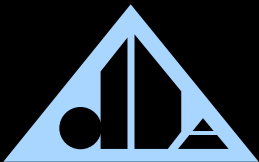
Sources: OIDA member companies, OIDA estimates, KMI, Infonetics, Ovum-RHK, TIA, IDC, CIR, Gartner, Dell'Oro, Aventis, Prudential Equity, Strategies Unlimited, CTIA, PIDA, OITDA, KAPID, Display Search, ISupply, MIC Japan



Michael Leby (leby@oida.org)

All segments showing strong growth

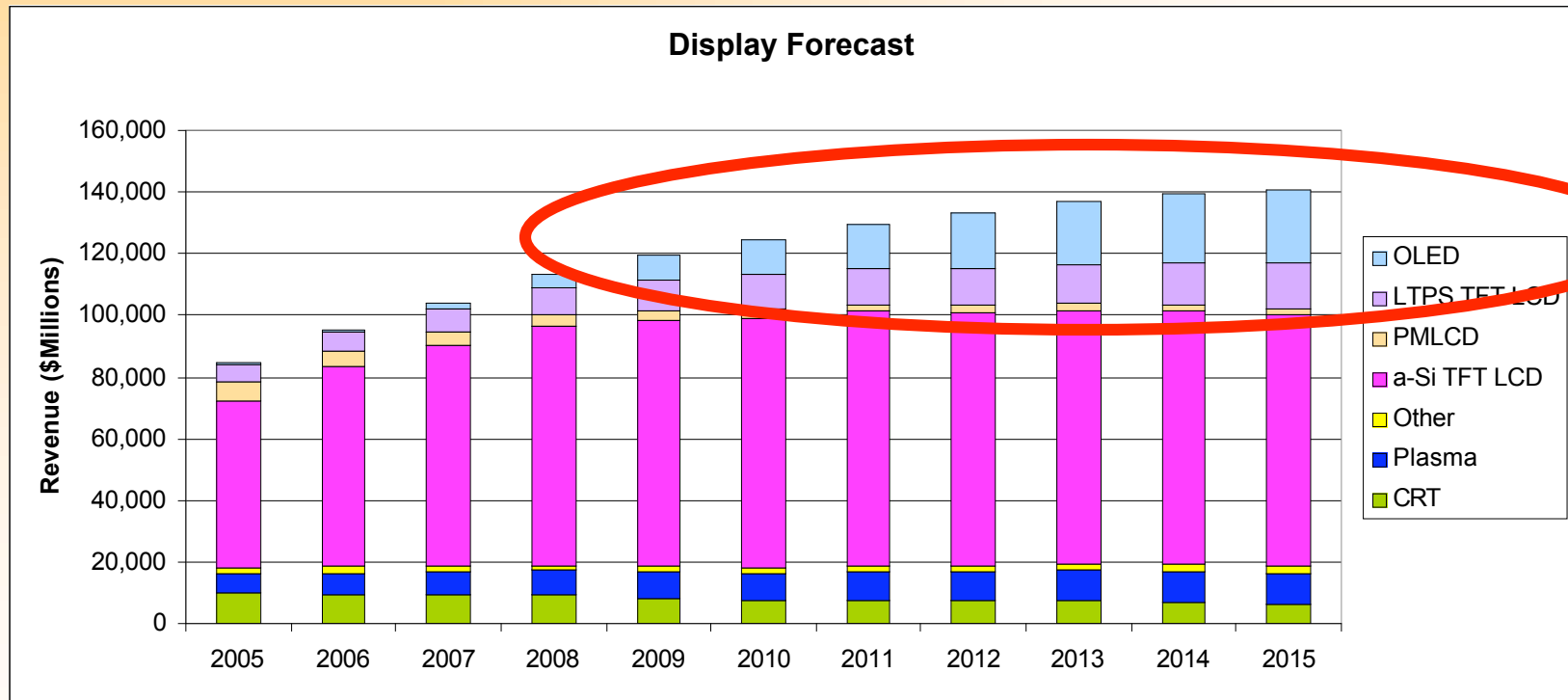
Display trends



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

Global display market

- n a-Si TFT becoming the silicon (Vs GaAs) of displays
- ÿ OLEDs expected to grow into huge opportunity



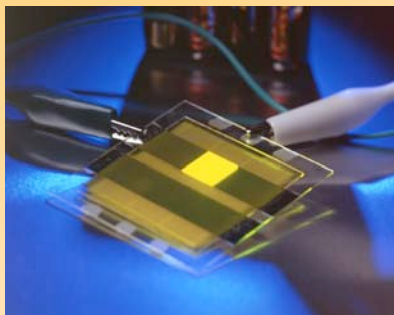
Sources: Display Search, ISupply, OIDA



Michael Leby (leby@oida.org)

Watch OLEDs !

OLEDs – emissive displays



n A flat radiating surface

- New functional and design opportunities in comparison to point light sources. 150x150 mm² products available



n A wide viewing angle

- Excellent readability from all perspectives (e.g. self emitting logos)



n An integrated luminaire

- The fusion of the lamp and luminaire world

Sources: EDM, Merck

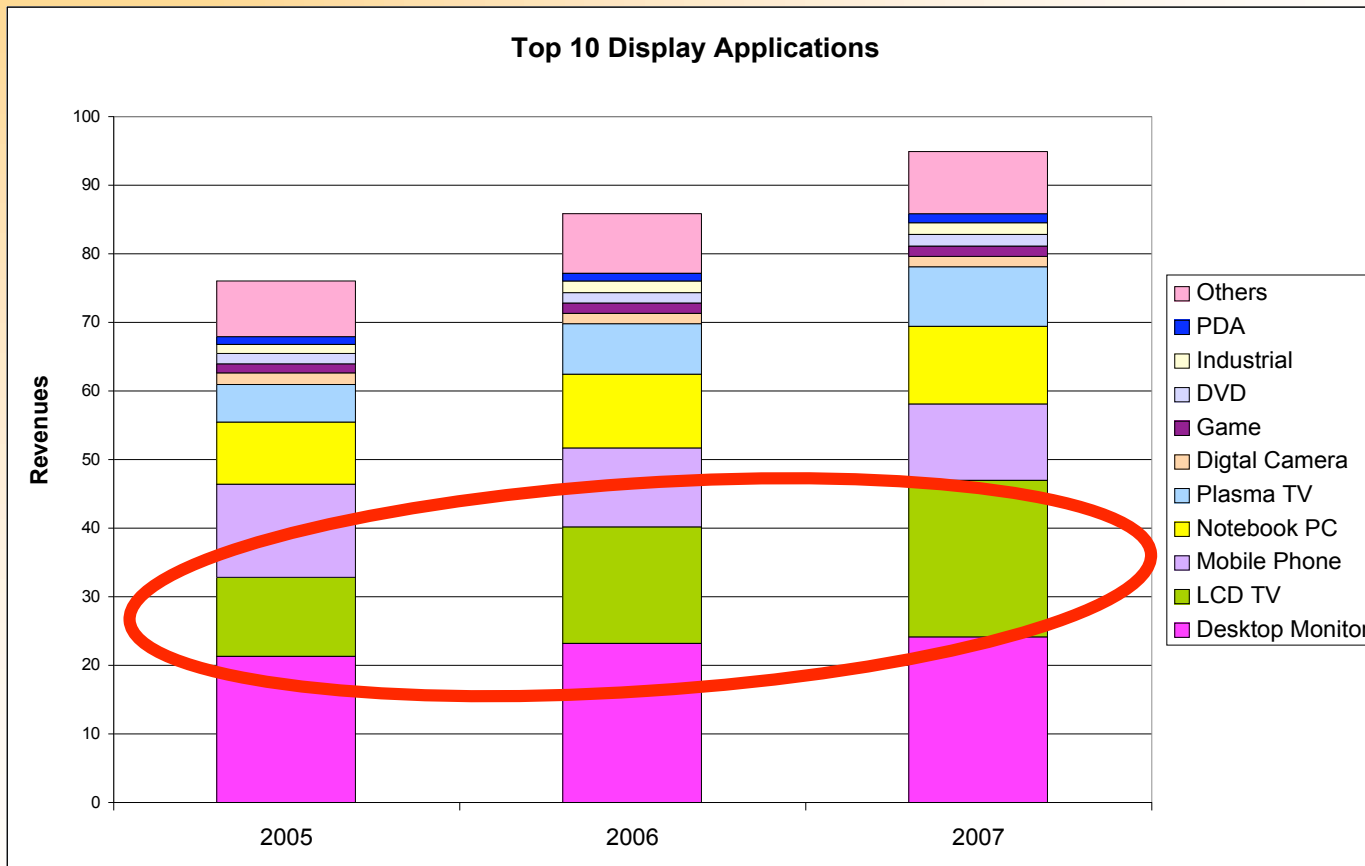


Michael Lebby (lebby@oida.org)

Differentiation has to be strong...

Top 10 display applications

n LCD TV 29% CAGR as key application



Sources: OIDA, Display Search, OIDA member companies



Michael Lebbby (lebbby@oida.org)

Top 10 mostly consumer/entertainment

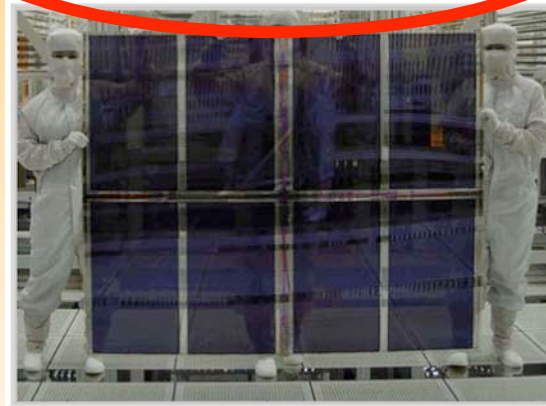
LCD "Glass" Size for Perspective

Year: 2000
Largest "Glass" size = 3.5G
Optimized for Monitors
and Notebook Screens



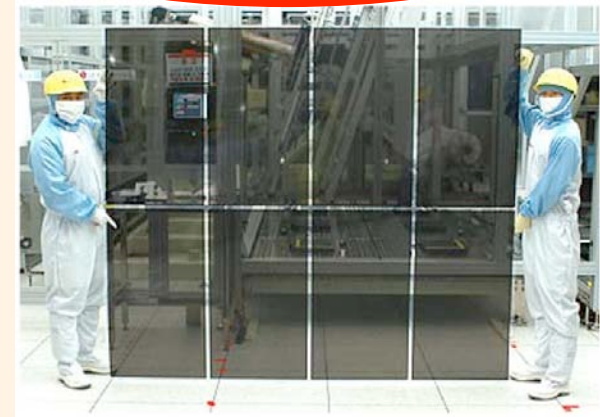
2000

Year: 2004
Largest "Glass" size = 6G
Monitors and Larger TVs
(and Digital Signage / Public Displays)



2004

Year: 2006
Largest "Glass" size = 7G
Larger TVs and Digital Signage /
Public Displays



2006



Source: DisplaySearch. LG.Philips LCD



Michael Lebbby (lebbby@oida.org)

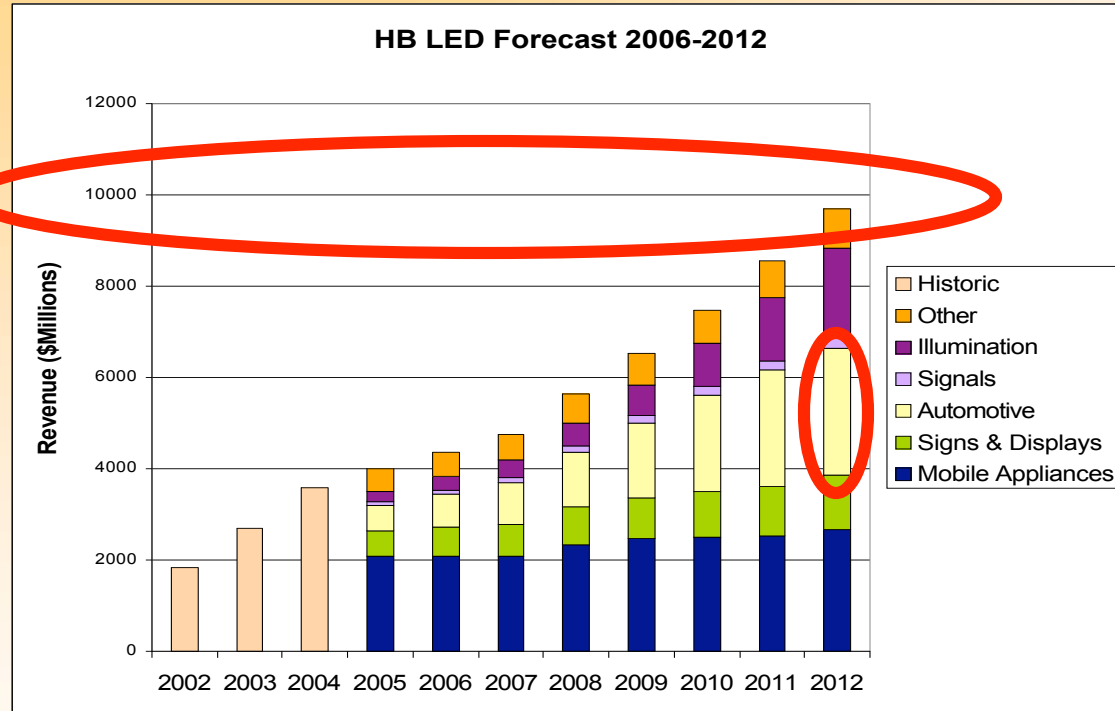
6G & 7G technologies poised for ramp

HBLEDs become 'hot'



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

The rise of the HBLED...



- n Assumptions
- n Maturing Mobile Appliance Market
 - ÿ Continuing ASP price erosions
 - ÿ Offset by unit growth
 - ÿ OLEDs boost segment 2008
- n Signs & Displays growth
 - ÿ Brighter, full color +
- n Expanding deployment Automotive applications
 - ÿ Tail Light adoption 2006
 - ÿ 2008 – Forward Lighting
- n Illumination enters commercial general lighting market slowly
 - ÿ increasing momentum 2010

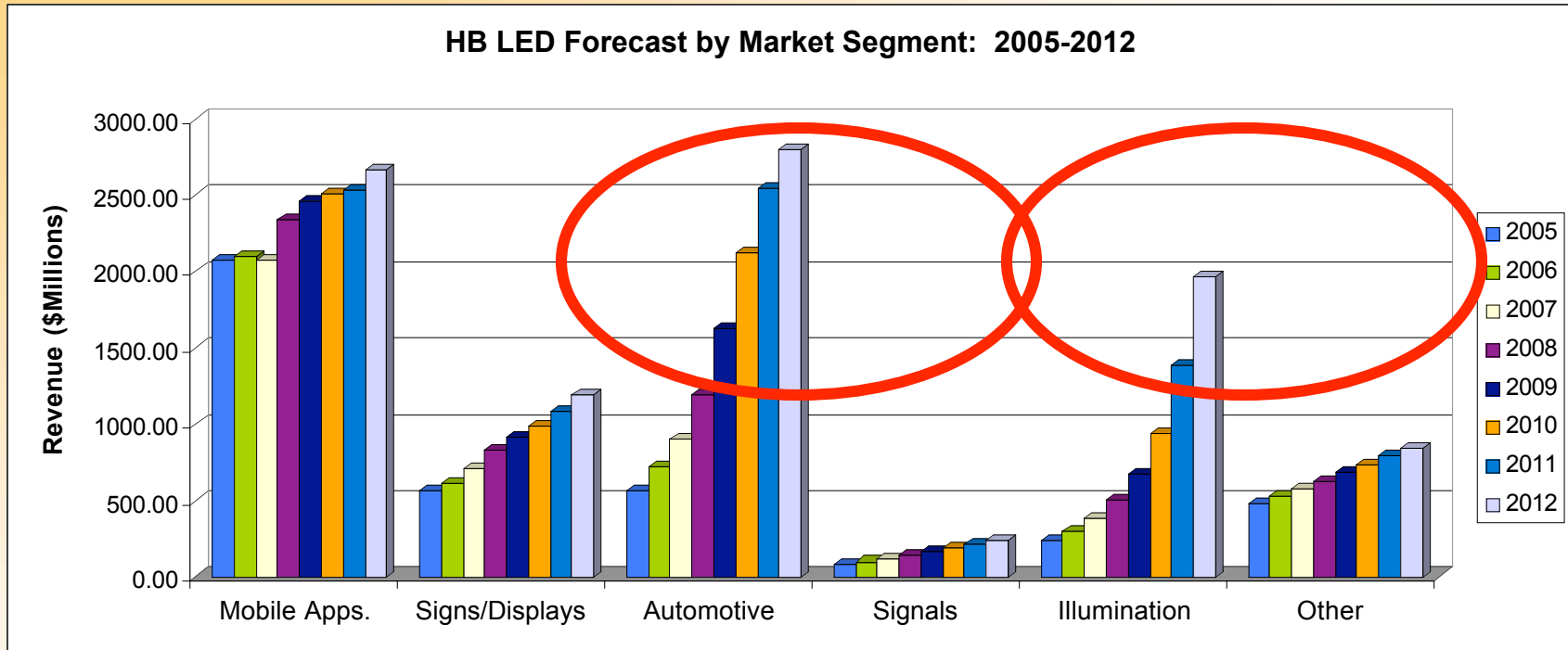
Sources: OIDA, Strategies Unlimited (historic data), iSupply, IoP, Yole Development, OITDA



Michael Lebby (lebby@oida.org)

Opportunities are now outside comms

HBLEDs forecast to grow quickly



n Complex market segments

ÿ Mobile Appliance segment more mature

ÿ More growth still ahead for Signs & Displays, Automotive, & Illumination

– Illumination may get further kick from government initiatives

Sources: OIDA, Strategies Unlimited (historic data), iSupply, IoP, Yole Development, OITDA

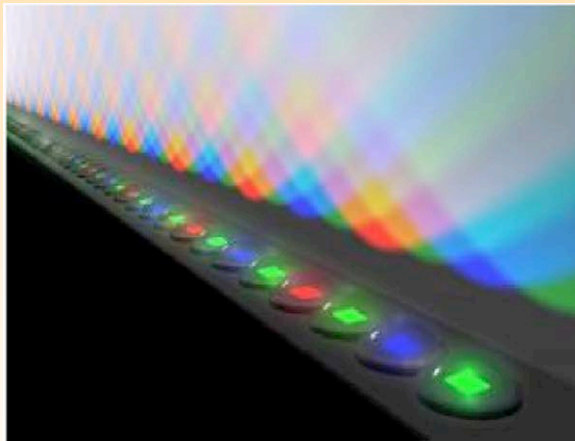


Michael Lebby (lebby@oida.org)

All segments with positive vectors

LED driving innovations

- n 48 LEDs (sorted from 10K) – 18 red, 20 green, 10 blue
- n Folded light guide technology



2 Green LEDs to every 1 red and blue

Sources: DisplaySearch, NEC



Michael Leby (leby@oida.org)

Green LED performance low

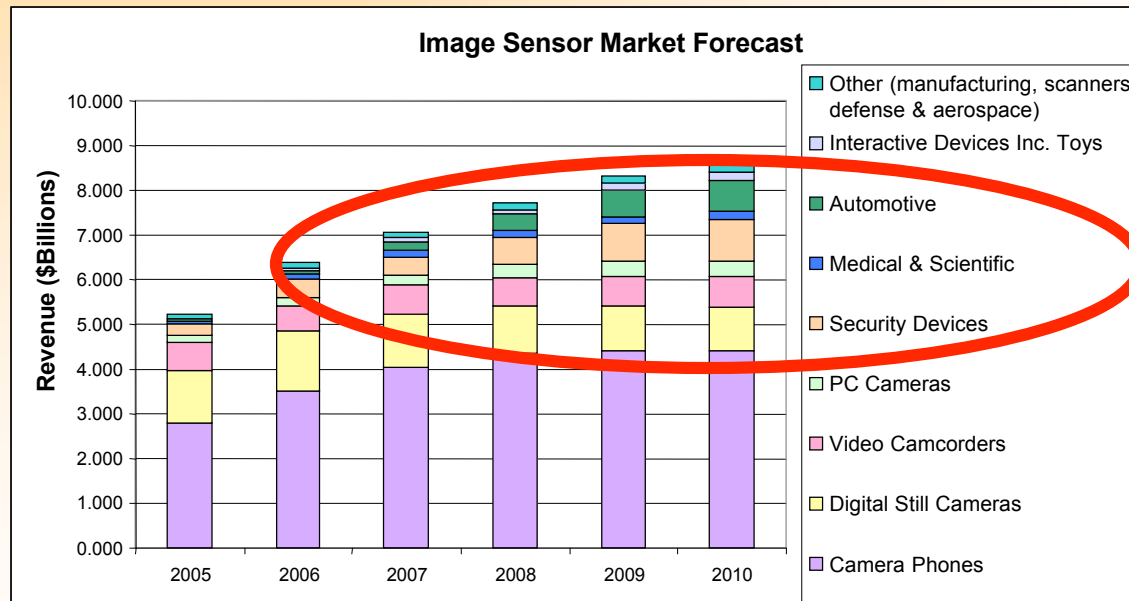
Image sensors



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

Image sensor market

- n Driven by camera phones
- ÿ Security and automotive exciting areas to watch



Sources: Strategies Unlimited, Micron, IC Insights, NE Asia, OIDA

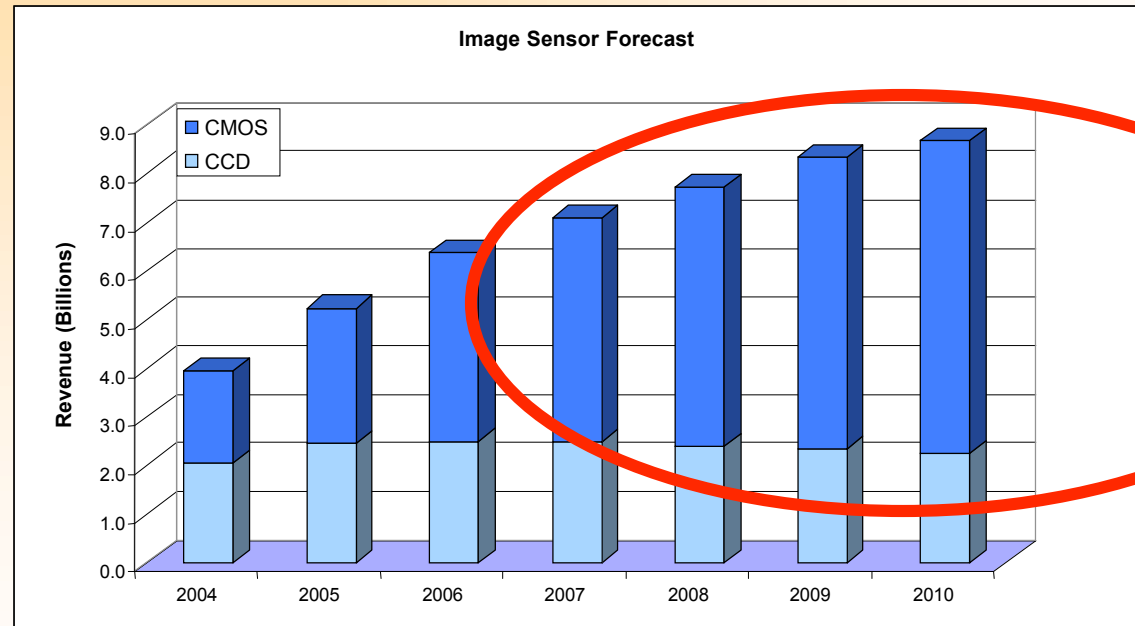


Michael Leby (leby@oida.org)

New opportunities emerging

Image sensor technology

- CMOS is now dominant through consumer volume applications



Sources: Strategies Unlimited, Micron, IC Insights, NE Asia, OIDA



Michael Leby (leby@oida.org)

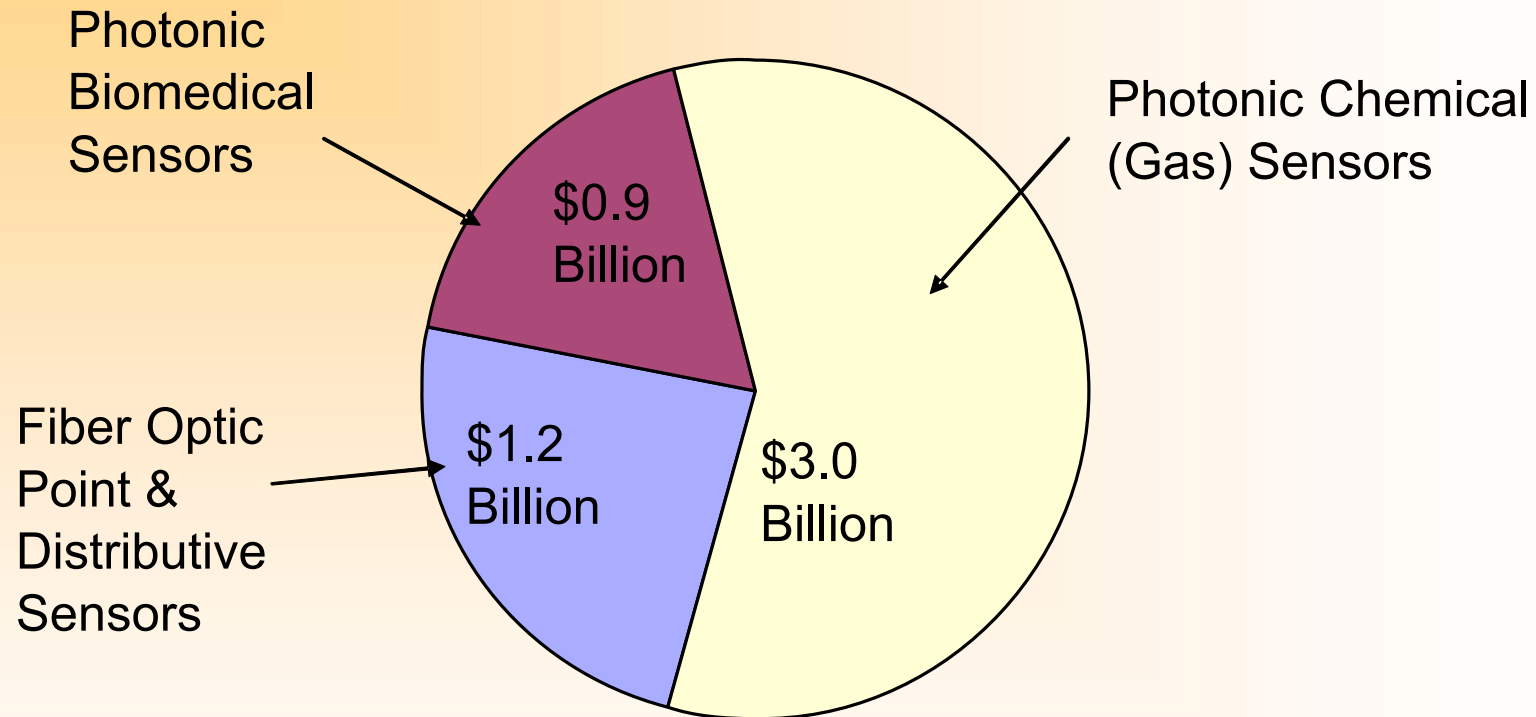
CMOS now cost effective

Photonic sensors



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

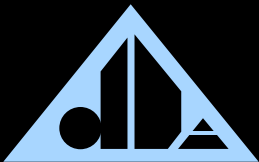
Photonic Sensor Market Potential (2009)



Michael Leiby (leiby@oida.org)

Strong opportunities in sensing

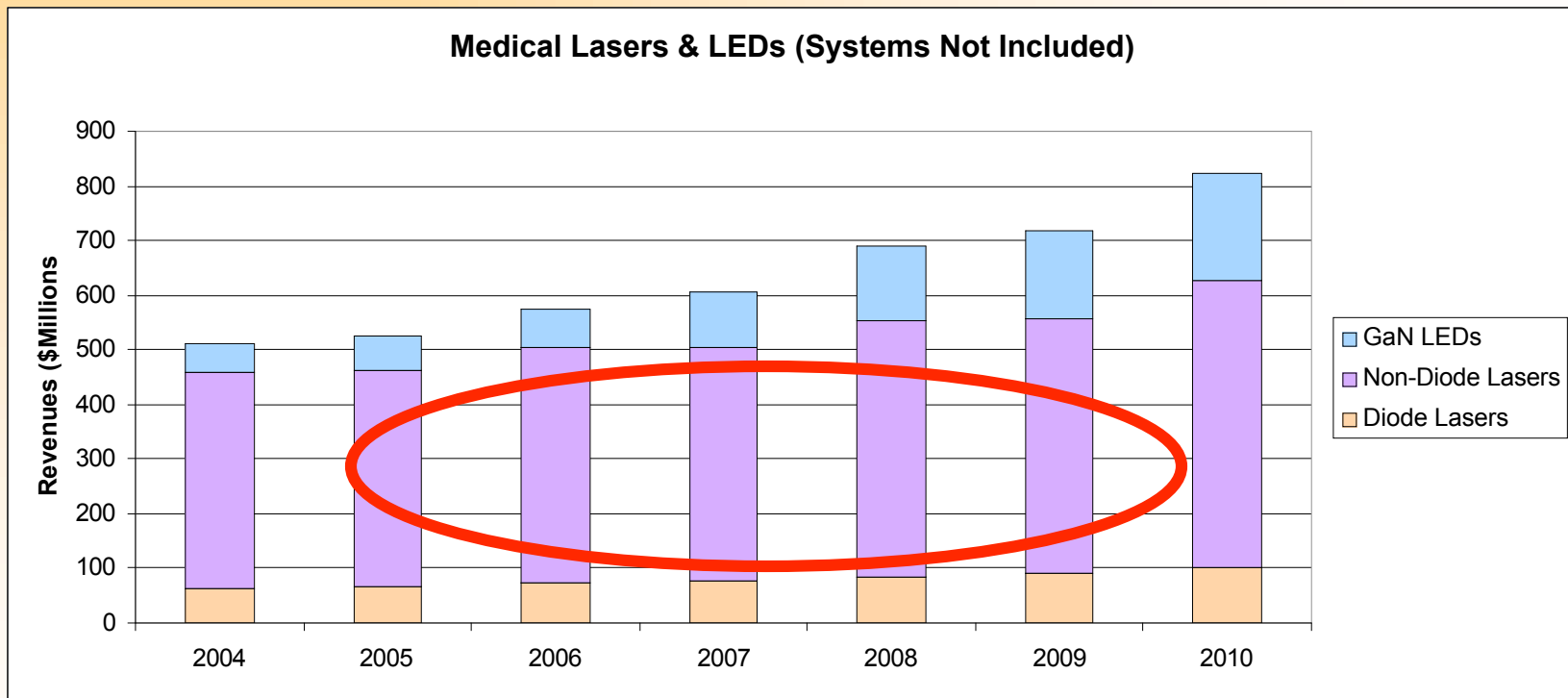
Medical photonics



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

Medical photonics

- n Many communications companies exploring this segment with their core technologies



Sources: Laser Focus, Strategies Unlimited, OIDA



Michael Lebby (lebby@oida.org)

Strong nondiode business

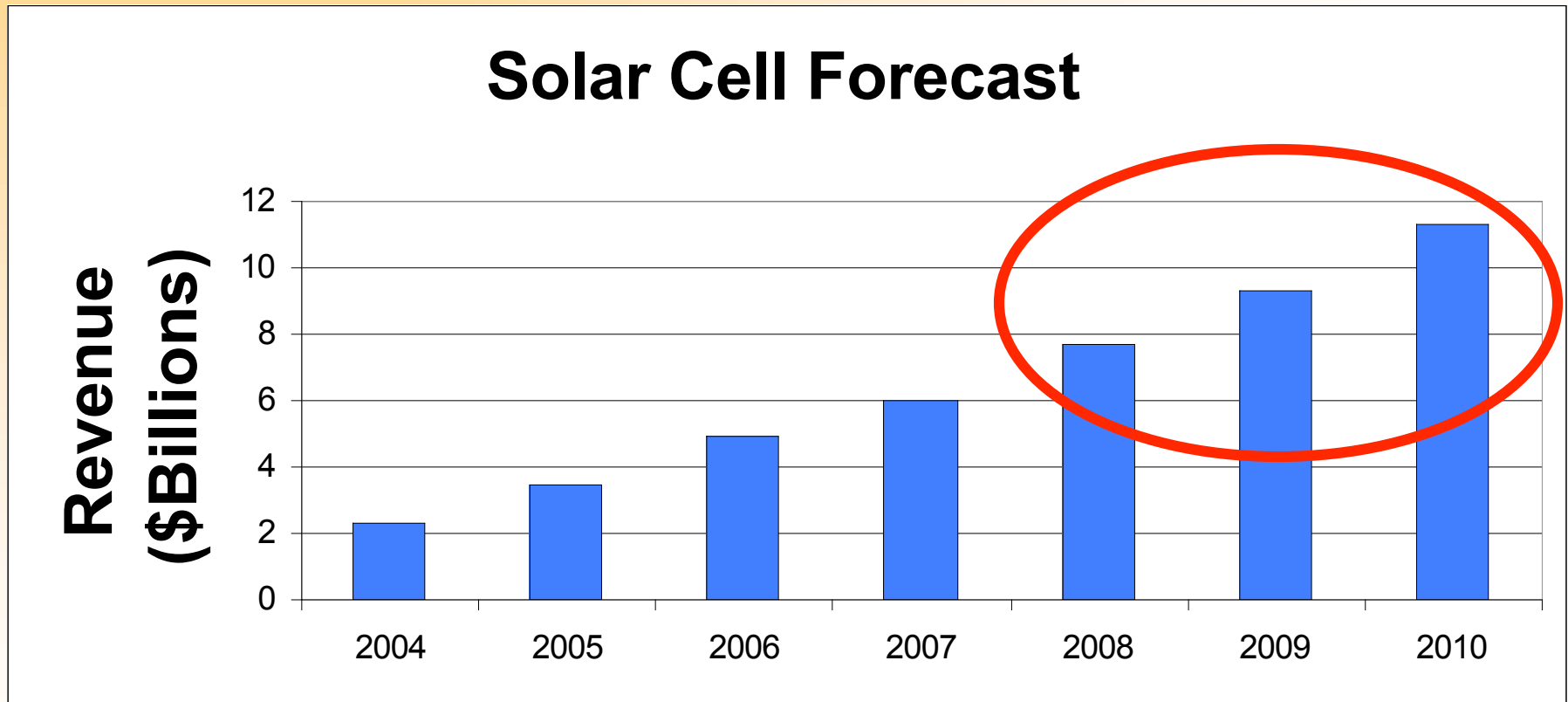
Solar



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

Global solar cell forecast

n Fueled mostly by Japan and Germany



Sources: CLSA, Solar Power Sector Outlook 2005, OIDA



Michael Lebbby (lebbby@oida.org)

Revenues grow to >\$11B by 2010

Silicon based photovoltaic value chain

- n Improved cell efficiency means fewer modules are needed for same power production
- n Wafer costs could be reduced further with panels



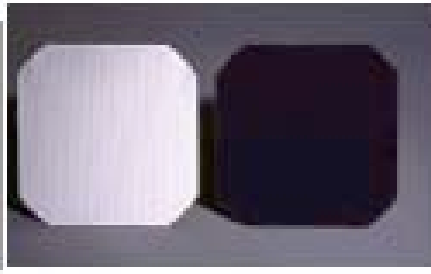
Silicon



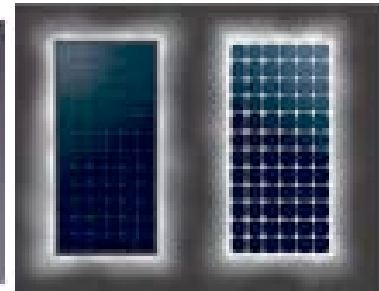
Ingot



Wafer



Solar Cell



Solar Module

50% Cost

25% Cost

25% Cost

Source: Ilan Gur – University of California, Berkeley

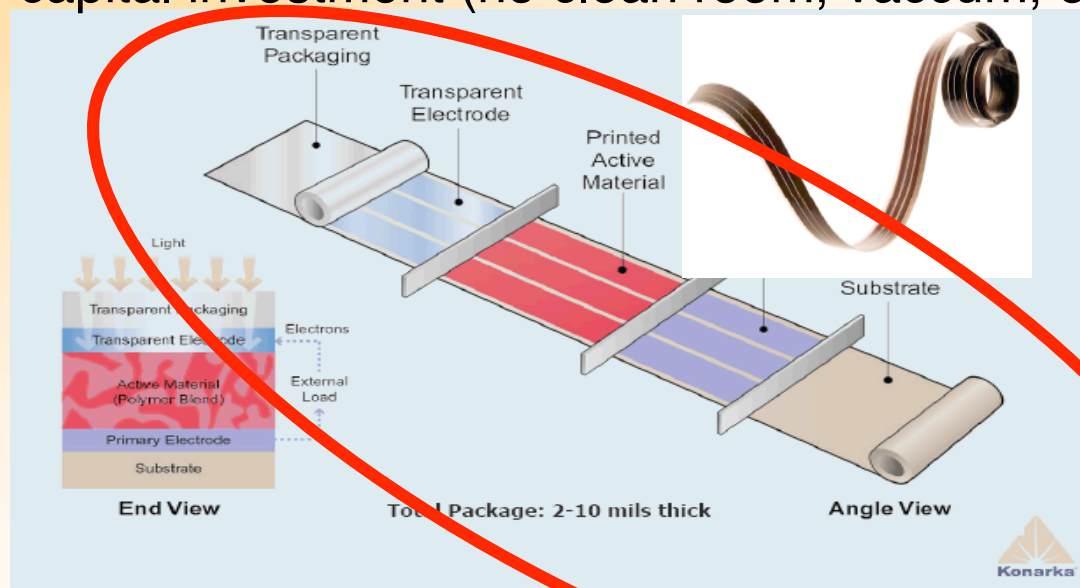


Michael Leby (leby@oida.org)

Innovative manf like displays is needed

Printing approaches to solar cells

- n Organic carbon based inks technology
- n Printing process allows continuous roll process
 - ÿ Lower capital investment (no clean room, vaccum, or silicon)



Source: Konarka

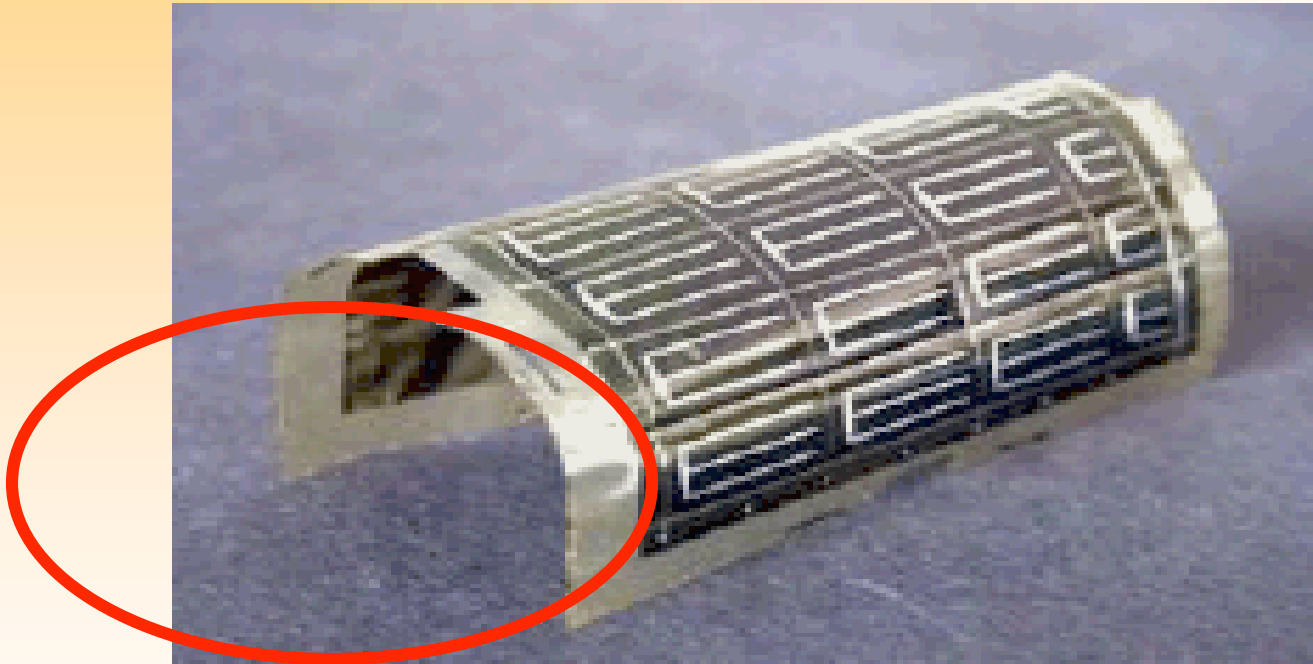


Michael Lebby (lebby@oida.org)

Capital investment in plant: big driver

Manufacturing focused

n CIGS (copper indium gallium diselenide) materials



Source: Thin Film Physics Group – ETH Zürich



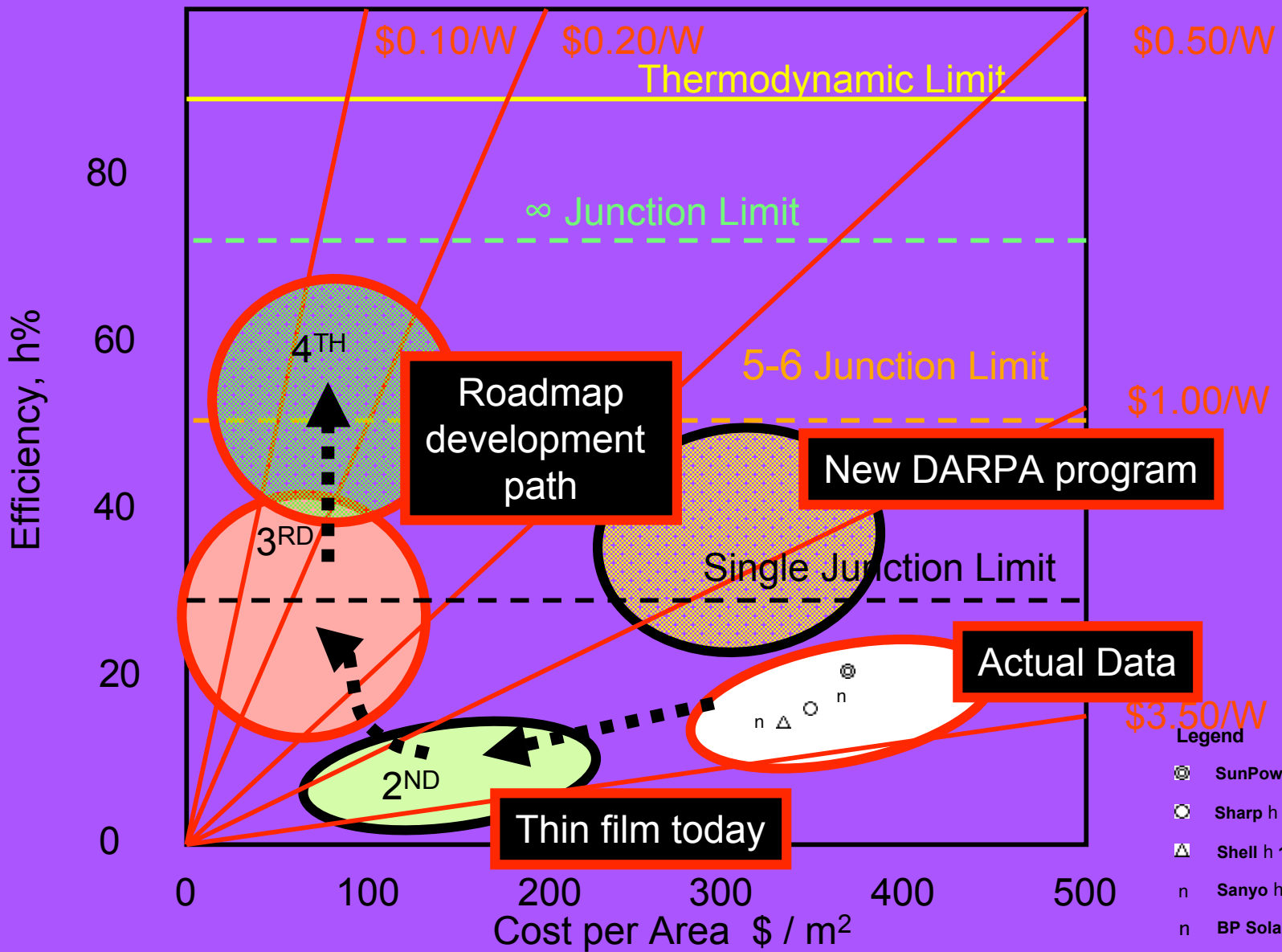
Michael Leby (leby@oida.org)

Improved efficiencies ~20% today

Solar roadmap 2005

OIDA

Solar cell platform roadmap



Roadmap development path

New DARPA program

Actual Data

Thin film today

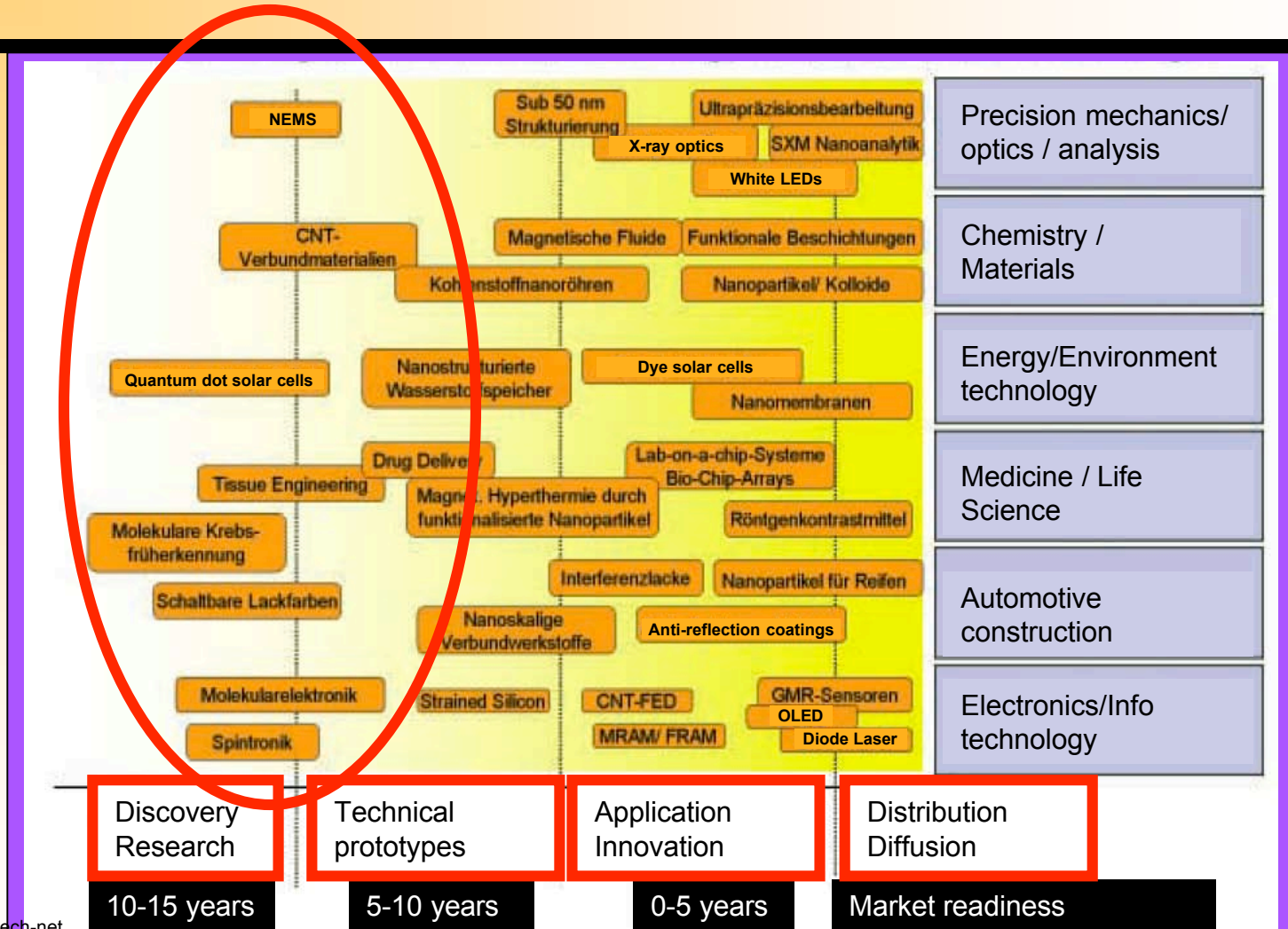
- Legend**
- ⊙ SunPower h 21.5% cell
 - Sharp h 15% cell
 - △ Shell h 14% cell
 - n Sanyo h 19% cell
 - n BP Solar h 14.2% cell

OIDA: comparing roadmaps...



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

European nanotechnology roadmap



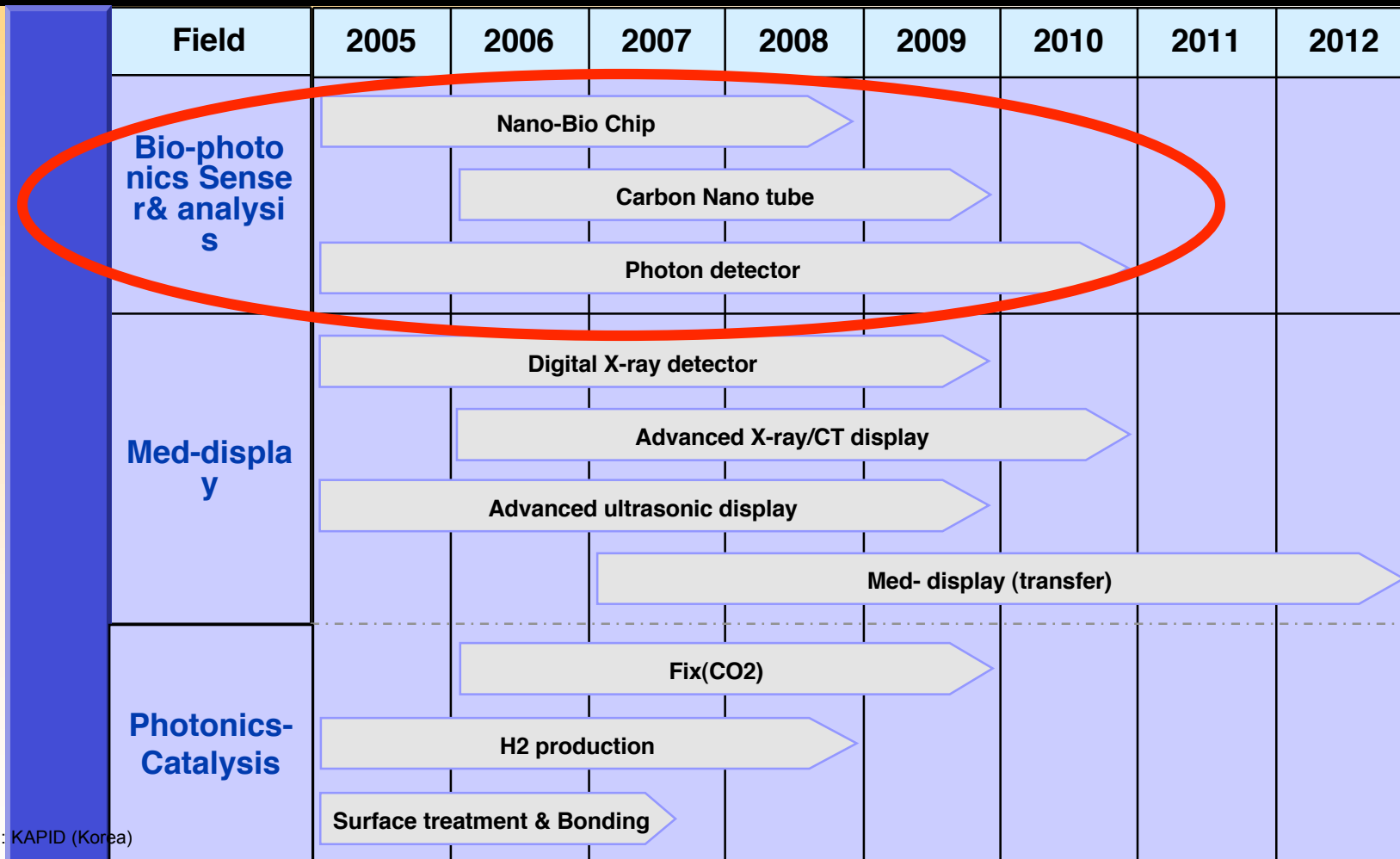
Sources: BMBF, Optech-net



Michael Lebbby (lebbby@oida.org)

Trends towards advanced analysis

Korean biophotonics roadmap



Source: KAPID (Korea)

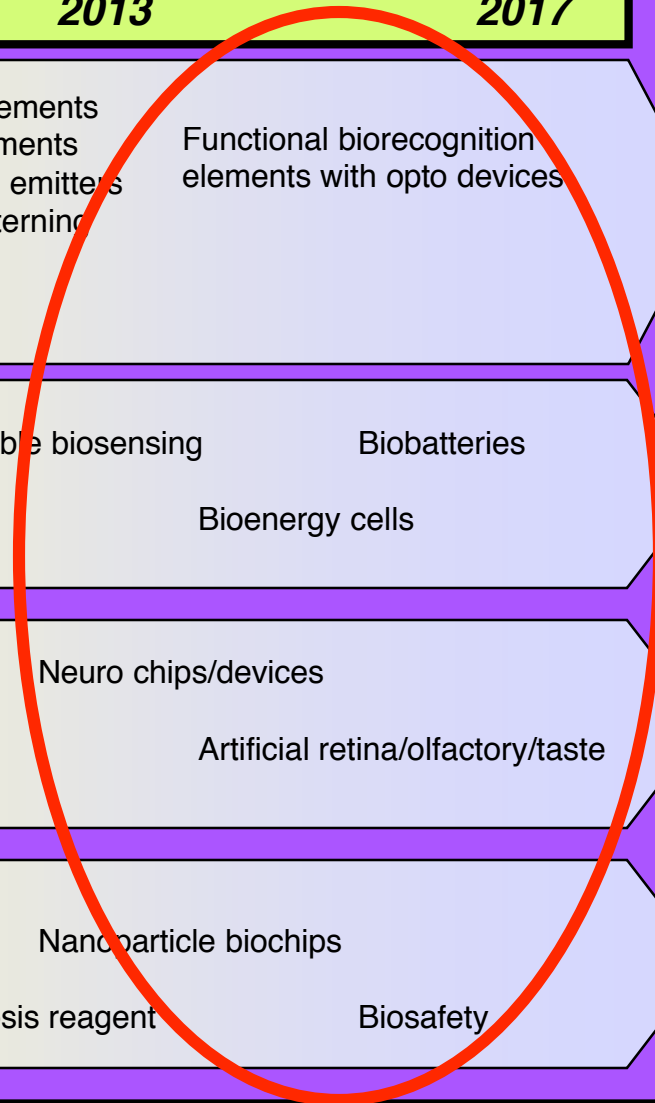


Michael Leby (leby@oida.org)

Trends of advancing technologies

OIDA Bio-nano-photonics trends roadmap

OIDA	2005	2009	2013	2017
Technology level	Multianalyte Detection Biorecognition Molecules Fluidics In-vivo sensors Chemical ID Biosensors Data processing, Pattern Recognition, Automation	Patterning biorecognition elements Coupling biorecognition elements with arrays of detectors and emitters Imprint technologies for patterning Real time monitoring Long term stability testing		Functional biorecognition elements with opto devices
Biocompatible in-vivo nanodevices	Diagnosis reagents (optically sensitive devices)	Drug delivery (nano spheres/capules)	Implantable biosensing	Biobatteries Bioenergy cells
Nanodevice biometric sensing	Nanodevice signal transport Nanosensor arrays	Nanobiosensors	Neuro chips/devices	Artificial retina/olfactory/taste
Nano biolabeling and diagnosis	Nano biolabeling	Nanoparticle biolabeling	Nanoparticle biochips	Nanoparticle diagnosis reagent Biosafety



Michael Lebbby OIDA (2006)

Michael Lebbby (lebbby@oida.org)



Trends towards advanced applications

OIDA Sensor Roadmap

OIDA	2005	2009	2013	2017
Health Care (medical, welfare, health)	O2 monitoring	Optical mammography	Optical computed tomography	→
	Gene therapy	Micro chemistry	Fully automated diagnosis	→
	Laser therapy	Metabolism monitoring	Wellness monitoring	→
	UV monitors	Partially automated diagnosis	Sickness forecasting	→
Data (highway, living, society)	Glucose monitoring	Glucose monitoring		
	Pulmonary monitoring	Gene monitoring		
	Highway sensing	Advanced highway sensing	Auto network infrastructure	→
	Smart highways (tolls)	Laser based cruise control	mm-wave cruise control	→
	Pollen sensing	Stress & fatigue sensing	Lifestyle orientated networks	→
Environmental (industrial, energy, agriculture)	Information sensing	Pollen sensing	Odor, taste sensing	→
	Weather, UV sensing	Information sensing		→
	Weather, UV sensing	Weather, UV sensing		→
Advanced technology	NOx, Sox, Dioxin	Crisis mgt (tsunami, food)	Environmental networks	→
	Forest, river ocean, atmosphere monitoring	Sensing network	Femtosecond photon processing	→
	Energy storage sensing			
	Industrial lasers	X-ray lasers	Alto-second pulse sensing	→
	Nano-sensing	THz frequency sensing	Quantum non-destructive measuring/monitoring	→
	Plastic decomposition	Plastic decomposition	Global environment simulator/modeling	→
	Agricultural photonics	High harmonic sensing		
Femtosecond lasers	Global monitoring			
Single photon measuring				

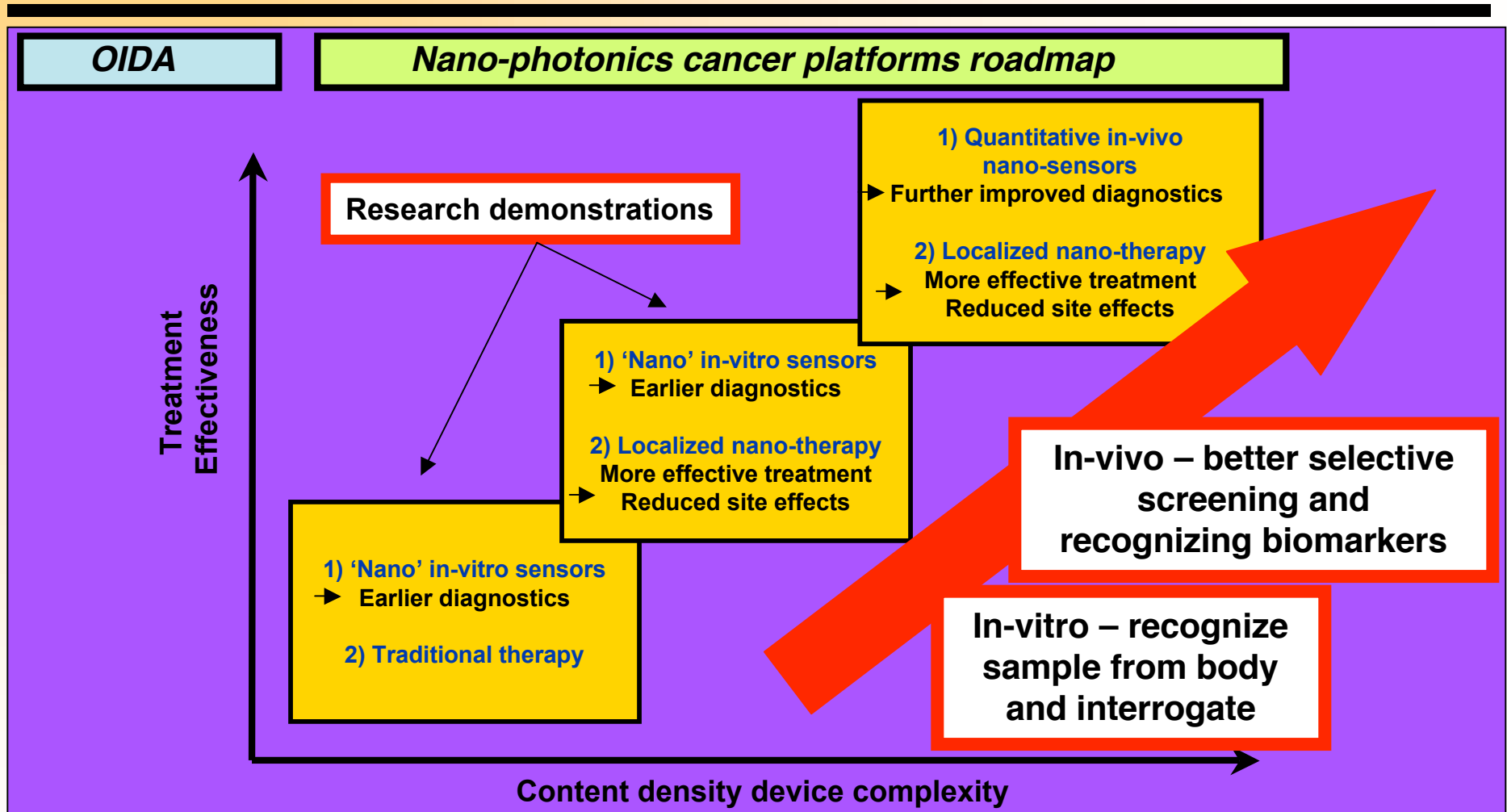
Michael Lebbby OIDA (2006)

Michael Lebbby (lebbby@oida.org)

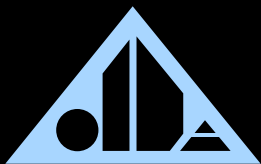


Trends towards integrated sensing

Evolution of treatment: from single- to multi-functional nanotech platforms



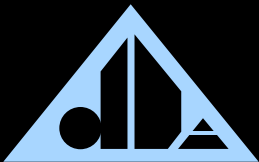
Source: NIH-NCI



Michael Lebby (lebby@oida.org)

Roadmap to more complex treatments

***DARPA/OIDA new R&D
matching program***



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

University Photonics Research (OE Centers)

- n DARPA/MTO funds 4 University Consortia for photonics research
 - ÿ Novel materials, devices, system on a chip
 - ÿ In 2nd year of 4 year program

- n *DARPA would like UPR Centers to have industry collaboration to accelerate specific programs for development*

- n *DARPA is willing to match industry participation*
 - ÿ *Trending towards 50% DARPA, 50% Industry (post doc)*
 - ÿ *Post doc will work on specific industry interest to accelerate project through research*
 - ÿ *Expectation*
 - *10 accelerating programs (DARPA total commitment \$500k)*
 - *Per person: \$100k (ie \$50k match)*
 - *Type of match TBD*

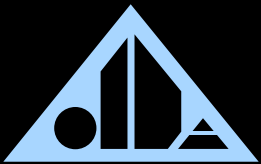


Michael Lebby (lebby@oida.org)

DARPA wants industry supporting R&D

Summary

- n Optoelectronics market is now vibrant**
 - ÿ Consumer/entertainment driving growth today
 - ÿ OE penetration in many new markets, driven by displays
- n Key trends**
 - ÿ Displays – the LCD gathers momentum; OLEDs grow quickly
 - ÿ HBLEDs: solid state lighting and automotive exciting
 - ÿ Image sensing, fiber sensors, lasers and solar vibrant
 - ÿ Consumer products multiply with optoelectronics
- n OIDA now very active...**
 - ÿ Bringing industry closer to academia...
 - ÿ Helping DARPA match projects between industry/academia



Michael Lebbby (lebbby@oida.org)

OIDA is *Optomistic* J

End



OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

OIDA industry membership and...

Voting Members

Avanex
Avago
Bookham
Corning
CyOptics
Digital Optics/Tessera
EMCORE
General Dynamics
Infinera
IQE
JDSU
Telcordia
Translucent

Associate Members

Arasor
BinOptics
Calient Networks
Canadian Microelectronics
Canadian Phot. Consortium
Ciena
CRI
CSEM
DTI

EM4 Photonics
Finisar
Incubic
Infotonics Center
Kotura
Light Wave Venture
Lumileds Lighting
LxSix
MergeOptics
Nat'l Optics Inst., Canada
Nat'l Res. Council of Canada
OpNext
OptiComp
Panasonic Boston Lab
Redfern Integrated Optics
Rsoft
Sandia Nat'l Laboratories
SCHOTT North America
Syntune
Teraxion
TRA-CON
Xponent

University Affiliates

Boston University Photonics Center
Kent State University
Lehigh University
MIT-CIPS
Photonics Research Ontario
Rensselaer Polytechnic Institute
**University of California,
Los Angeles**
University of New Mexico – CHTM
**University of North Carolina,
Charlotte**
University of Michigan

Pending members

**Applied Materials, Cisco,
Lucent, Alcatel, Cree, Sun, Intel,
Motorola, Newport, Coherent,
Trumpf, Covega, Harris**



Michael Lebby (lebby@oida.org)

Broad range of opto technologies

OIDA – OSA Affiliate Members

3M Company	Electro-Optics Technology Inc	Morgenthaler Ventures	Promex Industries Inc
4D Technology Corporation	Elliott Scientific Ltd	MPB Communications, Inc	Quantronix Lasers
Aculight Corp	ELS Elektronik Laser System GmbH	New Focus Inc	Quintessence Photonics Corporation
ADE Phase Shift	EM4 Inc	New Scale Technologies	R Bradley & Assoc LTD
Advanced Glass Industries	Engineering Synthesis Design Inc	Newport Corporation	Rainbow Research Optics, Inc.
Advanced Photonix, Inc.	Essex Corporation	nLight Photonics Corp	Raydiance, Inc
Aerodyne Research, Inc.	Fiberguide Industries, Inc.	Northrop Grumman Information Technology	RED-C Optical Networking
Aerotech Inc	Fiberxon, Inc.	NP Photonics Inc	Research Electro-Optics, Inc
AFL Telecommunications	Fresnel Technologies Inc	NSG America	Rochester Precision Optics
Albert Einstein College of Medicine	Gemfire Corp	Nufren	Rockwell Science Co LLC
Alpine Research Optics	Goodrich Corporation	Ocean Optics Inc	RPC Photonics Inc
Apogee Photonics Inc	Greater Rochester Enterprise	OFR Inc, Optics for Research	RSoft Design Group
APPLIED IMAGE Group	Griot Group Inc	OFS, Specialty Photonics Division	S.I. Vavilov State Optical Institute
ARIA Technologies, Inc.	G-S PLASTIC OPTICS	Olympus Integrated Tech America Inc	Santec Corporation
ASML Optics LLC	Hamamatsu Corporation	Omega Optical Inc	Santur Corporation
Aurora Optical	Hardin Optical Co.	Ophir Optronics Inc	Scintera Networks
Avo Photonics	Harrick Plasma	Opnext Inc	Scottish Development International
Barr Associates Inc	Headwall Photonics Inc	Optical Air Data Systems	SENKO Advanced Components Inc
BinOptics Corp	Horiba Jobin Yvon Inc	Optical Research Associates	Siskiyou Corporation
Bioptigen	Ibsen Photonics A/S	Opticorp Inc	Special Optics Inc
Breault Research Organization Inc	IMRA America Inc	Optics for Devices, SCHOTT North America	Spectra-Mat Inc
Bright View Technologies	InPhenix, Inc	Optics Technology Inc	Spiricon Inc
California Eastern Laboratories	INRAD Inc	OpticsProfessionals LLC	Summers Optical
Cambridge Technology Inc	Intel Corp	Optigo Systems	Sutter Instrument Co
Cambridge University Press	Ionic Systems	Optikos Corporation	Sydor Optics Inc
CDM Optics Inc	IPG Photonics Corp	Optimax Systems Inc	TeachSpin Inc
Central Glass & Ceramics Res Inst	JDS Uniphase Corp	OptiPro Systems	Technical Manufacturing Corporation
CEYX Technologies Inc	JMAR Technologies, Inc.	Optiwave Corporation	Tempo Plastic Co
Chang Chun Bo Xin Photoelectric Co., Ltd.	Kaptayn-Murnane Laboratories	Optometrics Corporation	TeraXion, Inc
Checkpoint Technologies, LLC	KoSearch Inc	OptoSigma Corporation	The Institute of Optics
Christie Associates	Kotura, Inc.	Orbits Lightwave, Inc.	Thorlabs Inc
Chroma Technology Corp	LabNow, Inc.	OZ Optics, Ltd	Tinsley/SSG Precision
Coherent Inc	LaCroix Optical Co	Pacific Biosciences, Inc.	Toptica Photonics Inc
ColorChip, Ltd.	Lambda Research Corporation	Palomar Technologies	Tower Optical Corp
Conoptics Inc	Laser Focus World	PD-LD Inc	u2t Photonics AG
Coming Inc	Lasertel Inc	Pennsylvania State University	Univ of Arizona Optical Sciences Center
Covega Corporation	Light Brigade, Inc	Pentax Corp	University of Central Florida, CREOL
CRI Inc	LINOS Photonics Inc	PFG Optics	US Conec Ltd
Crystal Fibre	Louis Rudzinsky Associates Inc	Photonics Industries International Inc	Verrillon Inc
CVI Laser LLC	Lumen Flow Corporation	Photonics On-Fiber Devices Inc	VPIsystems
Del Mar Photonics Inc	Lumetrics	Photonics Spectra	Wafer World Inc
Delta F Corp	Luna Technologies, Inc	Photop Koncent, Inc	Xponent Photonics Inc
Deposition Sciences, Inc.	Lydall Inc.	PI (Physik Instrumente) L.P.	Zygo Corporation
Diamond USA Inc	Market Tech, Inc.	piezosystem jena GmbH	piezosystem jena GmbH
Digital Optics Corp	Massachusetts Inst of Tech Lincoln Lab	Polatis, Inc.	Polatis, Inc.
Directed Energy Solutions	Meadowlark Optics	Polymicro Technologies Inc	Polymicro Technologies Inc
DSS	Melles Griot Inc	Precision Photonics Corporation	Precision Photonics Corporation
Edmund Optics	Merck KGaA	Princeton Lightwave, Inc.	Princeton Lightwave, Inc.

192 companies represented

Highlighted Companies (10) are also Full OIDA Members



Michael Lebby (lebby@oida.org)

~ 250 Companies Represented