
***“A sneak preview of a
few grand photonics
challenges”***

Michael Lebby

President and CEO

OIDA



OIDA: Optoelectronics Industry Development Association

Overview

- **Optomism** and excitement...
 - How far we've traveled; where we're going
 - The next 10yrs for optoelectronics: market trends
- Grand challenges defined...remember these takeaways...
 - Terabit Photonics
 - Mobile Photonics
 - Plastic Photonics
 - Green Photonics
- Summary



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Your assignment: remember 4 phrases

***We are great at
conceptual ideas...***



OIDA: Optoelectronics Industry Development Association

Dick Tracy cartoon character



- 1946 – two-way wrist radio
- 1964 – wrist TV

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And in 2066...will this be implanted?

Advanced phone watch

- Prototype: does this mean the wrist is back?



Source: LG, engadget



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CES '08

***In 10 years from
now...we have to
imagine how will we
live our lives?***



We'll need to anticipate future lifestyle needs...

- Aging population in developed countries
 - Medical needs
 - Assisted living issues
- Energy
 - From hydrocarbon-based to hydrogen-based
 - Distribution
- Data explosion and mobility
 - Need knowledge – not just data – anywhere anytime
 - Need to work anywhere, anytime
- Water
 - Potable
 - Agricultural
- Food
 - Quantity
 - Quality (spoilage, nutrition)
 - Safety

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Green, healthy and knowledgeable

Once we anticipate future lifestyle needs, we then have to see if future technology and products can support those needs...



→ Interesting grand challenges...

In a decade... our communicator will be part of our life...



Sources: OIDA, Philips, RIM, Digital Optics, Sony Ericsson, HP, Siemens, Apple, OIDA members

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Photonics *will* support our lifestyle

Personal information medic...

- Tricorder (web definition)
 - “A scanning device used for Medical, Geological, Biological, Radiological, Technological, Positronic, Neurological, and many other types of scans. hand held, portable, and accurate.”

- Triquarter (web definition)
 - “A Triquarter used for medical purpose. It has attached to it a cellular scanner and has the ability to scan for injuries, internal bleeding, organ damage and status, biological data, vitals, chemistry data, microscopic scans, neural activity.”

- Medical data management/access & mobility



Sources: Paramount, www.angelfire.com

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Baby boomers age...increased need

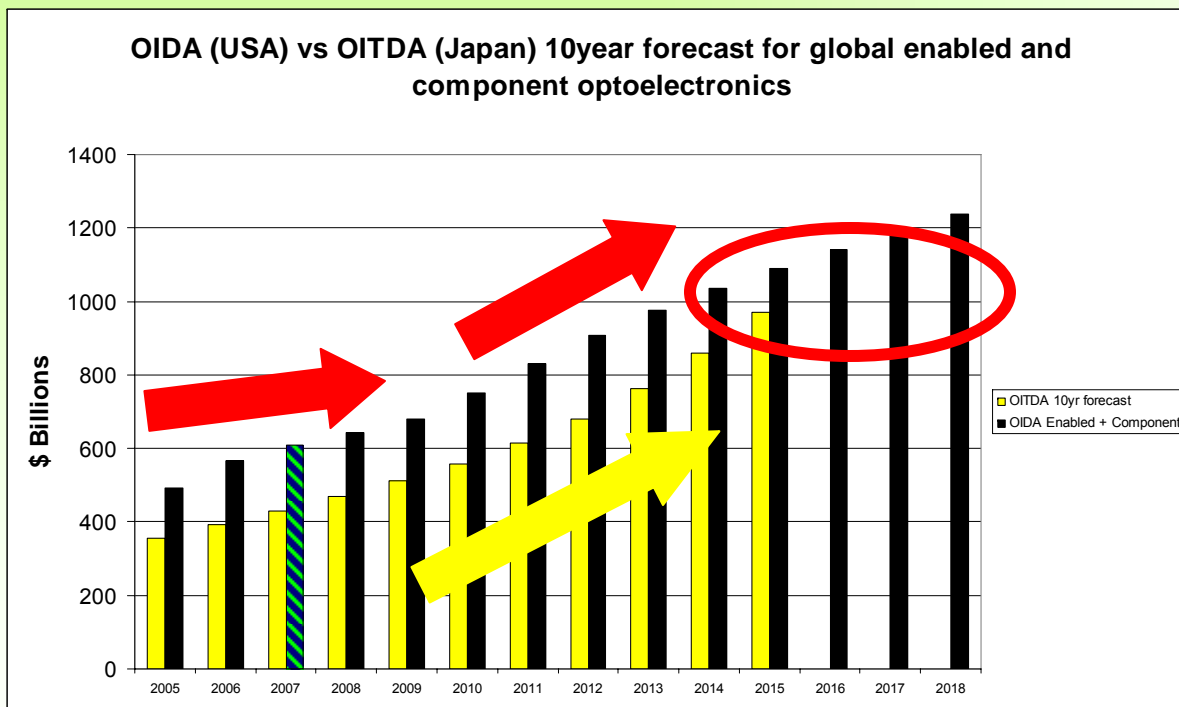
Next decade in Photonics



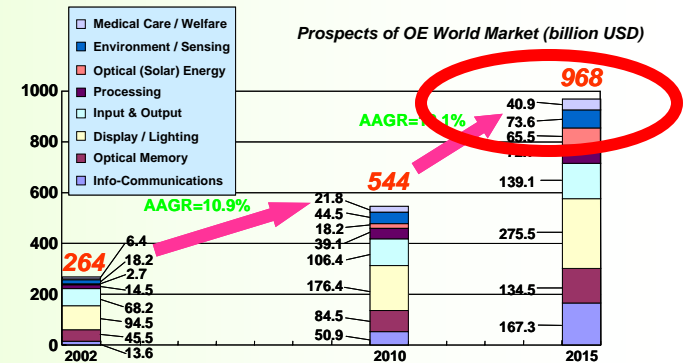
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OIDA vs OITDA OE markets

- OIDA 2007-2018 CAGR 6.8%
- OITDA 2007-2015 CAGR 10.6%



Sources: OIDA, OITDA



Initial draft forecast:
Awaiting peer review

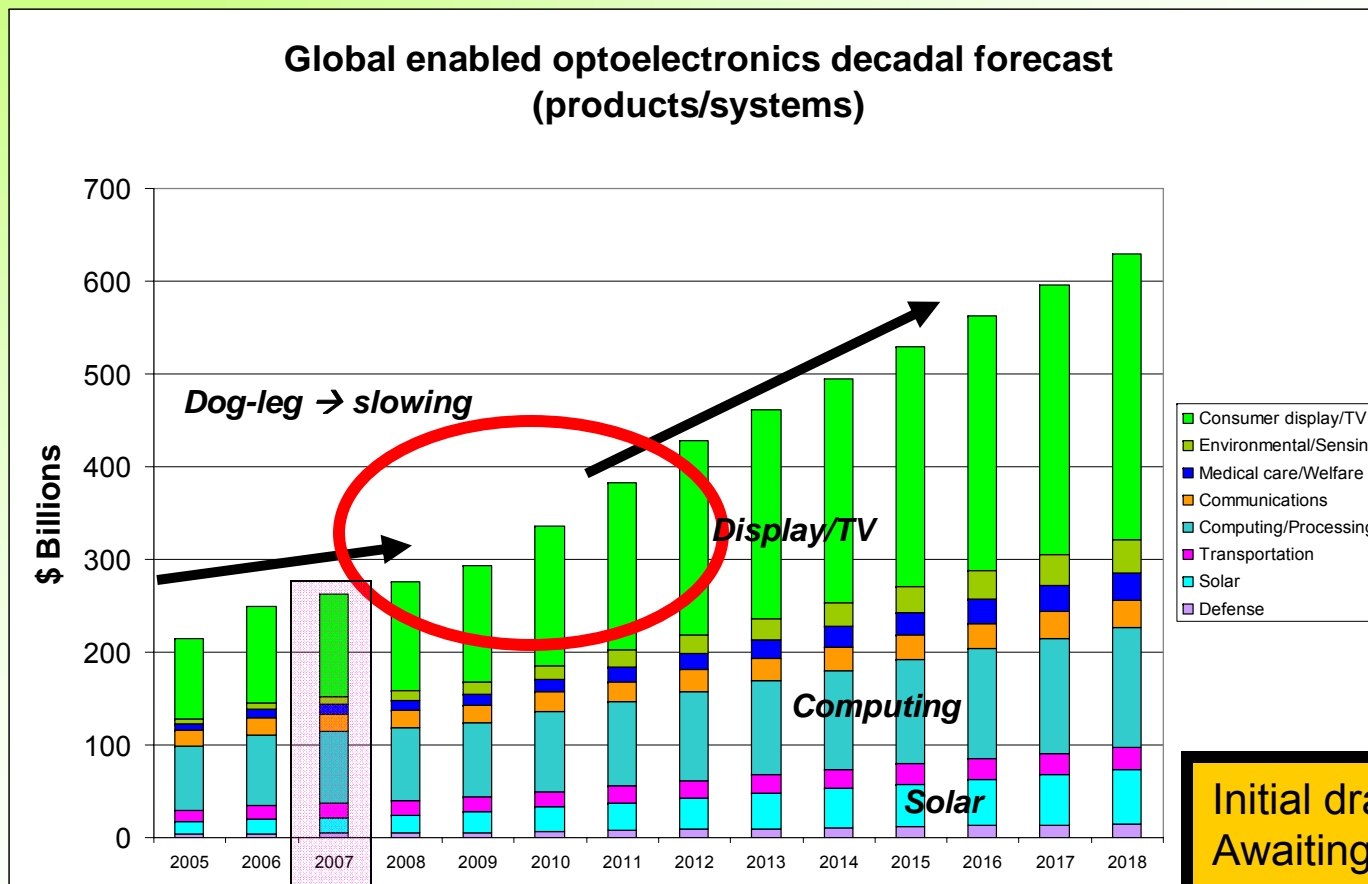


Both forecast >> \$1T OE enabled business

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Photonics enabled products & systems

- In 2007 mkt slowing, and will continue to slow to ~2010



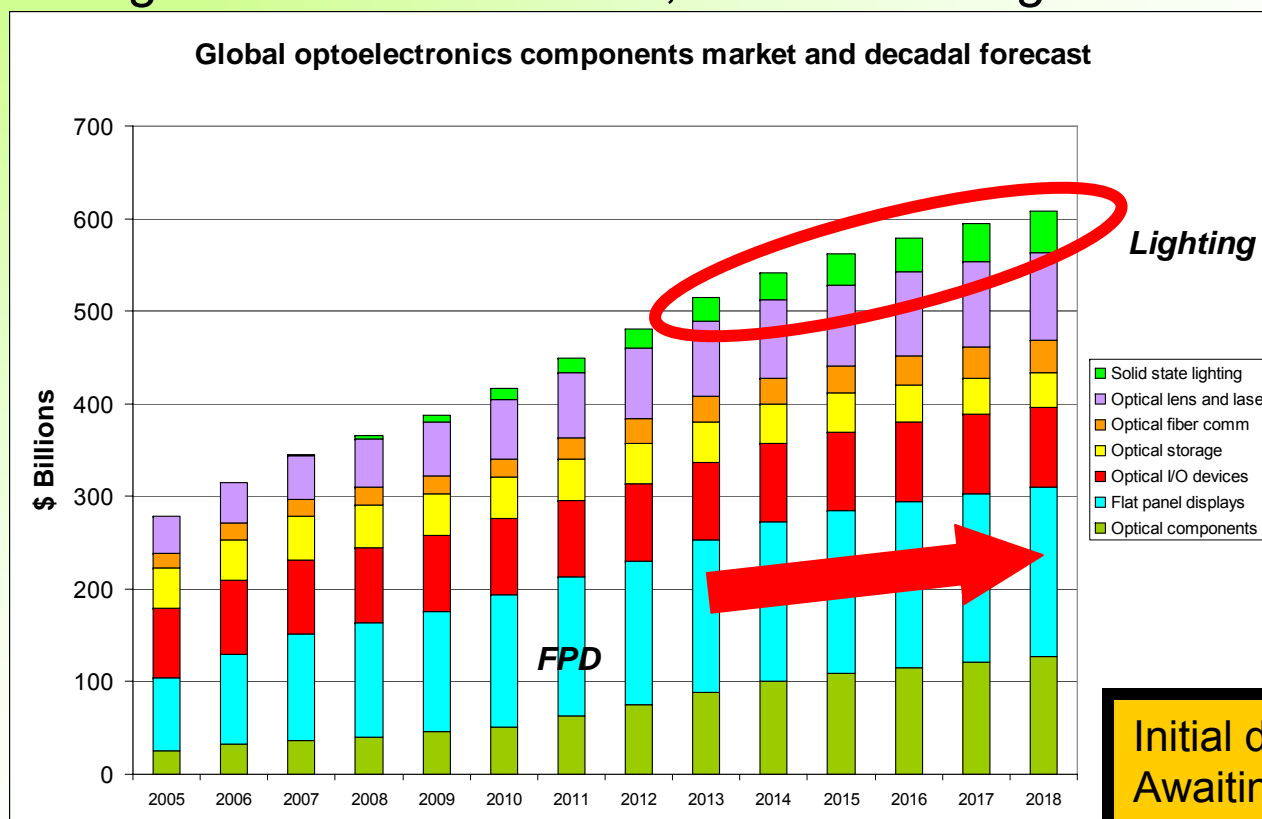
Sources: OIDA, OIDA members, IOA members, PIDA, OITDA

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Big 3 grow to ~\$500B by 2018

Global photonics components market

- Growing from \$345B in 2007 to \$608B in 2018
 - FPD big driver → CAGR 5.5%; SSL still best growth CAGR 49%



Sources: OIDA, OIDA members, IOA members, PIDA, OITDA

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SSL growing to ~\$40B in 2018

***Overall bandwidth
drivers are strong...***



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Video on Demand (VOD) + IPTV is the biggest change in TV since color



- How many of us see going back to Black & White TV?
- Today's change to **High Definition TV** resolutions is minor compared to TV's change to **interactivity** via Personal Video Recorders, Interactive TV & VOD

Source: Cisco

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is this the killer app...?

Filling the pipes with data...

■ Triple / Quad play services

- HDTV, high speed internet, VoIP and wireless

■ Content on-demand

- YouTube.com
- Nico Nico Douga (Japan YouTube)
- iTunes
- Slingbox (3x bandwidth)

■ Migration of Mobile Carriers to 3G

- Mobile TV

■ New Content Service Providers

- Google, Yahoo, Virgin, MSN....



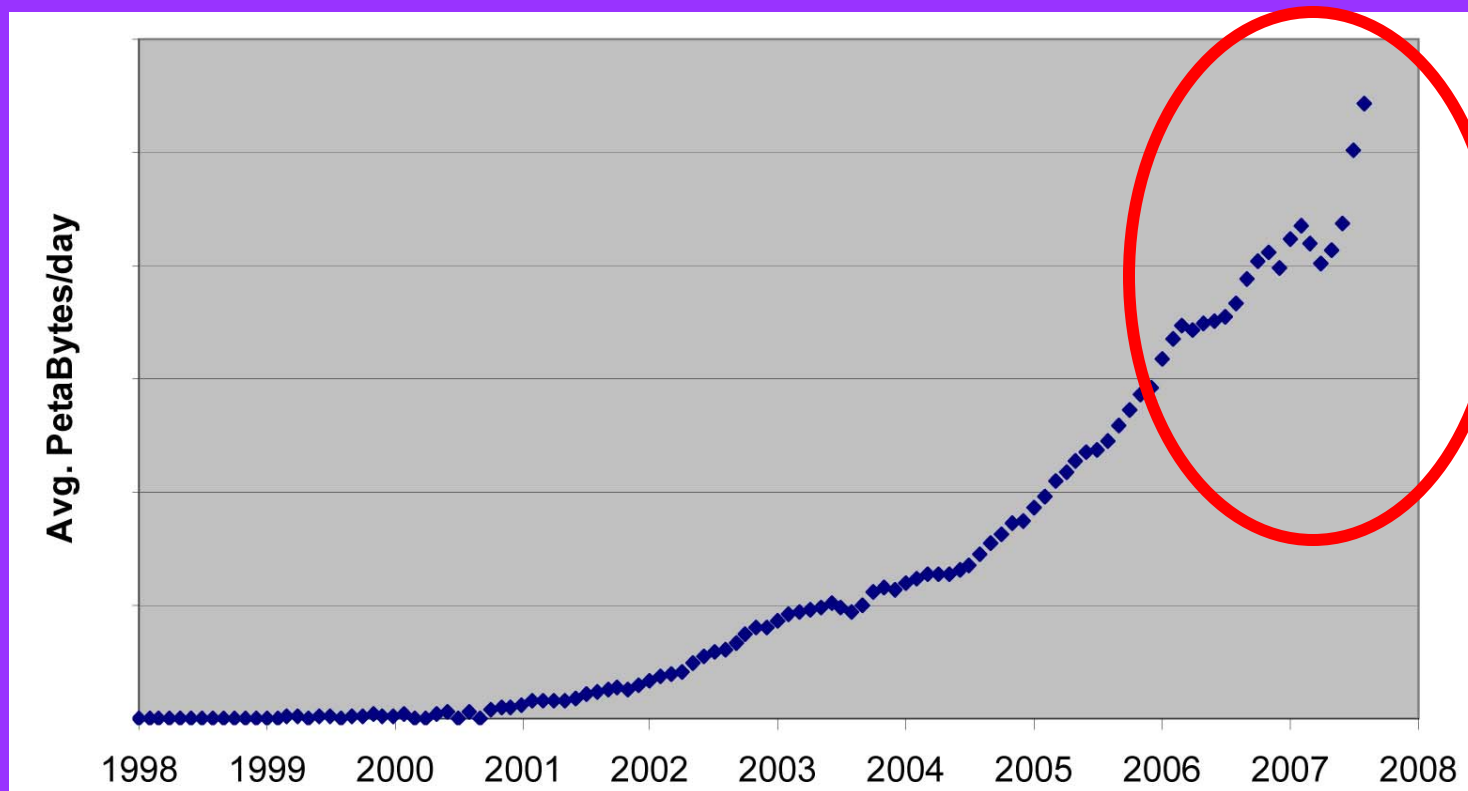
Sources: Nico nico douga, google, skype, microsoft, youtube, JDSU

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Optical networks must be able to cope

Traffic crossing the AT&T network



Source: K. Cambron, AT&T Labs

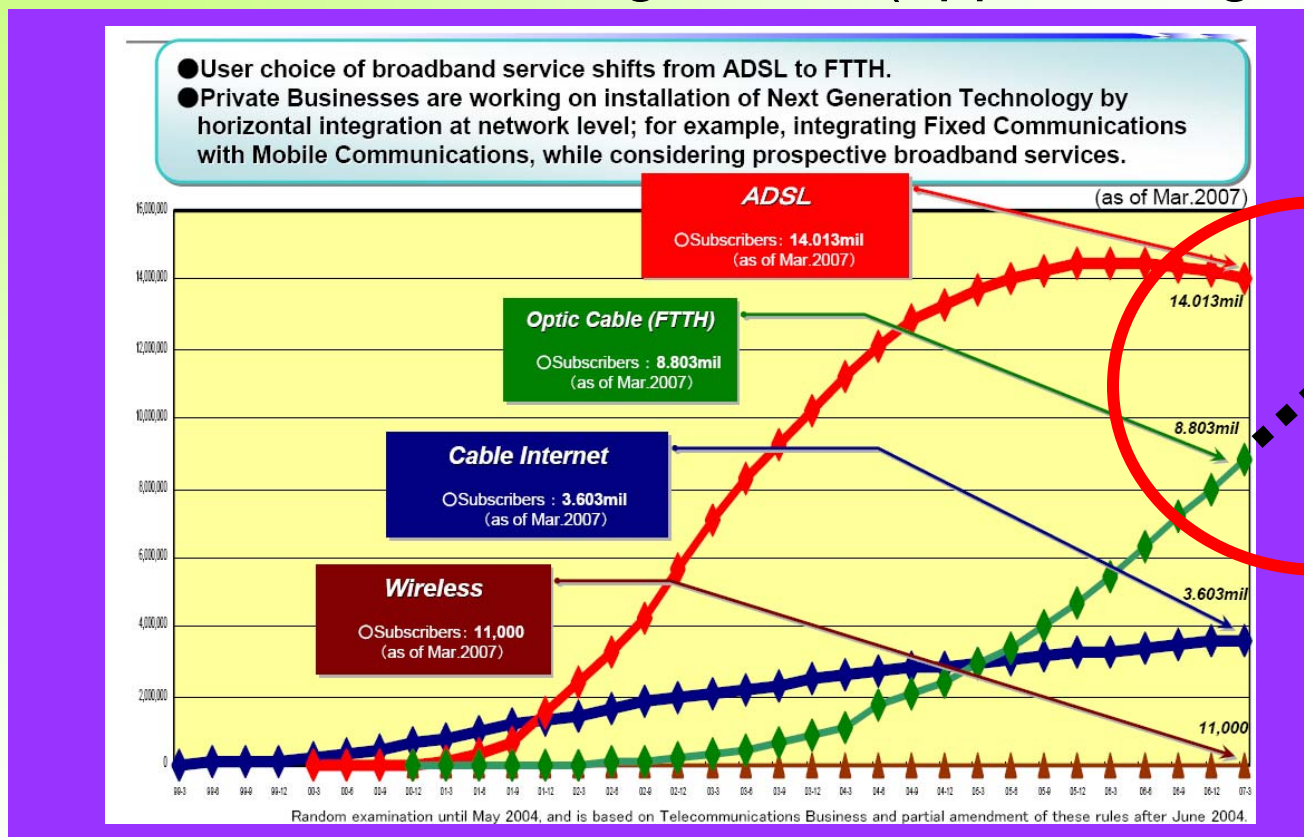
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We're using more bandwidth...

Japanese fiber optics explodes

- Rise of FTTx in 2007 is significant (approaching ADSL)



Source: MIC Japan

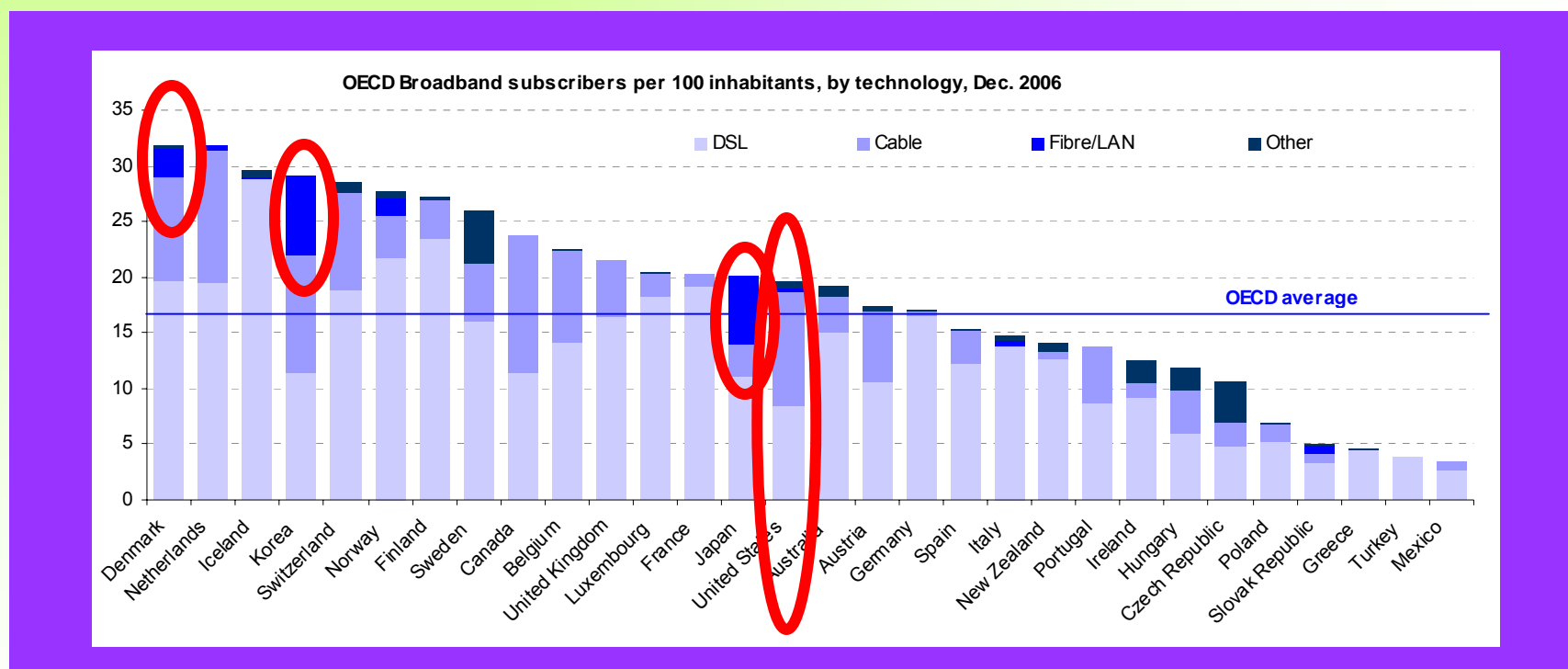
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Best example of FTTx today

FTTx progress in Asia strong

- DSL is being used worldwide for broadband
- Fiber based systems growing quickly (Japan/Korea/Denmark)



Source: OECD

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DSL dominant; fiber growing in Asia

100Gbps and beyond...

■ Confidence:

- We will fill up the bandwidth just like we fill-up disk space and memory...



Source: Y2U.co.uk, Ciena

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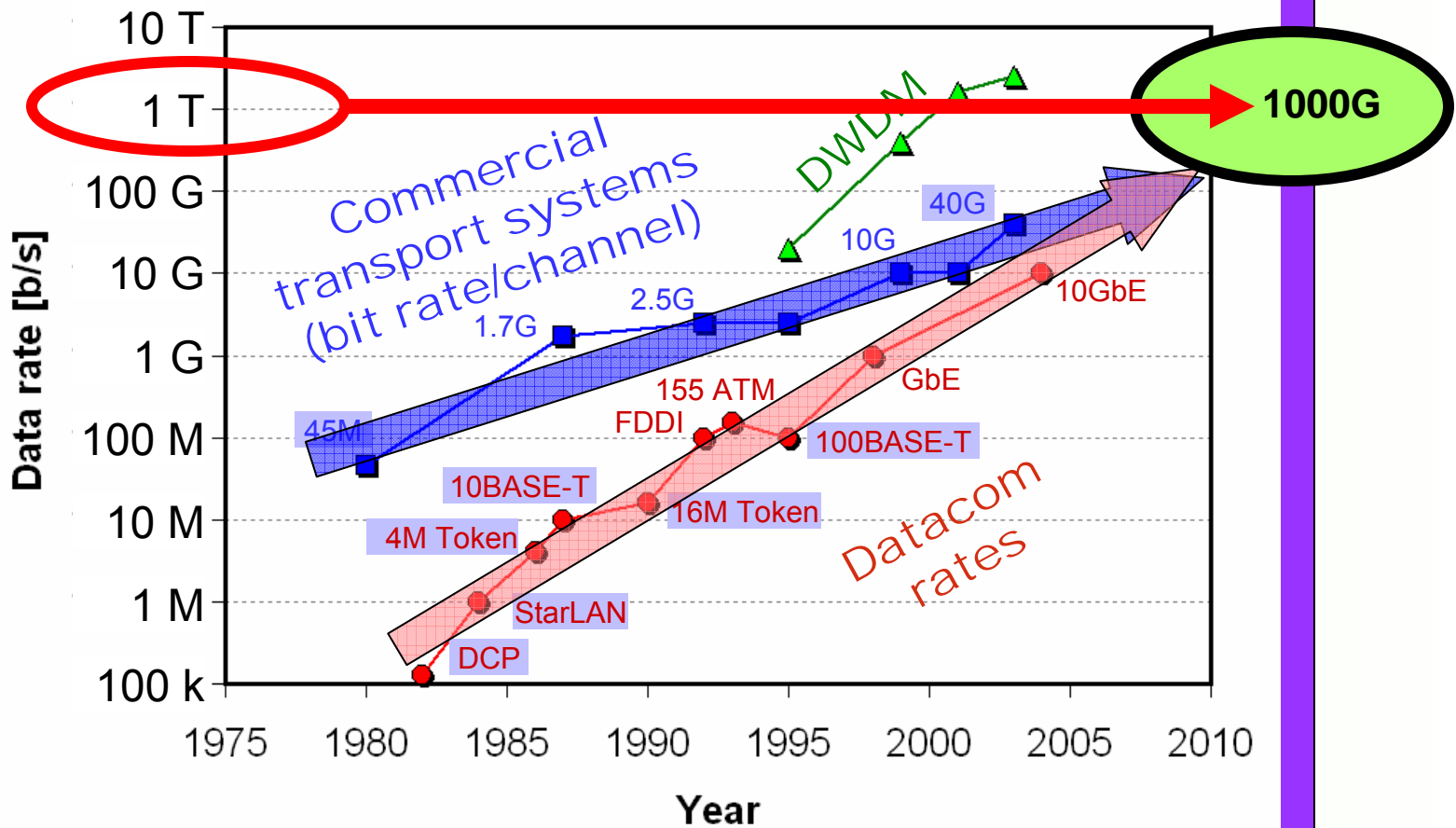
It's fasten your seat-belt time...

Terabit Photonics...



Important takeaway !

On the path to 1000G...(Terabit)



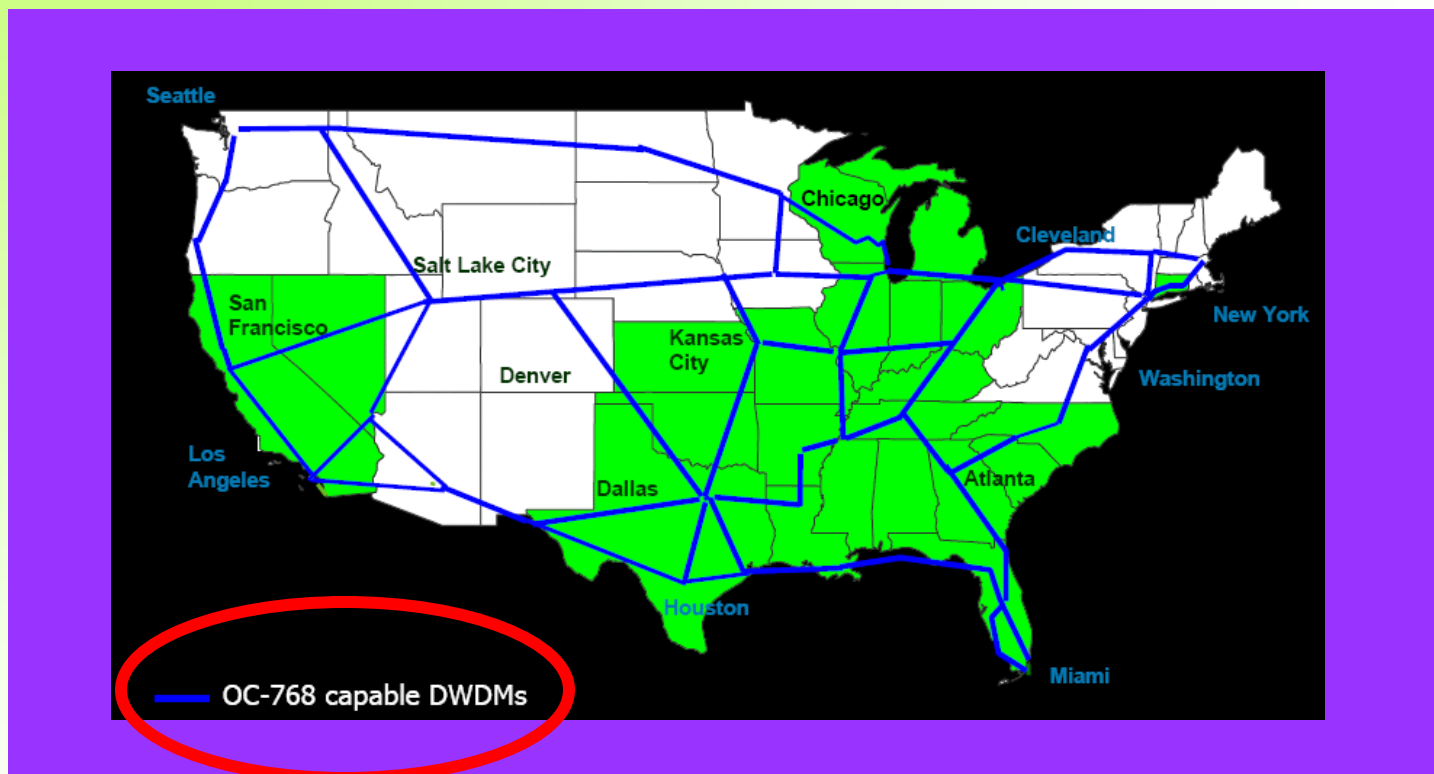
Source: Telcordia, OIDA

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1T node represents a new paradigm

Photonic backbone across USA



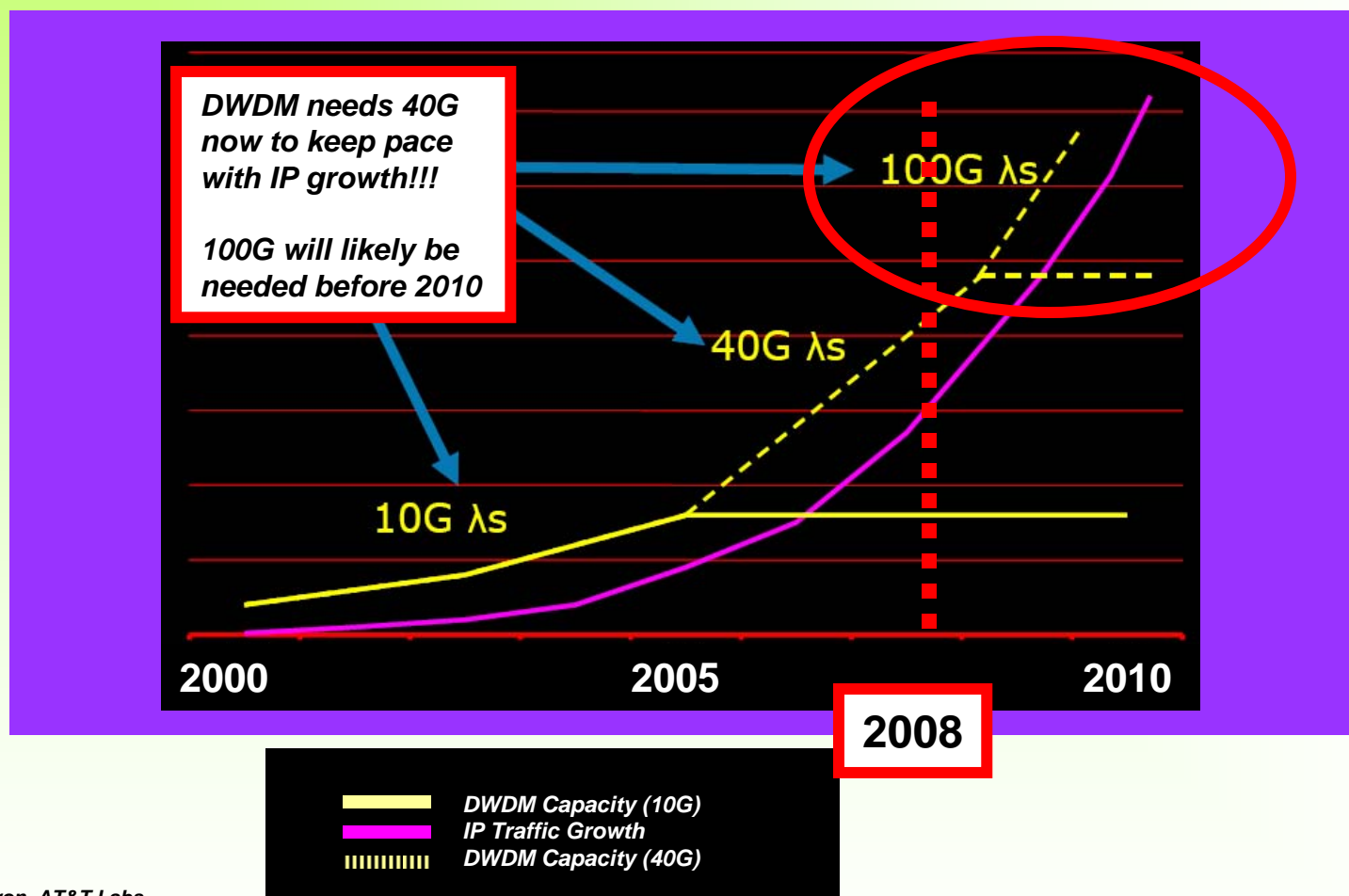
Sources: Cambron, AT&T Labs

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Upgrades to 40G are taking place

IP traffic & DWDM system trends



Sources: Cambron, AT&T Labs

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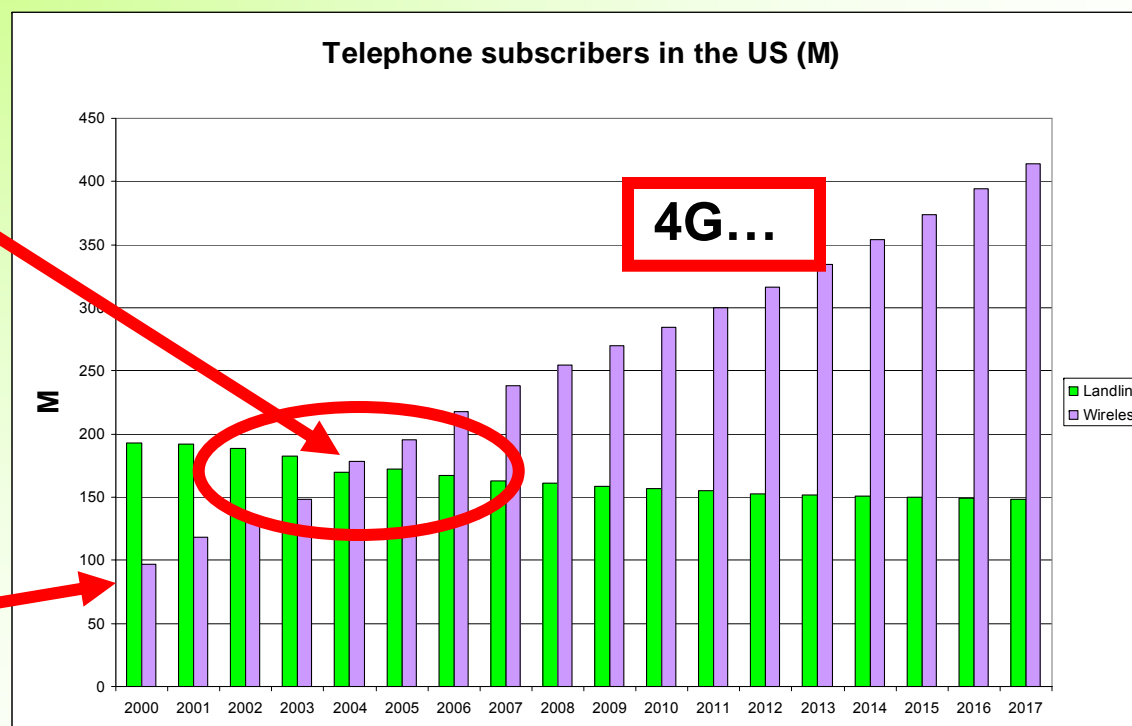
40G demand today → 100G soon!

Telephone subscribers in USA

- Landline supported by broadband at home
- Wireless expected to >400m subscribers by 2017

Wireless surpassed landline in 2004

Internet traffic surpassed voice traffic in 2000



Sources: OIDA, OIDA members, TIA, FCC, CTIA

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Wireless becoming de facto

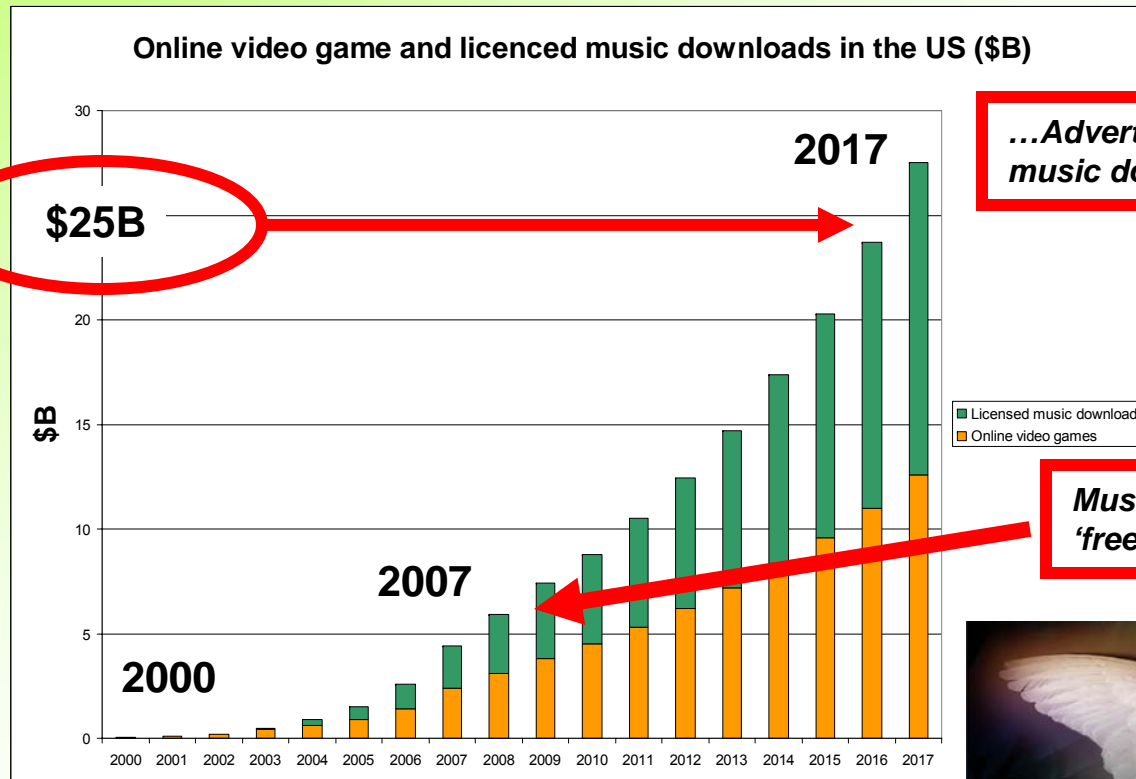
Mobile Photonics...



Important takeaway !

Online video and 'licensed' music downloads

- Surpassing \$25B in next decade



...Advertising during music downloads

Music downloads become 'free' again: Qtrax (2008)



Sources: TIA, OIDA, OIDA members, Qtrax

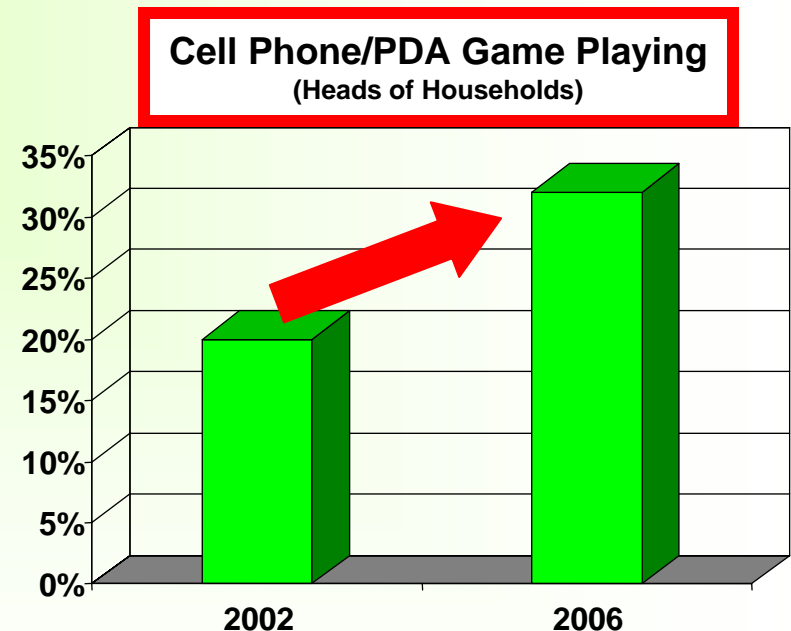
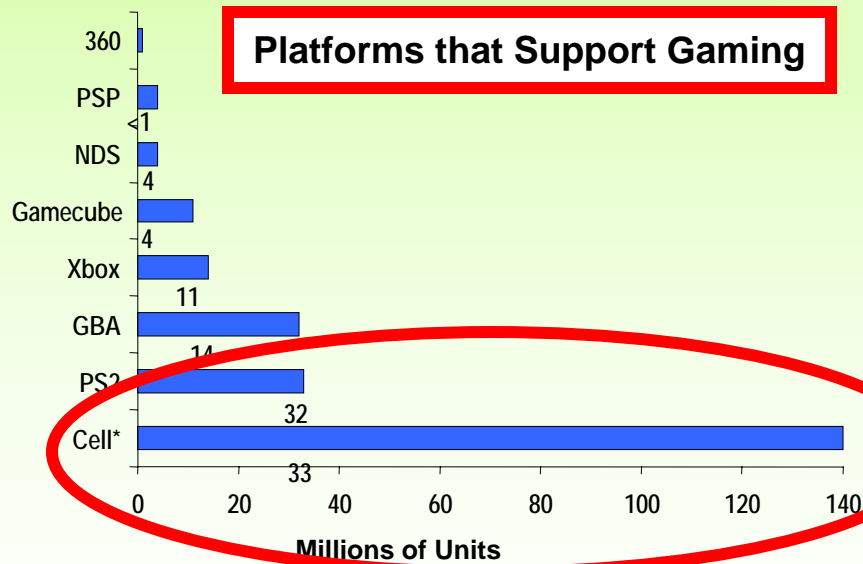
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Subscriber lifestyle/model will change...

Evolving human behavior

- Individual & group sharing of pictures/videos from phones & digital cameras is now commonplace
 - Growth of mobile phone video subscriptions:
 - ABI forecasts 514M subscribers to mobile TV services by 2011 up from 6.4M in 2005*
 - In US, 4M subscribers expected in 2007 up from 1.5M in 2006 (where advertising will help fuel growth)
 - Most services expected to be ~\$10 month*



Sources: OIDA, TI, ABI research (2006), NPD, Entertainment Software Association (2006)



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***Our* mobile 'lifestyle' will drive displays**

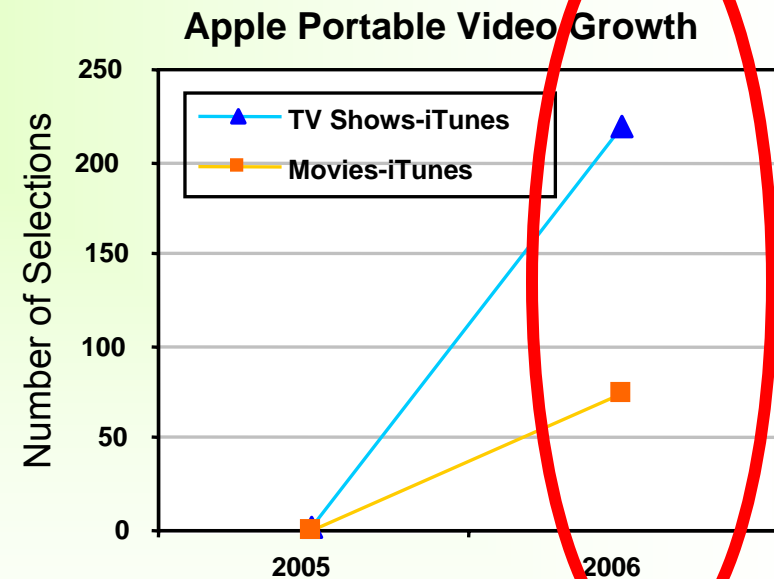
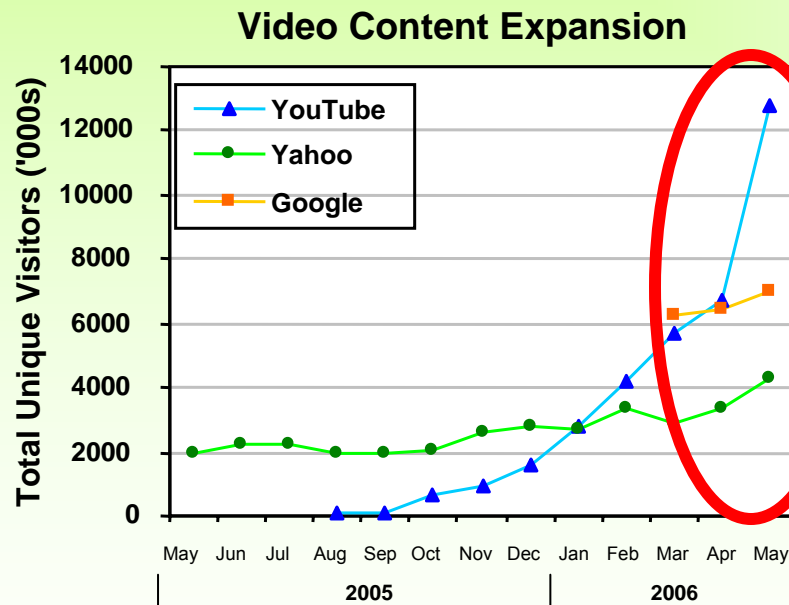
Content keeps expanding...

■ Rampant Growth – Free Content

- YouTube: >100M videos viewed per day
- >65000 videos uploaded every 24 hours
- As of July '06, 20M unique visitors/month

■ Solid Growth - Content for Purchase

- First Music Videos, TV shows...now movies
- Studios aligning with content delivery vehicles



Sources: OIDA, TI, Wikipedia, Mashable social networking 2.0; P Cashmere (2006), Yahoo news (N Finn 2006)

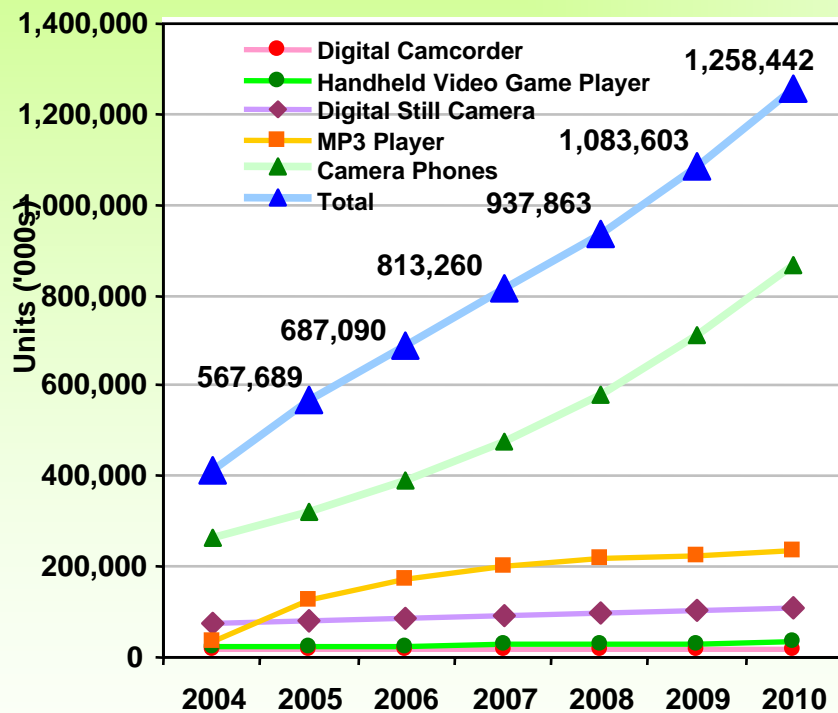


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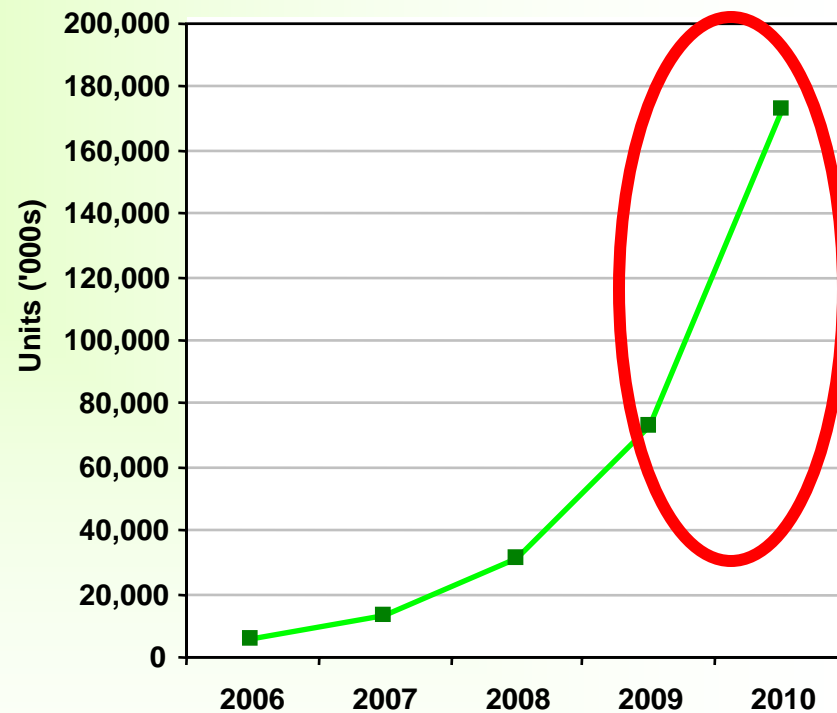
Drivers for the 'mobile living room'

Mobility keeps on increasing...

"Display Challenged" Device Growth



Mobile Phones-TV Capable



Sources: OIDA, TI, iSupply

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Displays become major driver & challenge

Media-rich communicators...

- Early adopter user profiles (wrt iPhones)
 - 51% have watched a YouTube video
 - 46% have watched a music video
 - 34% have watched the news
- GUI (graphical user interface) is popular
- Television is taking off (CTIA April 2008)
 - Mobility is key
- Younger generation concept of
 - “Personal Space”
 - Must have a display and audio...



Sources: AT&T, Verizon

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Vehicles for content...medical next wave

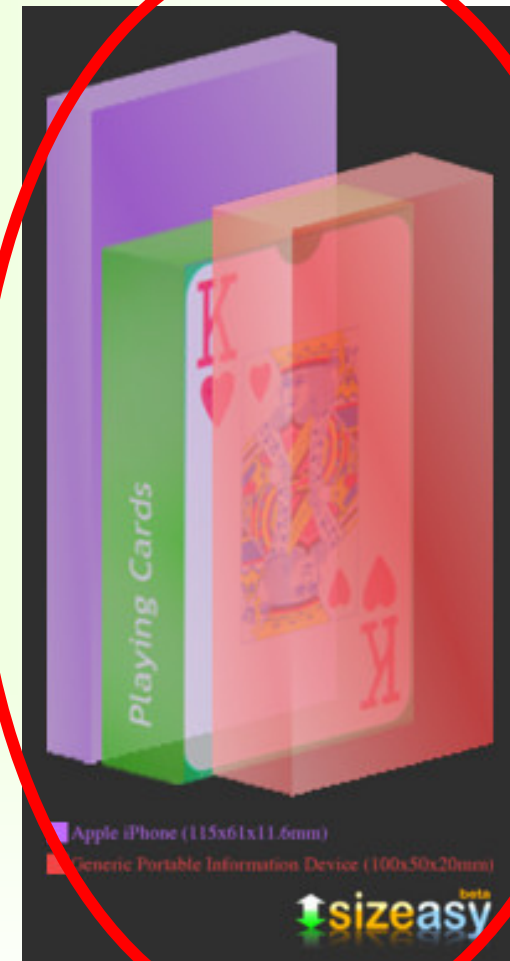
***Photonics is enabling
the wireless
revolution...***



displays, HBLEDs, OLEDs, lasers, cameras

Form-fit-function: pack of cards

- Products today all fit into most hand shapes/sizes
- Pack of cards has product dimensions that have worked for centuries...
- Next generation PDAs, blackberries, iPhones will work within these design constraints



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Mobile, light, convenient...

High photonics content wireless devices

- Photonics allows **converged products** with high functionality
 - 5.0 mega-pixel main camera with auto focus and macro mode
 - Video clips, LED flash, WiFi, Bluetooth, GPS and more!



Wireless Device (Nokia N95) with Extensive Optoelectronics Content
Source: Nokia



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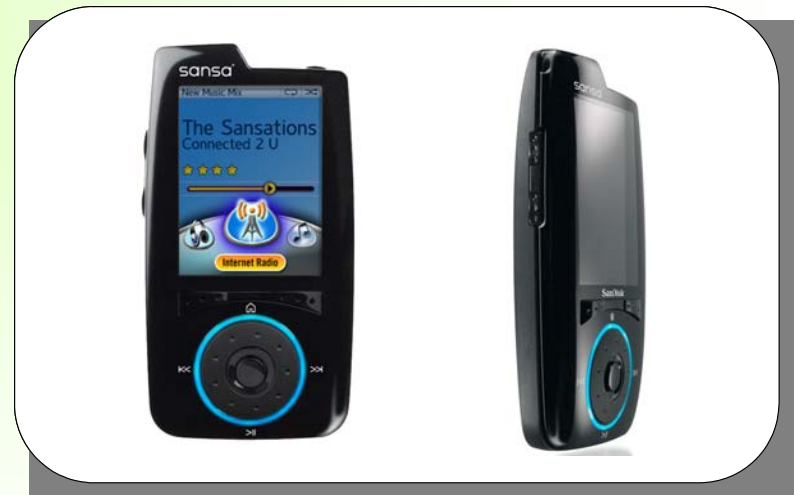
Photonics enabled converged solutions

Wireless connectivity

- Sharing your experience in real time!
 - Uploading digital content to PC & mass storage systems
 - Download music and photos, internet radio



Consumer Digital Camera (Nikon COOLPIX S7c) with Wi-Fi Wireless Connectivity
Source: Nikon



Portable Media Player (Sandisk Sansa Connect) with Wi-Fi Wireless Connectivity
Source: Sandisk

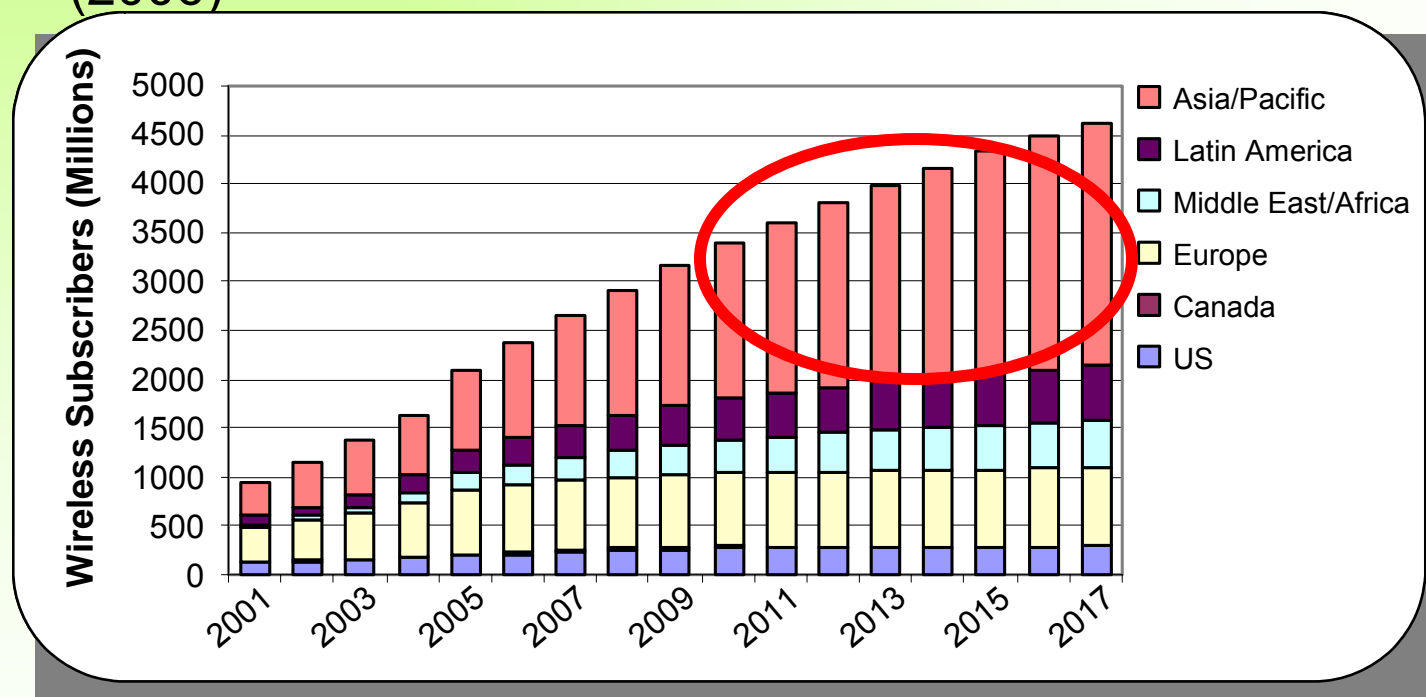


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Phenomenon → sharing experiences

Global wireless subscriber trends

- Asia is big growth opportunity (>2B subscribers in 2017)
 - Wireless penetration >100% in Western Europe, 88% all Europe (2006)



Forecast Worldwide Wireless Subscriber Growth, 2001-2017
Sources: TIA, OIDA

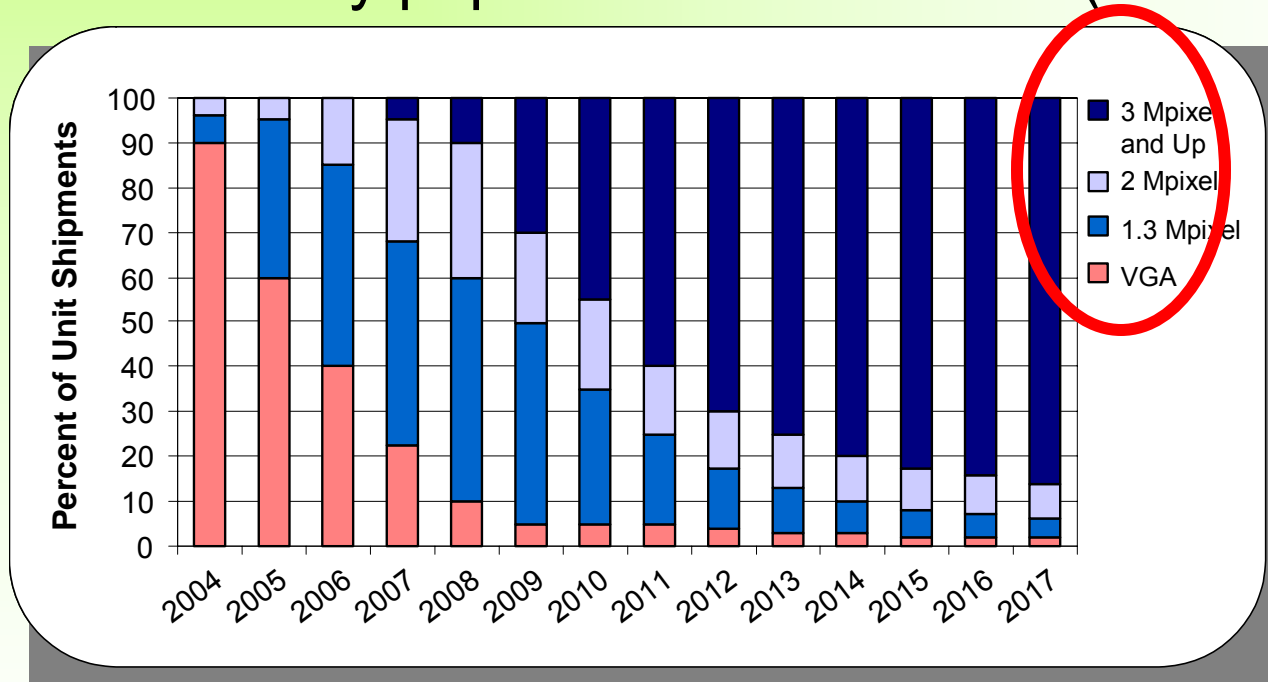
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Asia becoming dominant in wireless

Camera communicators will be key

- Over 41% phones with camera in 2006
 - By 2010, over 500M camera phones
- RIM blackberry popular without camera (Govt use)



Trend in Camera Phone Resolution
Sources: IC Insights, OIDA

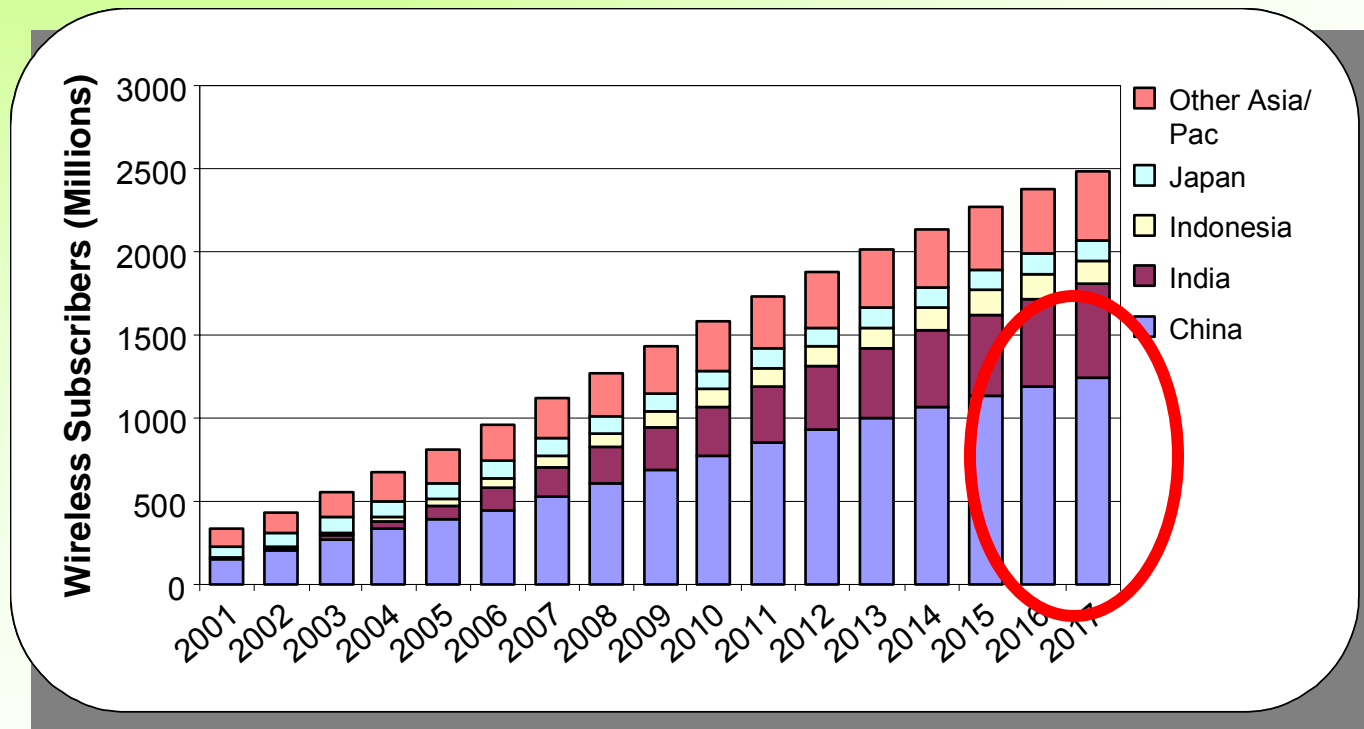
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DSC will become *the* platform...

Global demand for **low cost** handsets

- Highest growth in developing markets
- Indian and China forecast >1.5B subscribers by 2017



Growth of Four Largest Wireless Service Markets by Subscriber in Asia
Sources: TIA, OIDA

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Asia will drive new trends in wireless

Low cost mobile handsets

- E-ink (electronic paper) display



Low Cost Mobile Handset Incorporating an Electrophoretic (E-ink Electronic Paper) Display
Source: Motorola

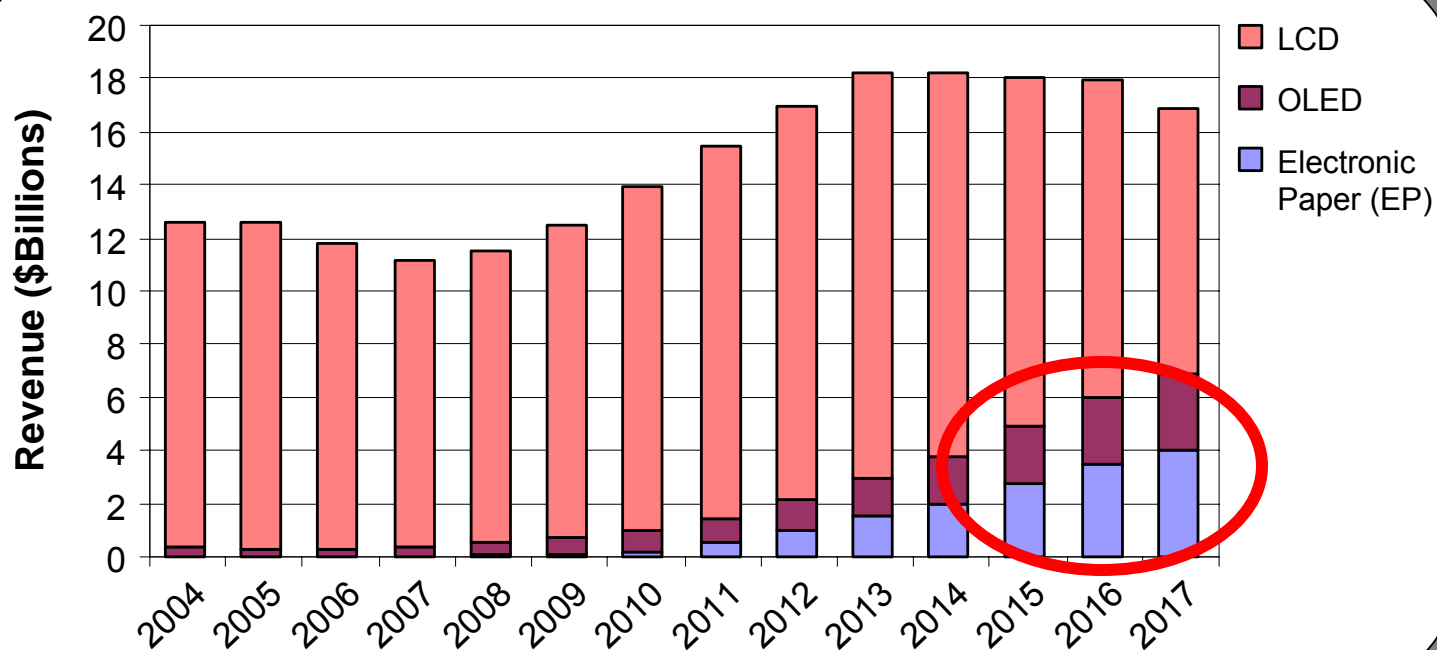
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Drive for low cost will continue strongly

Global wireless displays by technology

- OLED and EP take hold during later part of decade



Forecast Revenue for Wireless Device Display Market by Technology, 2004-2017
Sources: OIDA, Display Search, iSuppli

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LCD (incumbent) will slowly allow entrants

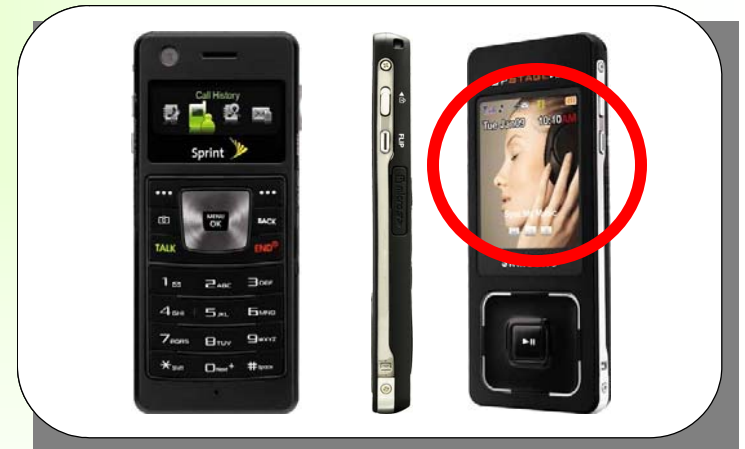
Influential product application trends

■ Portable media players (PMPs)

- Wireless connectivity key for product success
- Double sided phones, **AMOLEDs jazz up the products**



The Archos 605 PMP with Wi-Fi Connectivity and the iRiver Clix with 2.2 inch AMOLED Display
Sources: Archos, iRiver



The Samsung Upstage Mobile Phone with Dual Displays
Source: Samsung



Displays are jazzing product designs

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High resolution displays offer design freedom

- Combination of Advanced Technologies, Improved Human Interface, and Industrial Design with Software resulting in dramatic improvements in customer satisfaction?
 - Gestural input through high resolution display and touchscreen (1/2 VGA 320 by 480 at 160 ppi)
 - Mode switching display enhances phone and video experiences
 - 2.0 megapixel camera
 - Ambient light sensor controls display illumination



Source: Phil Wright, Apple, Cingular Wireless



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Optoelectronics is a key design element in PIDs

iPhone hardware BoM cost

- Optoelectronics comprise an estimated \$45-75 (20-30%) of the total hardware cost (\$230-260) of the Apple iPhone
- The range in optoelectronics cost arises from differing estimates (\$33 – 60) for the cost of the display and integrated touch screen.

Preliminary Apple iPhone Functional Cost Assessment (Costs in US Dollars)		
Functionality	4Gbyte	8Gbyte
<i>iPod/Media Player Functionality</i>		
Application Processor	\$18.50	\$18.50
Video Processor	\$6.50	\$6.50
DSP	\$5.50	\$5.50
Audio Codec	\$0.90	\$0.90
Power Management/Battery Charging Etc.	\$2.20	\$2.20
Memory (NAND-Type Flash)	\$35.00	\$70.00
<i>Total</i>	<i>\$68.60</i>	<i>\$103.60</i>
<i>Other Functionality</i>		
802.11b/g	\$15.35	\$15.35
Bluetooth 2.0/EDR Baseband Plus RF Section	\$3.75	\$3.75
<i>Total</i>	<i>\$19.10</i>	<i>\$19.10</i>
<i>GSM/EDGE Air Interface Functionality</i>		
Baseband Section	\$11.25	\$11.25
Additional Power Management	\$1.20	\$1.20
RF Transceiver Section	\$4.70	\$4.70
Power Amplifier Section	\$2.10	\$2.10
<i>Total</i>	<i>\$19.25</i>	<i>\$19.25</i>
<i>Other PCB Level Functions and Components</i>		
Other Memory - Mobile DRAM (512Mbit)/NOR Flash (128Mbit)	\$10.80	\$10.80
Accelerometer, Proximity Sensor, Ambient Light Sensor	\$2.25	\$2.25
Touch screen Controller	\$1.15	\$1.15
PCB Substrate	\$4.00	\$4.00
Other Passives, and Other Discrete Semiconductors	\$19.00	\$19.00
<i>Total</i>	<i>\$37.20</i>	<i>\$37.20</i>
<i>Camera Module</i>		
2.0 Megapixel Camera Module - CMOS Fixed Lens	\$11.00	\$11.00
<i>Total</i>	<i>\$11.00</i>	<i>\$11.00</i>
<i>Display</i>		
3.5-Inch LTPS Touch Screen - 320x480 160ppi	\$33.50	\$33.50
<i>Total</i>	<i>\$33.50</i>	<i>\$33.50</i>
<i>Mechanical Components / Enclosure</i>		
<i>Total</i>	<i>\$12.00</i>	<i>\$12.00</i>
<i>Battery</i>		
<i>Total</i>	<i>\$5.20</i>	<i>\$5.20</i>
<i>Accessories / Packaging Etc.</i>		
<i>Total</i>	<i>\$8.50</i>	<i>\$8.50</i>
<i>Final Manufacturing and Margin</i>		
<i>Total</i>	<i>\$15.50</i>	<i>\$15.50</i>
Hardware Costs Subtotal	\$229.85	\$264.85
<i>Non-Hardware Costs</i>		
Royalties for EDGE	\$4.61	\$4.61
Operating System - OSX	\$7.00	\$7.00
Multimedia Standards and Software	\$0.40	\$0.40
Audio Processing Software	\$0.97	\$0.97
Voice Processing Software	\$3.00	\$3.00
Non-Hardware Costs Subtotal	\$15.98	\$15.98
Grand Cost Total	\$245.83	\$280.83

Source: Phil Wright, iSupply, Display Search

Source - iSuppli Corporation, January 2007



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Optoelectronics is a key cost element in PIDs

Wireless enabled handheld games

- Expect to see handheld game platforms and low cost mobile phones define the low cost wireless device spectrum



Nintendo DS Lite with Wi-Fi Connectivity and Two 3-inch TFT LCDs
Source: Nintendo

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Mobile shared play/content emerging...

***Camera
communicators...that
project...***



Mobile projection displays

- Consumers will find new opportunities to utilize
- Being able to enhance life at anywhere, anytime, anyplace



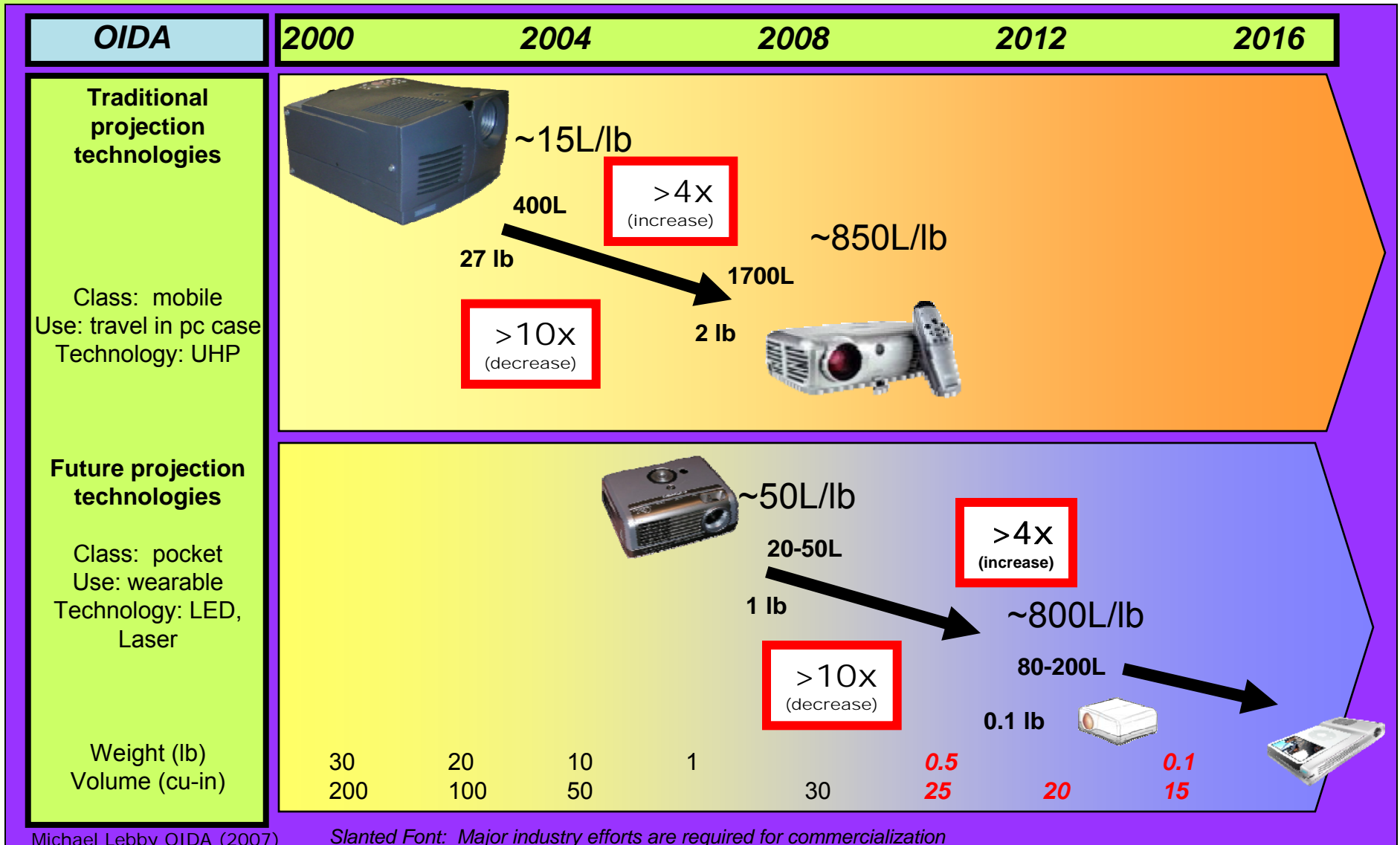
Sources: OIDA, Novalux, TI



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New lifestyle using laser technology

OIDA Projection Technology Roadmap



Technology & Components: Commercial Availability in Year Indicated

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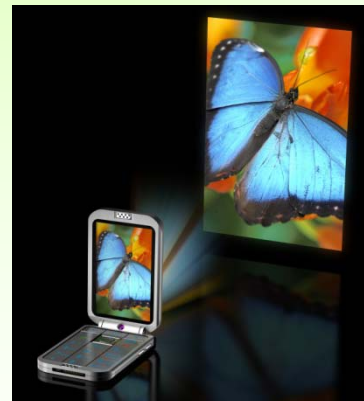
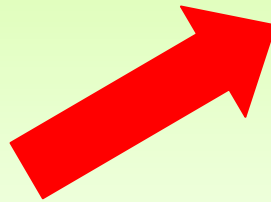
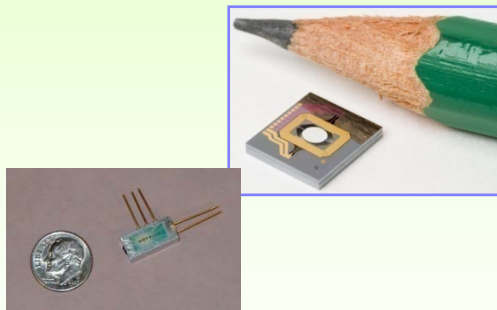
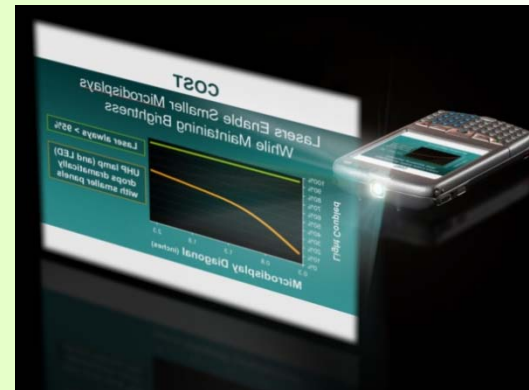


Challenge to shrink and be brighter

Laser based projection displays

■ Green doubled laser

- Limiter to packaging and display performance
- Temporal instability between MEMs scanner and green laser



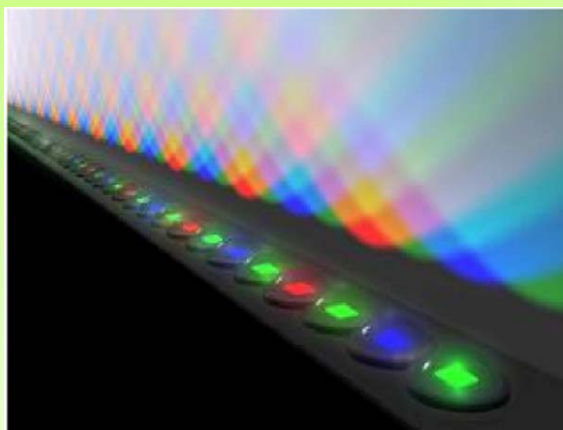
Sources: OIDA, TI, Motorola, Novalux, Microvision

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Lasers allow brighter, compact solutions

Challenge: Green LED and Laser Diodes

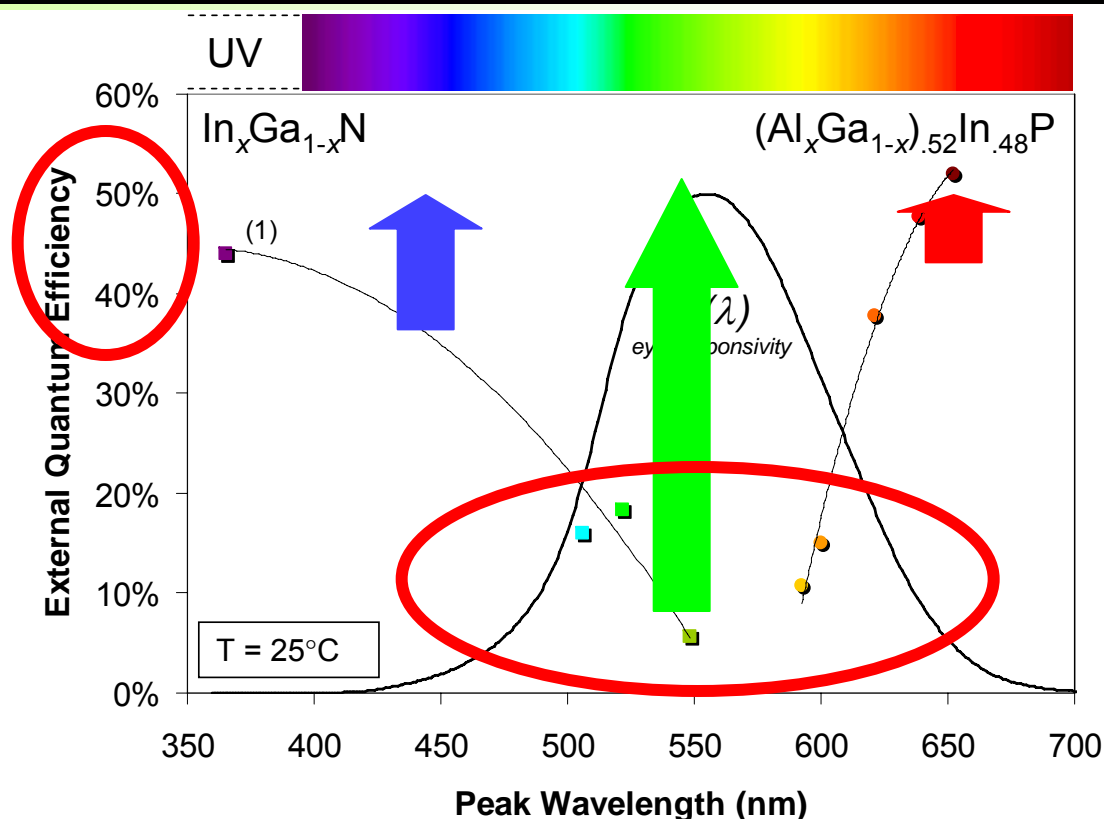


2 Green LEDs to every 1 red and blue

■ Green emission

- LEDs
- OLEDs
- Doubled lasers

Sources: Philips Lumileds, Nichia Chemical Co., IWN 2004, OIDA



Today's 1W HP-HBLED: green is the problem child

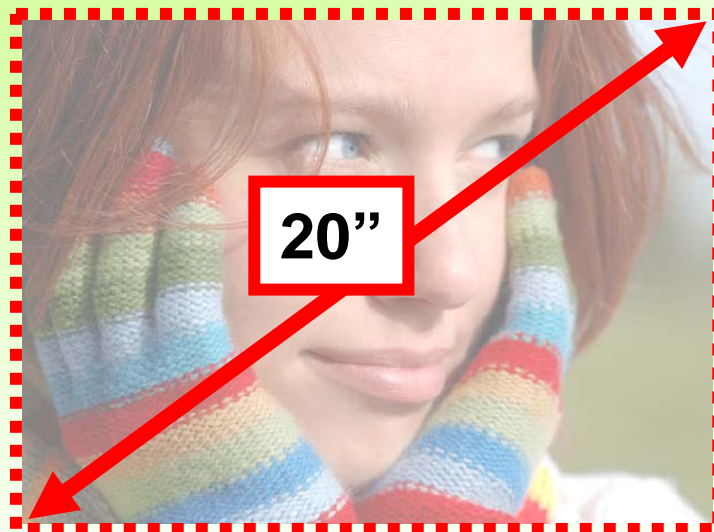


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It's a materials problem!

Challenges for the display industry...

- What exists → 2" display in 8oz package
- What the market desires → 20" display in 8oz package



Sources: OIDA, TI, TNS Research in Japan, August 2004



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Projection offers one solution

Today's trends for product designs

- Form factors similar to mobile phone/PDA



Sources: OIDA, TI, Motorola, Zeiss, Apple

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Brute force integration → not convergence

Handset projectors

- CTIA Las Vegas (April 2008) → hot topic



Embedded Microprojector and Handset Prototype
Source: Texas Instruments



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Mobile sharing data and video

Tactile feedback?

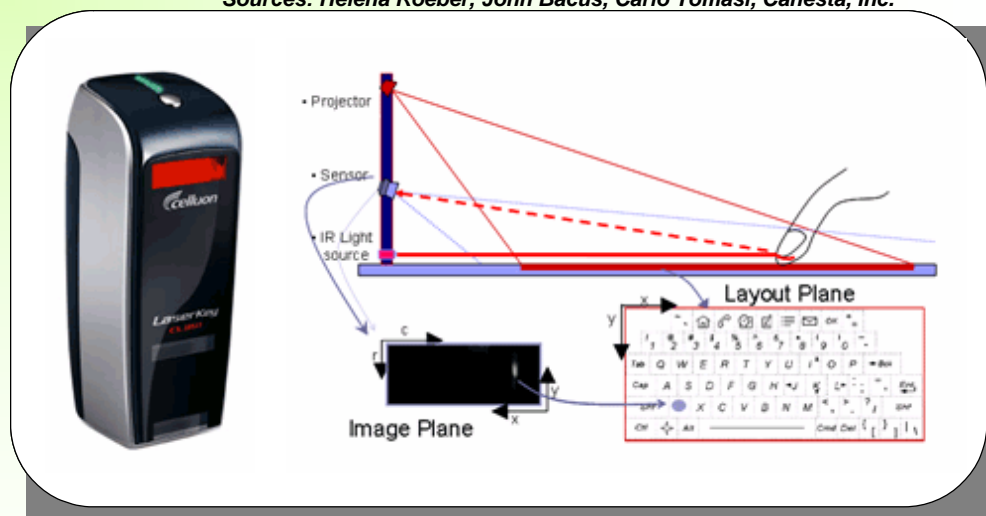
- Unique input mediums using compact photonics
- Blackberry comparison
 - Tactile keys

Input Device	WPM (Std Dev)	Error % (Std Dev)	Fatigue 5=Highest (Std Dev)
Graffiti	14.0 (6.1)	13.6 (10.8)	1.4 (1.3)
Thumb Keyboard	27.6 (4.8)	2.2 (1.8)	1.6 (0.7)
Mech. Keyboard	64.8 (17.3)	1.8 (0.9)	1.2 (0.8)
Canesta Keyboard	46.9 (9.8)	3.7 (2.4)	0.7 (0.6)

Usability Test Results for the Canesta/Cellulon Keyboard
Sources: Helena Roeber, John Bacus, Carlo Tomasi, Canesta, Inc.



Virtual Keyboard Concept for Wireless Handset
Source: Virtual Devices, Inc.



Virtual Keyboard with Bluetooth Connectivity for Wireless Handset
Source: Cellulon, Inc.



Michael Lebby (lebby@oida.org)

Can we be trained for non-tactile?

Novel data input devices

- Entering data to wireless handsets will evolve quickly over next decade



Optoelectronically-Enabled Handwriting Input Device for Delivering Text and Drawings to Wireless Handset
Source: CandleDragon, Inc.



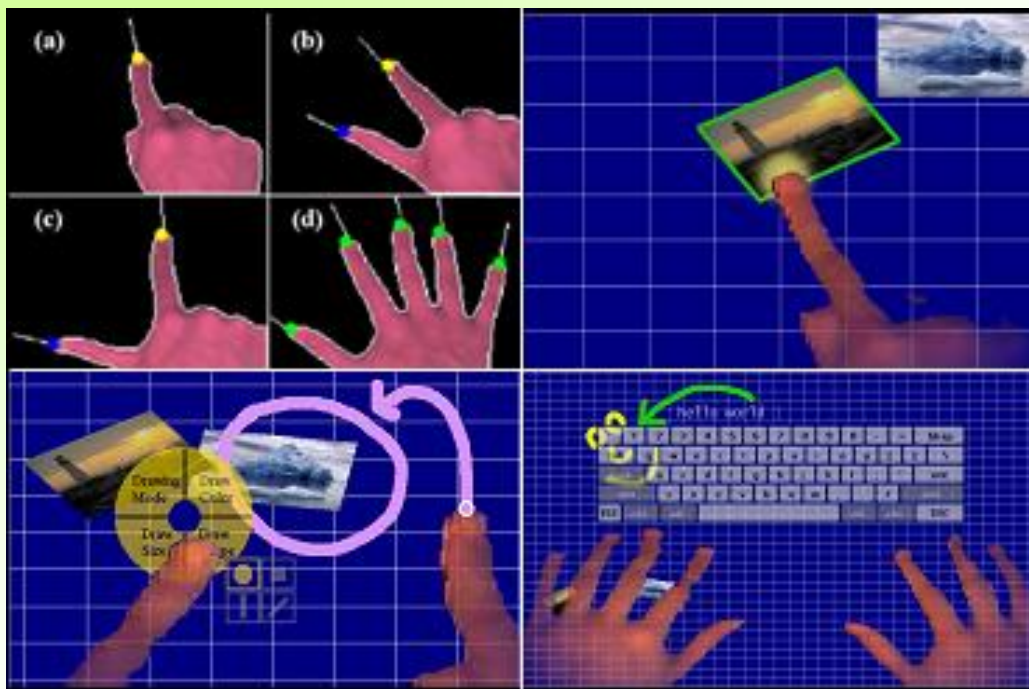
Michael Leby (leby@oida.org)

Writing and speaking → important

Gestural input and navigation

- Still in concept stage

- 2 webcams used to acquire stereo image: pair of hands above surface
- X,Y, height data on position and gestures used to control application



Optically Virtual Keyboard Concept for Wireless Handset

Sources: S. Malik, J. Laszlo, Department of Computer Science, University of Toronto



Michael Leby (leby@oida.org)

Advanced user interfaces will evolve

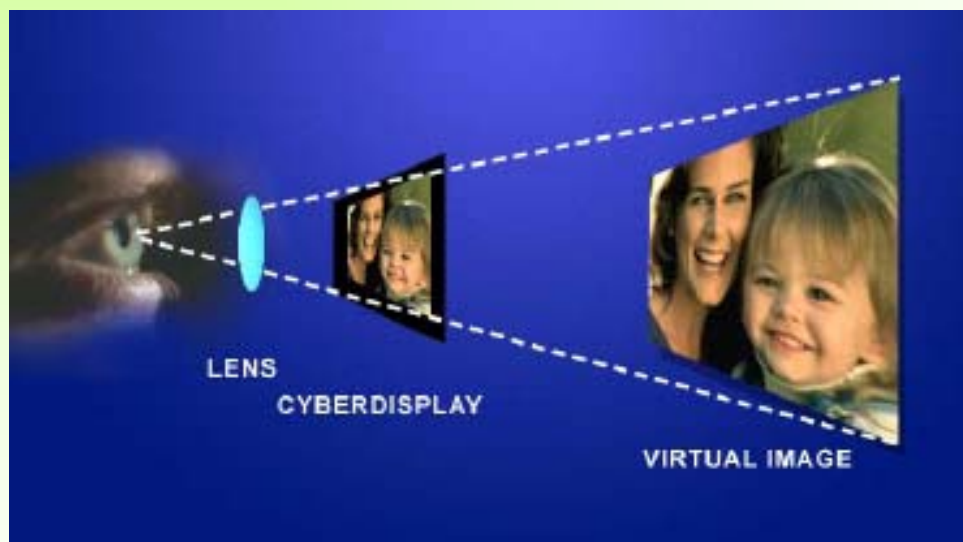
Wearing displays



OIDA: Optoelectronics Industry Development Association

Micro-displays

- Small display – big pictures
- Similar to looking into a video camera



Source: Kopin

Michael Leby (leby@oida.org)

Younger generation will ignite the trend

Would you wear these in 10 years?

- Happy and healthier lifestyle...I would !



Source: Kopin



Michael Leiby (leby@oida.org)



Image or real life: sometimes safer..

***Camera function will
advance...***



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Images are data...

■ Application of images as data

- Qode uses camera phone to acquire activated smartcode
- Links user directly to advertisers website
- Excellent concept for train-plane schedules, security, public info



Camera Phone Acquiring Image of 2 Dimensional Bar Code and Linking Mobile Handset to Advertiser's Web Site
Source: Neomedia Technologies



Michael Leby (leby@oida.org)

New ways to connect users to updates

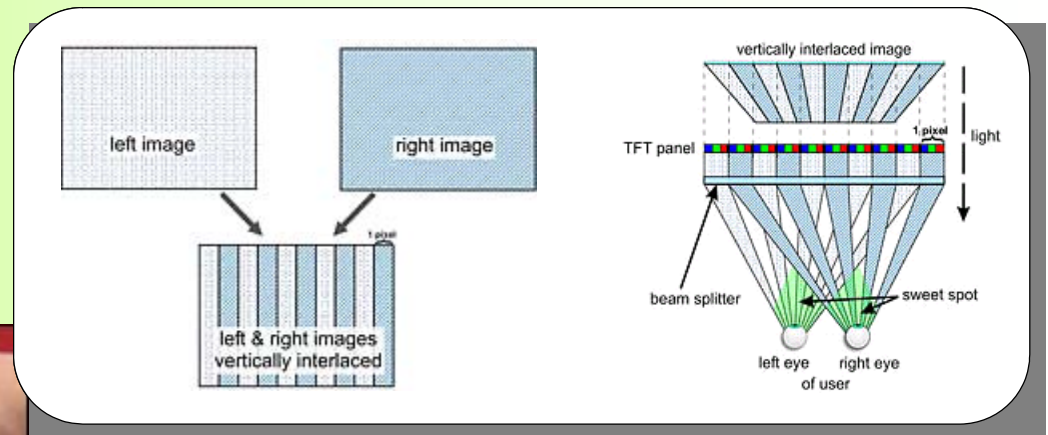
Cameras will allow 3D mobility

- Auto stereoscopy
 - No specs (phew!)
 - Winner?



Prototype Wireless Handset with Auto Stereoscopic 3D Display

Source: Ocuity Ltd, Photo Credit: Andrew Woods



Auto Stereoscopy Principle and Implementation

Source: SeeReal Technologies

- Samsung mobile (Aug'07)
 - Clam-shell design
 - Had to fight GenY'rs to see it!



Michael Lebbby (lebbby@oida.org)

Will this be the new display medium?

Plastic Photonics...



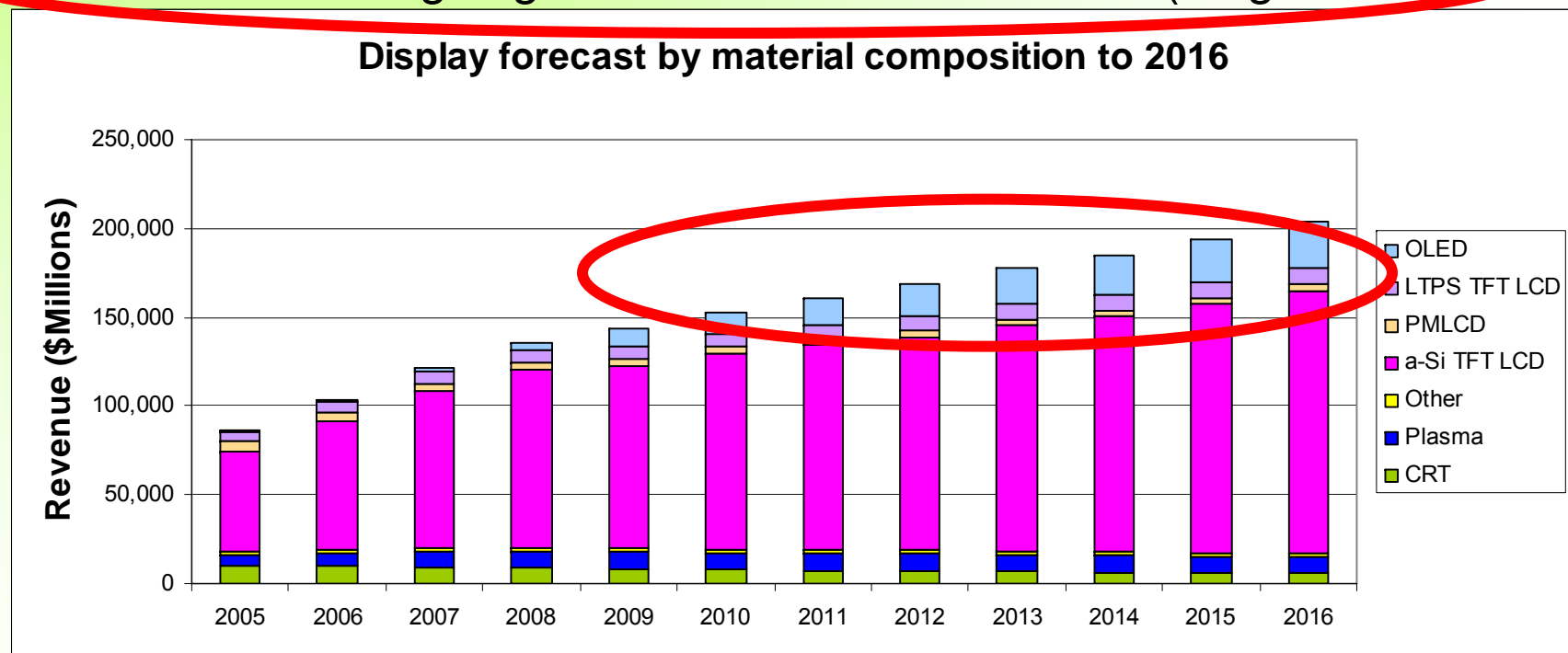
Important takeaway !

***OLEDs will be
ubiquitous...we now
call the segment
'plastic photonics'***



OLED trends over next decade

- OLEDs expected to grow into huge opportunity
 - a-Si TFT becoming the silicon (Vs GaAs) of displays
 - OLEDs are going head-to-head with a-Si TFT (tough battle)



Sources: OIDA, Display Search, ISupply, Displaybank

Michael Leby (leby@oida.org)



Do we know the killer app yet?

***...in 10 yrs will the
panels be glass or
flex (or both)?***



Windows @ 10G – (2.7m x 3m)



Source: Corning

Michael Leby (leby@oida.org)



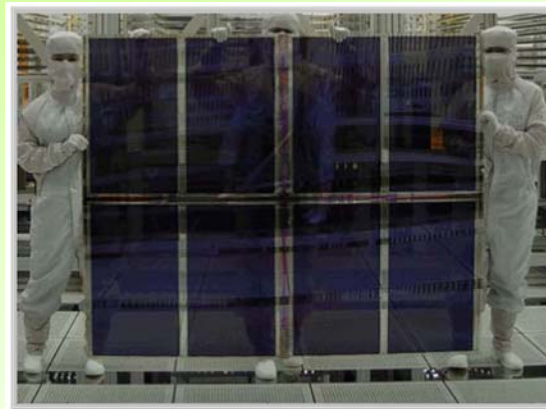
A substrate medium for plastic photonics

How large will we go?

3.5G LCD
2000



6G LCD
2004



7-8GLCD
2007



Sources: DisplaySearch, LG.Philips LCD, OIDA

Michael Leby (leby@oida.org)



Are these windows? Sure look like it...

World's largest display for the minute

- The new 150 inch Panasonic TV has a resolution of 4,096x2,160px.
- Panasonic says the 150 inch Plasma is well suited for cinema and commercial installations



Source: Panasonic



Michael Leby (leby@oida.org)

CES '08 – we'll need bigger living rooms...

Displays...

***Observation:
Wafers → Glass →
Flexible substrates***



In-line OLED production system

- Based on solution processed P-OLED and TFE (thin film encapsulation) technology



In-Line OLED Production System
Source: OTB Display

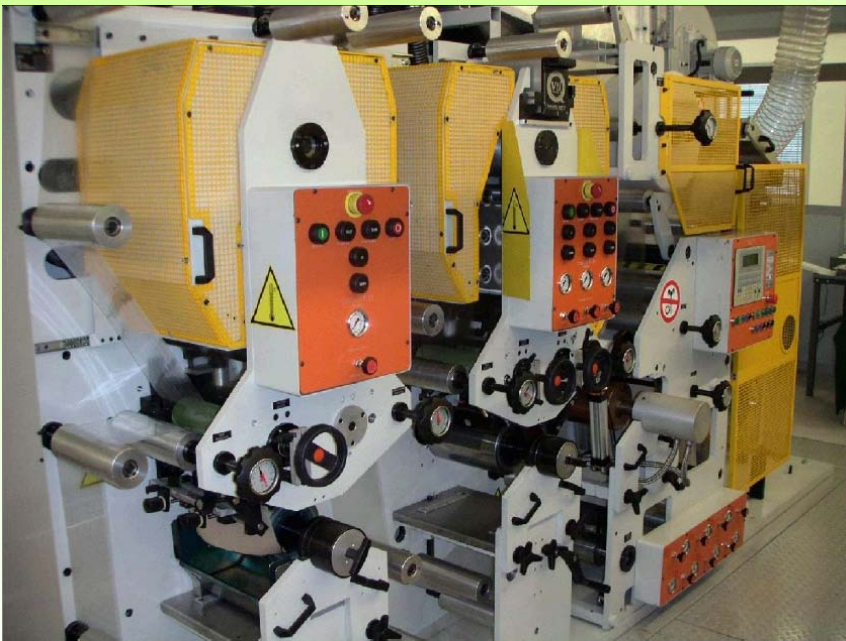
Michael Lebbv (lebbv@oida.org)



Tool development is very active today

Roll-to-roll OLED manufacturing

- ROLLED program in Europe
 - Goal to develop low cost, volume scale flex technology



Roll-to-Roll Pilot Production Facility for Flexible OLEDs
Source: ROLLED

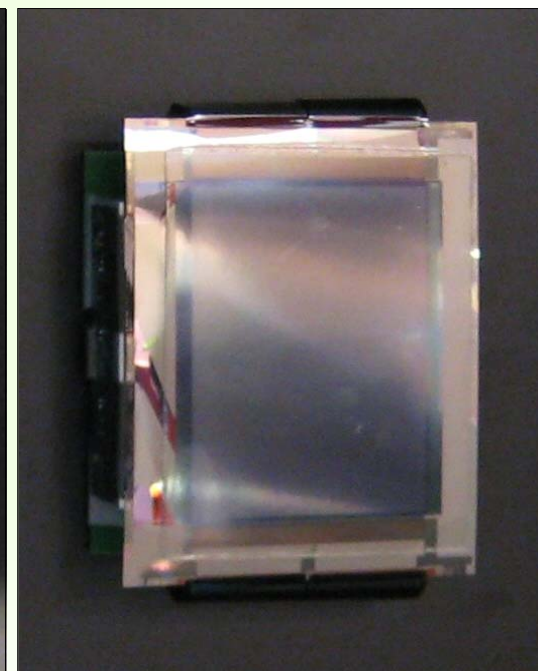
Michael Lebbby (lebbby@oida.org)



Challenges: ITO, printing, encapsulation

Steel substrates for Flexible OLEDs

- 4" QVGA (240x320 pixel) AMOLED on a-Si TFT array
 - Only 150um thick, opaque substrate limits pixel density (100 ppi)



Flexible AMOLED Display on Stainless Steel Substrate
Sources: LG.Philips, Universal Display Photo Credit: Phil Wright



Michael Leby (leby@oida.org)

Metal fab is similar to conventional LCD

OLEDs in automotive displays

- Already significant opportunity for OLEDs
 - Strong value (low cost, good resolution, contrast ratio, viewing angle, fast response, multiple color choices)



Source: Optrex

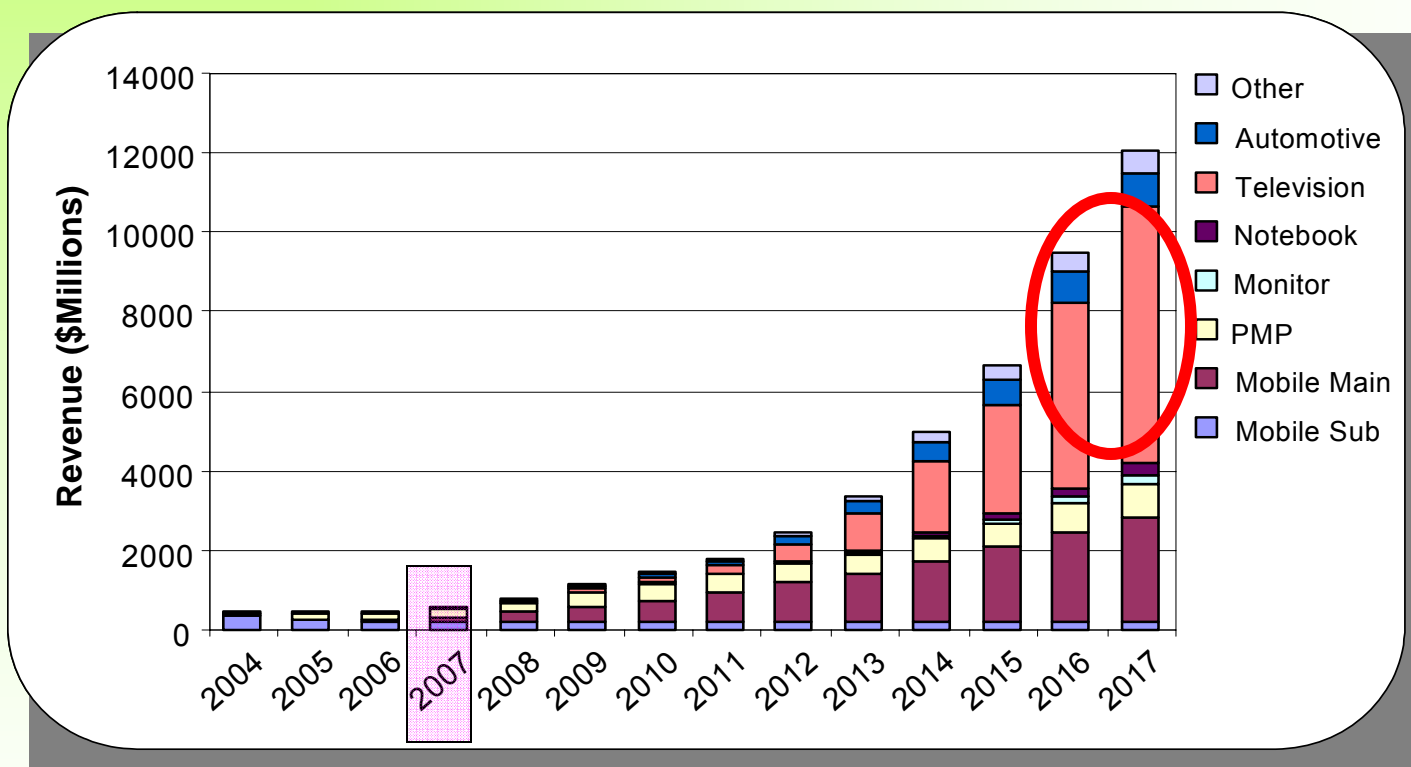


Michael Leby (leby@oida.org)

Existing commercial application

OLED forecast by market segment

- TV revenue surpasses \$6B in 2017



OLED Display Forecast by Market Segment, 2004-2017
Sources: OIDA, DisplaySearch, iSuppli, Displaybank

Michael Leiby (leiby@oida.org)

We don't include fashion.. mistake?

OLEDs go head-to-head with LCDs...



Sony OLED TVs at CES 2007



- Two prototype models were demonstrated:
 - 27inch TV with Full HD panel (resolution: 1920×1080)
 - 3mm in depth
 - 11inch TV with wide-SVGA panel (resolution: 1024×600)
 - less than 10mm in depth (at its thinnest point).

Sources: Phil Wright, OIDA

Michael Leby (leby@oida.org)



OLED vs LCD (incumbent) ?

AMOLED TVs

- CES 2007, bright colorful, thin, displays attracted much interest



Source: Sony

Michael Leby (leby@oida.org)



Brave new world for OLEDs

OLED-based TV's are coming!

- Samsung Electronics Co. Ltd. of Korea announced plans to sell OLED based TVs in 2008
- Toshiba Matsushita Display Technology Co. Ltd. (TMD) in 2009
- Sony Corporation's announced, at CES 2007 in January that they will launch an OLED based TV for sale in Japan late 2007.

Have the giants got it right?

Sources: Phil Wright, OIDA



Michael Leby (leby@oida.org)

Will OLEDs beat LCDs? Incumbent...

OLED TV hits the shelves...CES '08

- 11 inches display, 3mm thick (about the size of three stacked credit cards)
- Resolution: 940×540
- OLED technology can completely turn off pixels when reproducing black, resulting in more outstanding dark scene detail and a contrast ratio of 1,000,000:1
- \$2500 today's pricing



Source: Sony (XEL-1 TV)



Michael Leby (leby@oida.org)

Will the gamble pay off?

The 'green' nature of OLEDs

- OLED win outright in video applications
 - Fraction of full pixel intensity is used

Usage Scenario	Power Consumption (mW)	
	AMLCD	AMOLED
Typical Web page	226	360
Typical UI page	226	164
Typical still image page	226	164
Video on average	226	31

Power Consumption of 2.0-inch QVGA AMLCD and AMOLED Displays
Source: Nokia



Michael Leby (leby@oida.org)

Dark pixels save energy...OLED is better

OLED lighting



OIDA: Optoelectronics Industry Development Association

HBLEED & OLED lighting fixtures

- Designs similar to incandescent (left), fluorescent (right)



Sources: Progress Lighting, BASF, Philips

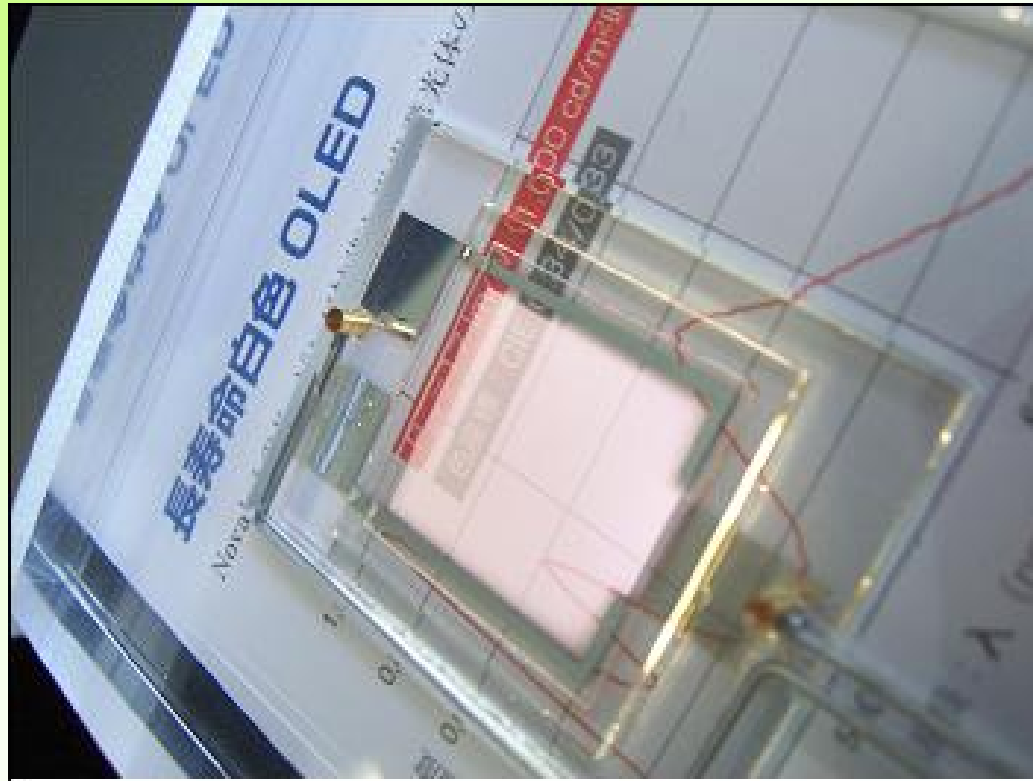


Michael Leby (leby@oida.org)

Form factors similar to luminaires today

Transparent OLED W-OLED

- “Day and night window”



Transparent White Light OLED Panel Prototype “The day and night window”
Source: Novaled

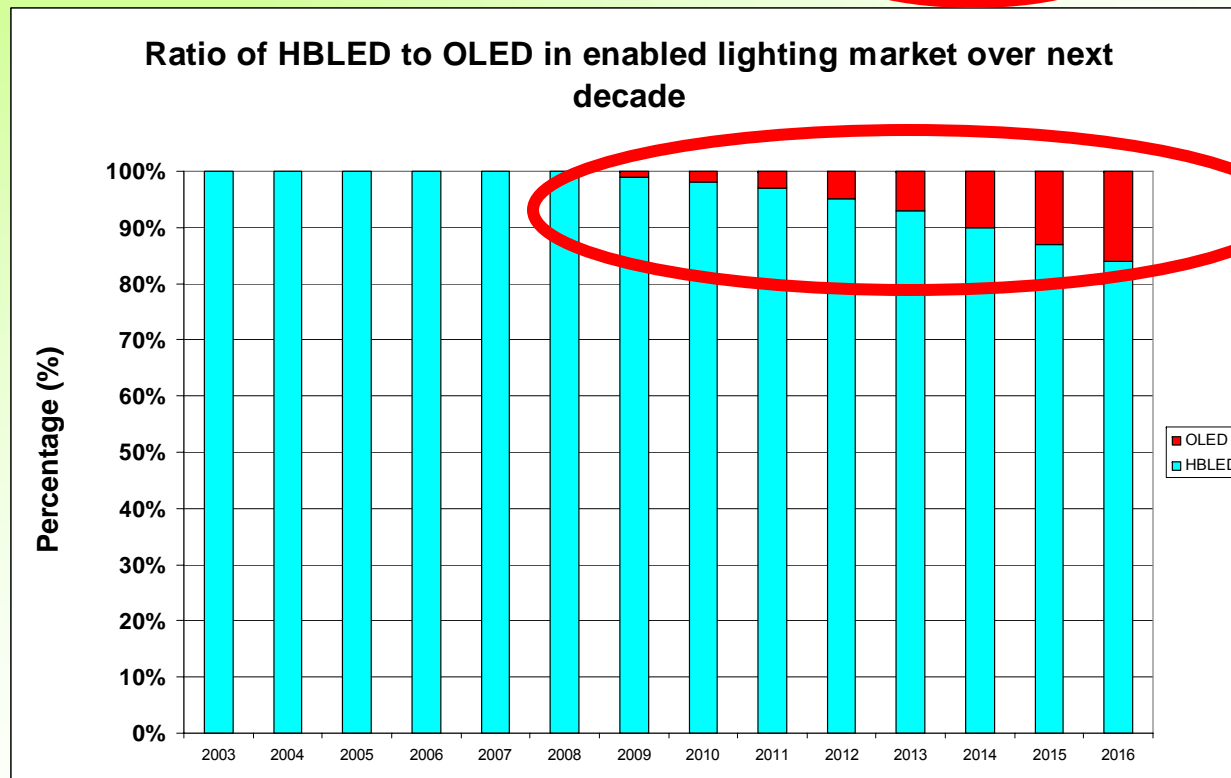
Michael Leby (leby@oida.org)



This could well be a killer app...

Enabled lighting market

- Growth of OLED lighting forecast to 16% by 2016
 - Main issue will not be spec's but will be **COST!**



Michael Leby (leby@oida.org)

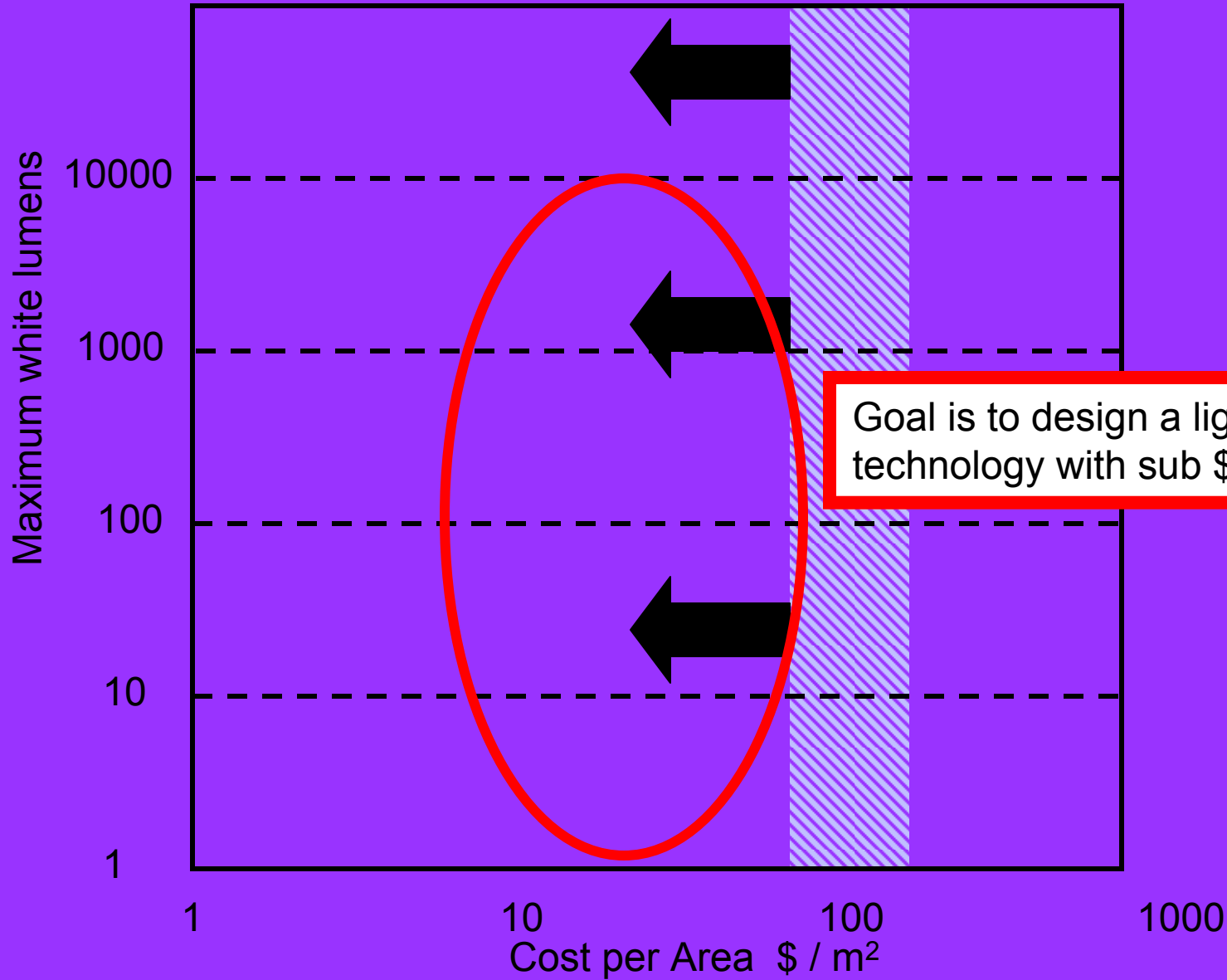


OLED cost structures still too high...

Lighting challenges for OLEDs

OIDA

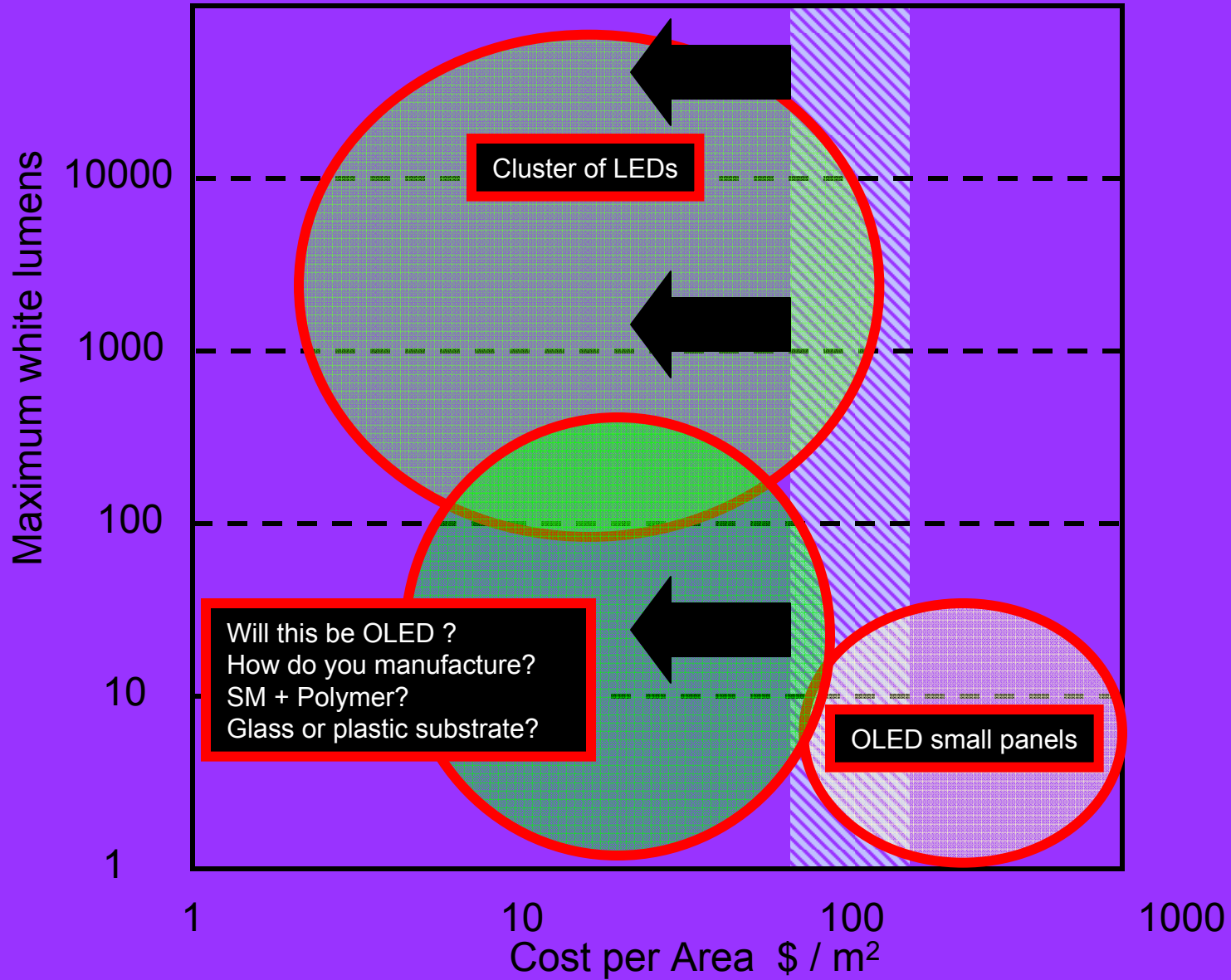
SSL lighting challenges platform



Lighting challenges for OLEDs

OIDA

SSL lighting challenges platform



***OLED challenge for
lighting is substrate
cost !!!***



OLED technology trends

- Commercial OLEDs today
 - Over 97% products are based on “Small Molecule” technology
- Pioneered by KODAK
 - + High efficiency
 - + Good lifetime
 - - Vacuum processing *limits substrate size*
 - But is simple though
- Pioneered by CDT (now Sumitomo)
 - + Simple Structure
 - + Potential for ink jet processing of *large substrates*
 - - Lower efficiency, and lifetime
- Trends...
 - SM fabrication techniques on polymer substrates
 - Multi-layer, multiple technologies (SM + Polymer)

Today

Small molecule

Polymer

Tomorrow

SM + Polymer

Source: OLED-T, IOA

Michael Leby (leby@oida.org)



Mixing of technologies will accelerate

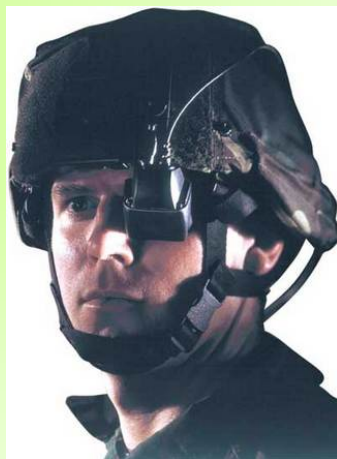
***Killer application for
flex.....fashion***



OIDA: Optoelectronics Industry Development Association

OLEDs become fashionable

■ Fashion in photonics



Sources: Groonk.net, Nyxjacket, OIDA, PIDA, General Dynamics, eMagin, Laser Focus World

Michael Lebby (lebby@oida.org)



Potential very high volume

Fashion with organics

- Particle sized photo-luminescent pigments with fibres that emits light without electricity.
 - Textile can be washed and can glow for about half a day



- OLEDs in clothing



Sources: Natalia Allen, culturebase.org, eyezotica.com, urbanscreens.org, techiediva.com, jkct, pioneer

Michael Leby (leby@oida.org)



Fashion allows high margins, low life

HB LEDs already offer attractive solutions

- Fashion using optoelectronics
 - HBLEDs interwoven into clothing
 - Wedding dresses
 - Children's clothing
 - Hip dress designs
 - Evening gowns
 - Office clothes
 - Safety wear
- Photonics festival conference
 - Taipei, June 2007
 - Lite-on fashion show



Source: OIDA, Lite-On



Michael Lebby (lebby@oida.org)

Shhhh – don't look for the batteries...

Green Photonics...



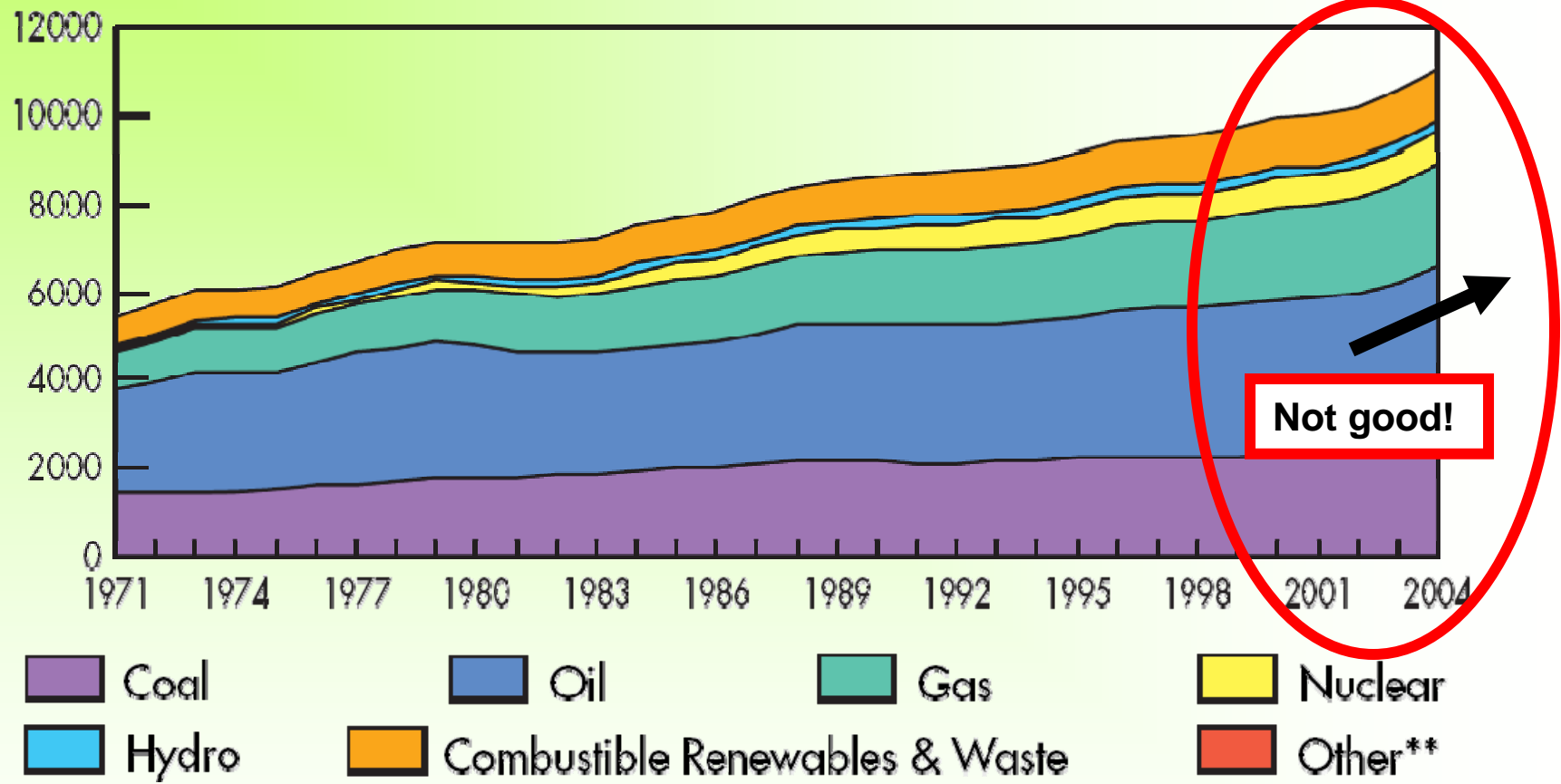
Important takeaway !

***Energy will be
important***



OIDA: Optoelectronics Industry Development Association

Evolution from 1971 to 2004 of World Total Primary Energy Supply* by Fuel (Mtoe)



Not good!

Why energy matters...

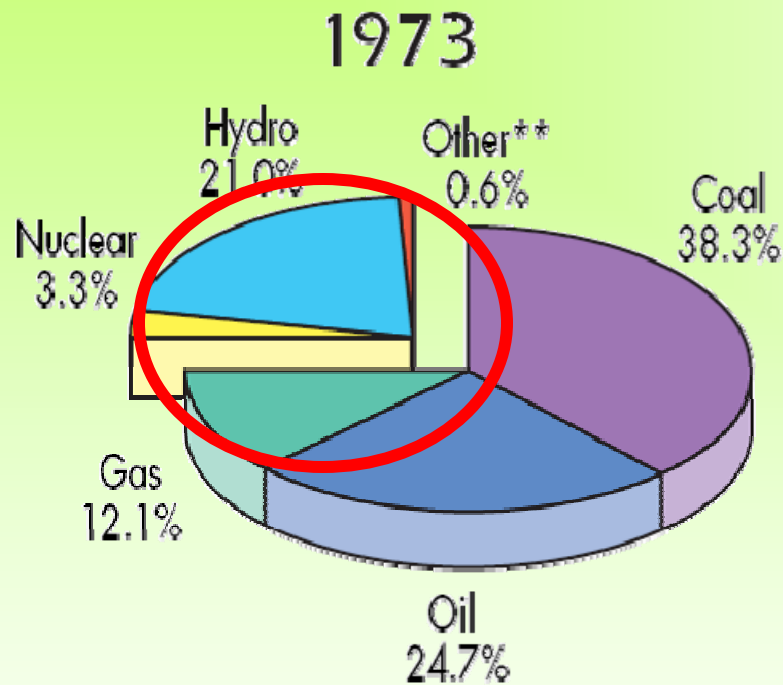
Source: IEA

Michael Leby (leby@oida.org)

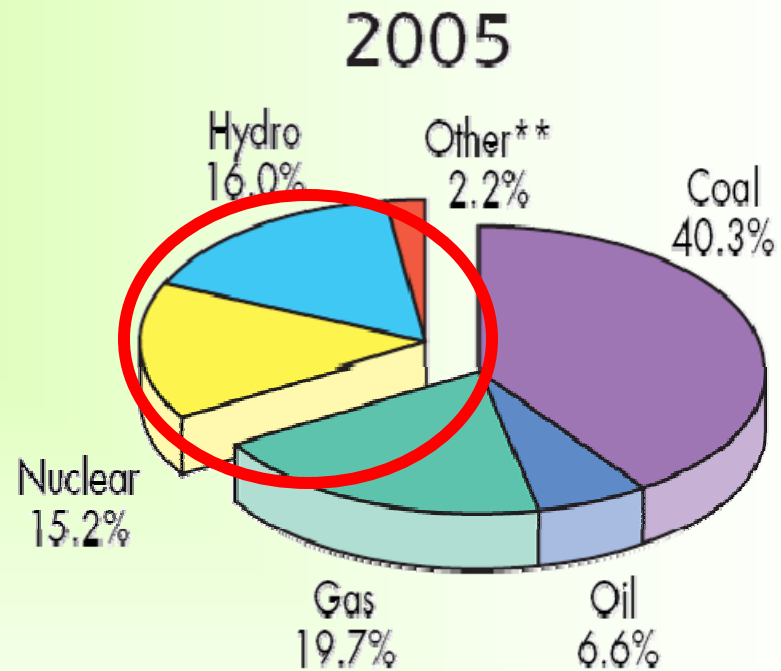


Double 1971 – 2004: trend kills the planet

1973 and 2005 Fuel Shares of Electricity Generation*



6 116 TWh



18 235 TWh

*Excludes pumped storage.

**Other Includes geothermal, solar, wind, combustible renewables & waste.

Source: IEA

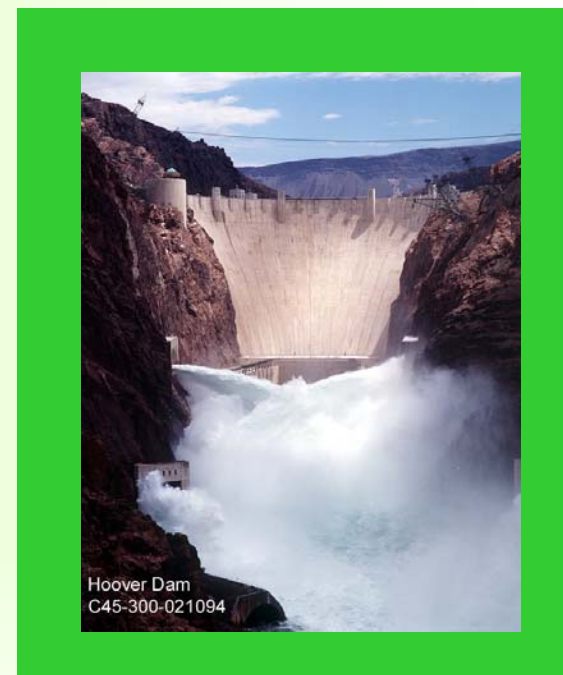
Michael Lebbv (lebbv@oida.org)



Non-carbon growth is small

Photonics is already 'green'

- Solar energy
 - PVs
- Power consumption
 - Communications hardware
 - Displays
 - Solid state lighting
- Materials processing
 - Semiconductor, laser machining
 - Chemical free processing
- Sensing
 - Monitoring (environmental, pollution)



Source: Finisar



Michael Leby (leby@oida.org)

We're running a green photonics forum...

Philips Eco-TV

- 42-inch, 1080p resolution, flat-panel LCD, model 42PFL5603D (due in March, \$1,399 MSRP)
- Able to dim the backlight--by up to five times peak brightness--in response to program material. Dimming the backlight in darker scenes has the dual benefit of saving power and improving black-level performance.
- Backlight can also be dimmed via a room lighting sensor, so in dark rooms it will use less power.
- There's also traditional a "power-saving" mode that caps the peak light output. The panel's power consumption dips to an impressive 75 watts. That's a bit more than a standard incandescent light bulb (approx. 30 watts less than the most 42-inch LCDs).
- Philips also built in a few other non-power-related greenie features, including lead-free materials and only "trace" amounts of mercury
- The box is made from recycled material.



Source: Philips

Michael Leby (leby@oida.org)



Green TVs become topical

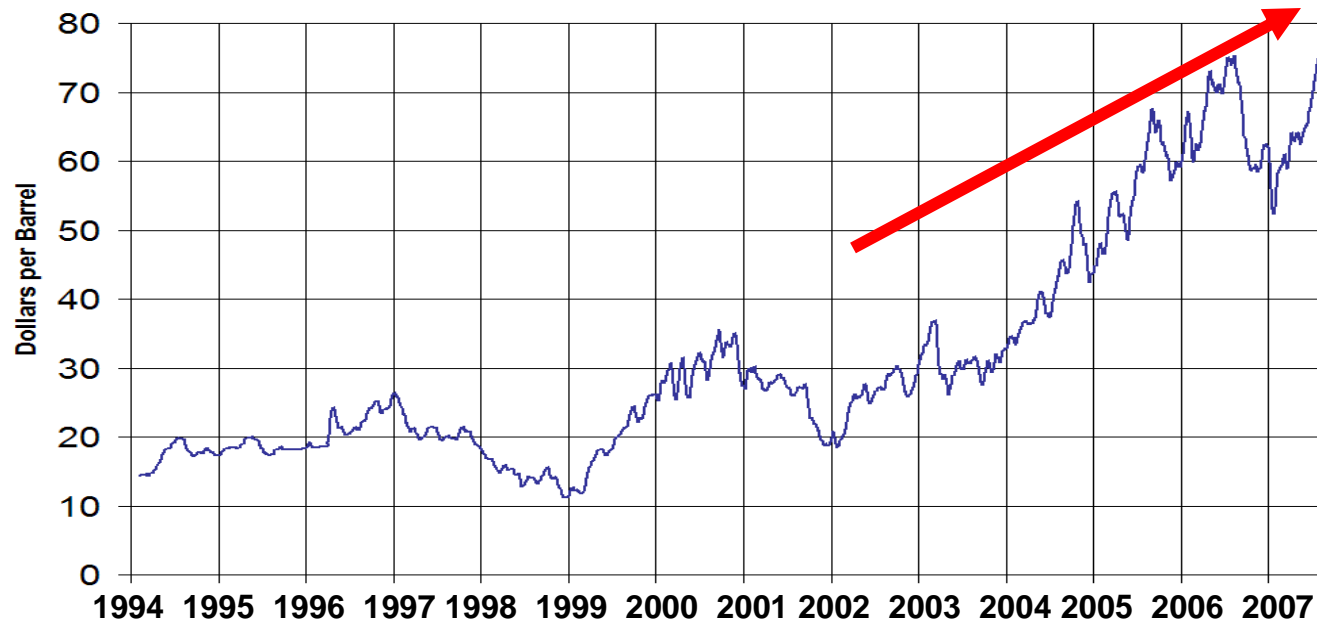
***Solar plays a huge
role...***



OIDA: Optoelectronics Industry Development Association

Oil prices sky-rocketing

Oil Prices, 1994-2007
NYMEX Light Sweet



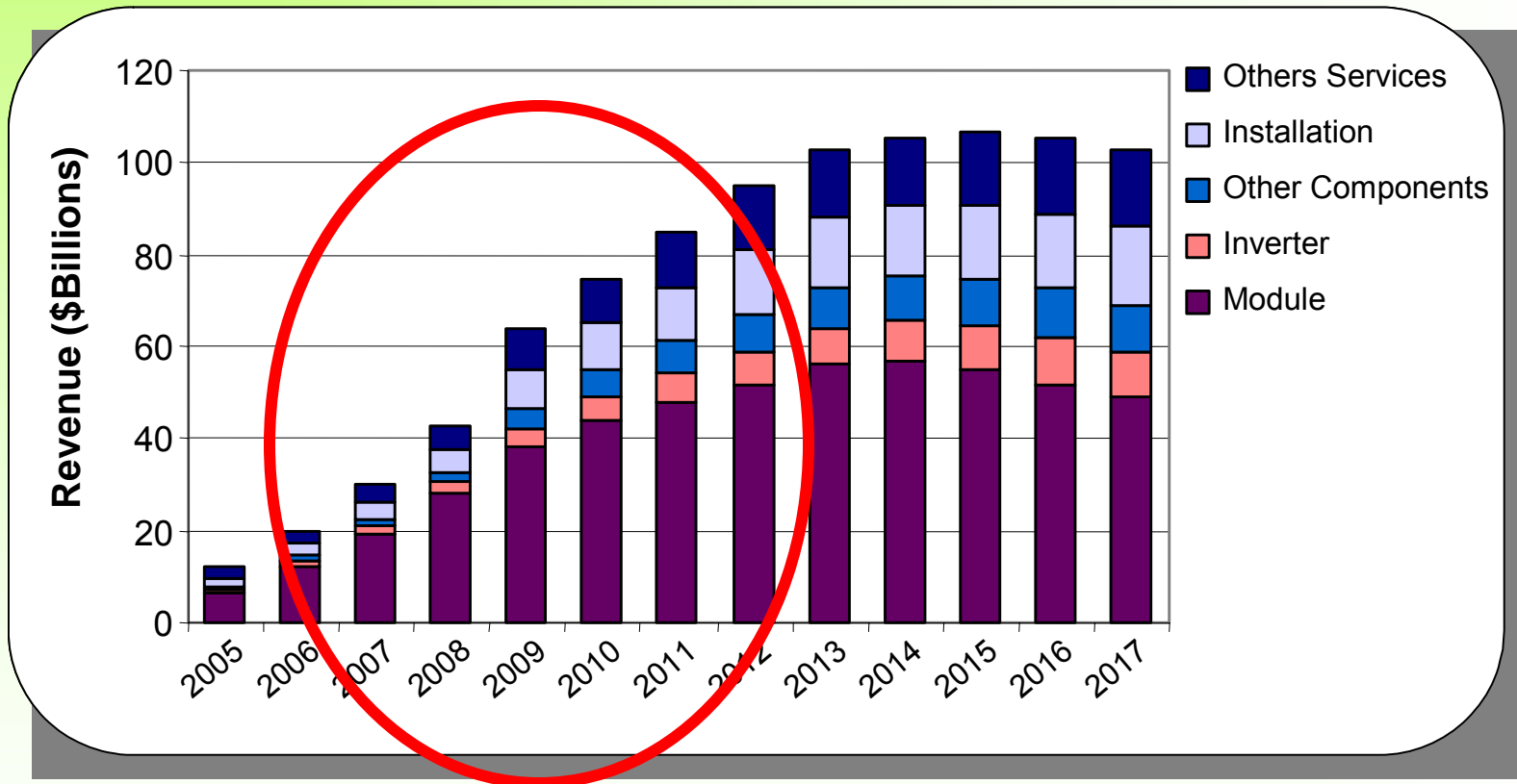
Thirteen Year Trend Crude Oil Prices
Source: NYMEX

Michael Leby (leby@oida.org)



Deja vu: motivation for solar?

Solar surpassing \$100B by 2013



Solar Sector Revenue and Forecast, 2005-2017
Sources: CLSA, Photon Consulting, OIDA

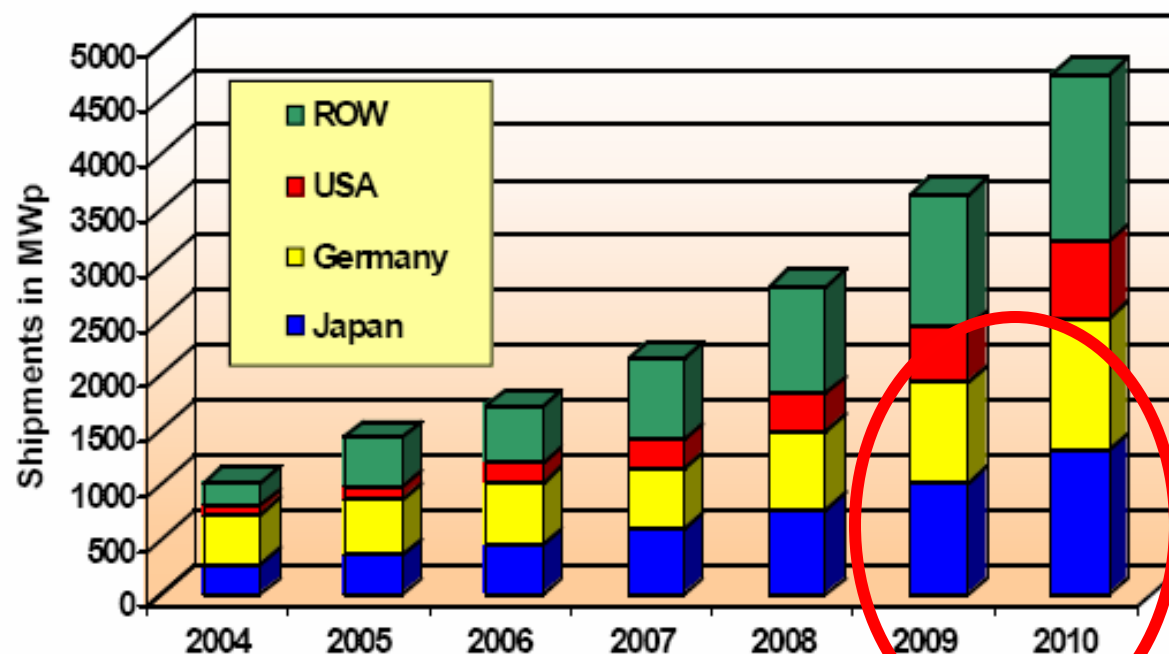
Michael Leby (leby@oida.org)



Strong growth over decade

Global PV shipments

- Germany and Japan lead the industry...



Source: Eric Weisoff, Greentechmedia

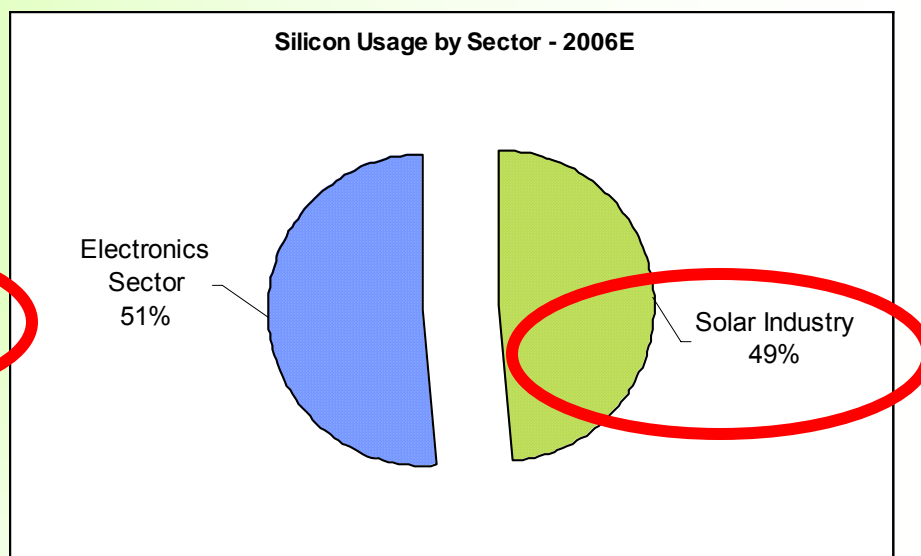
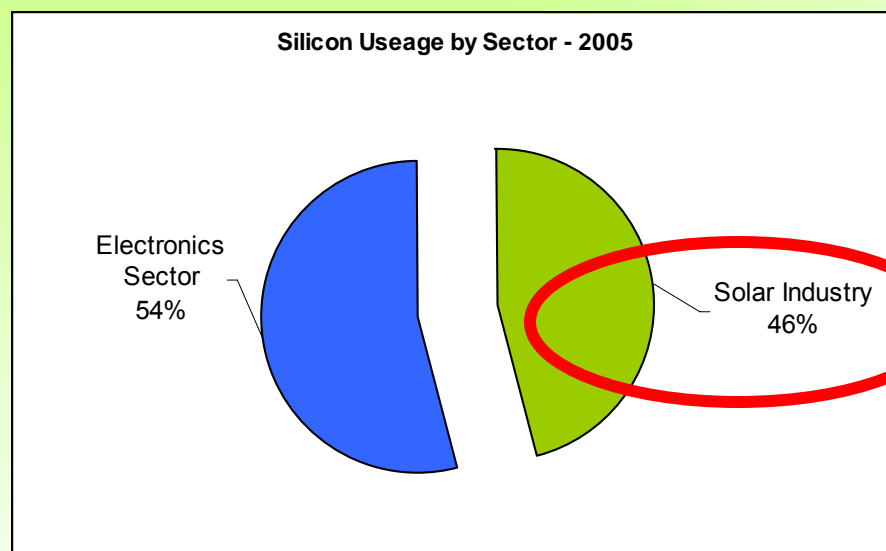
Michael Leby (leby@oida.org)



USA needs to join the team...

Silicon semiconductor usage

- Solar usage is expected to surpass 50% in 2007



Sources: CLSA Asia-Pacific Market Estimates

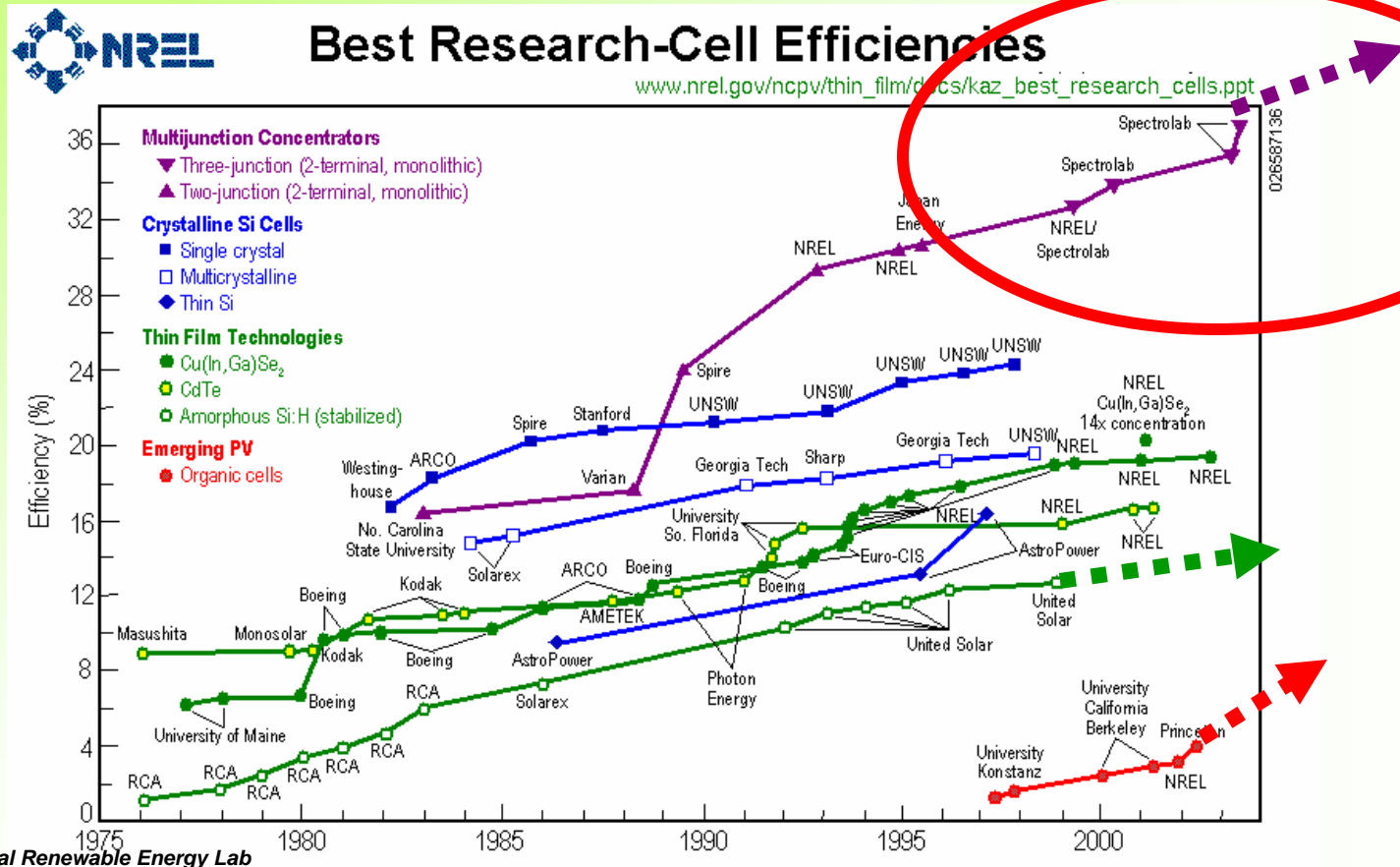
Michael Leby (leby@oida.org)



Supply-limited silicon opens doors...

Solar cell material efficiencies

- Best research results to-date



Sources: NREL – National Renewable Energy Lab

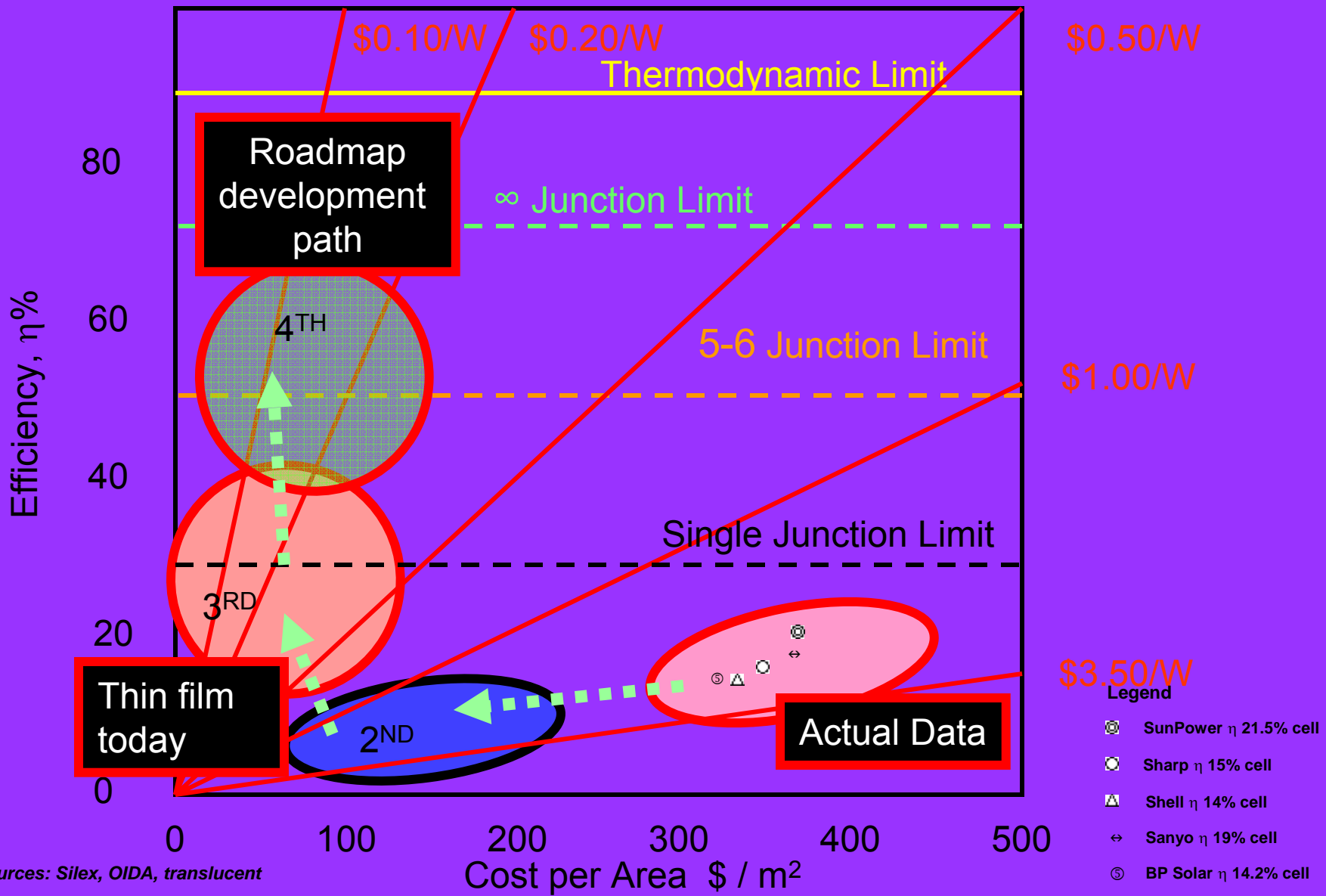
Michael Lebbv (lebbv@oida.org)

Multi-junction concentrators lead

OIDA solar roadmap 2007

OIDA

Solar cell platform roadmap



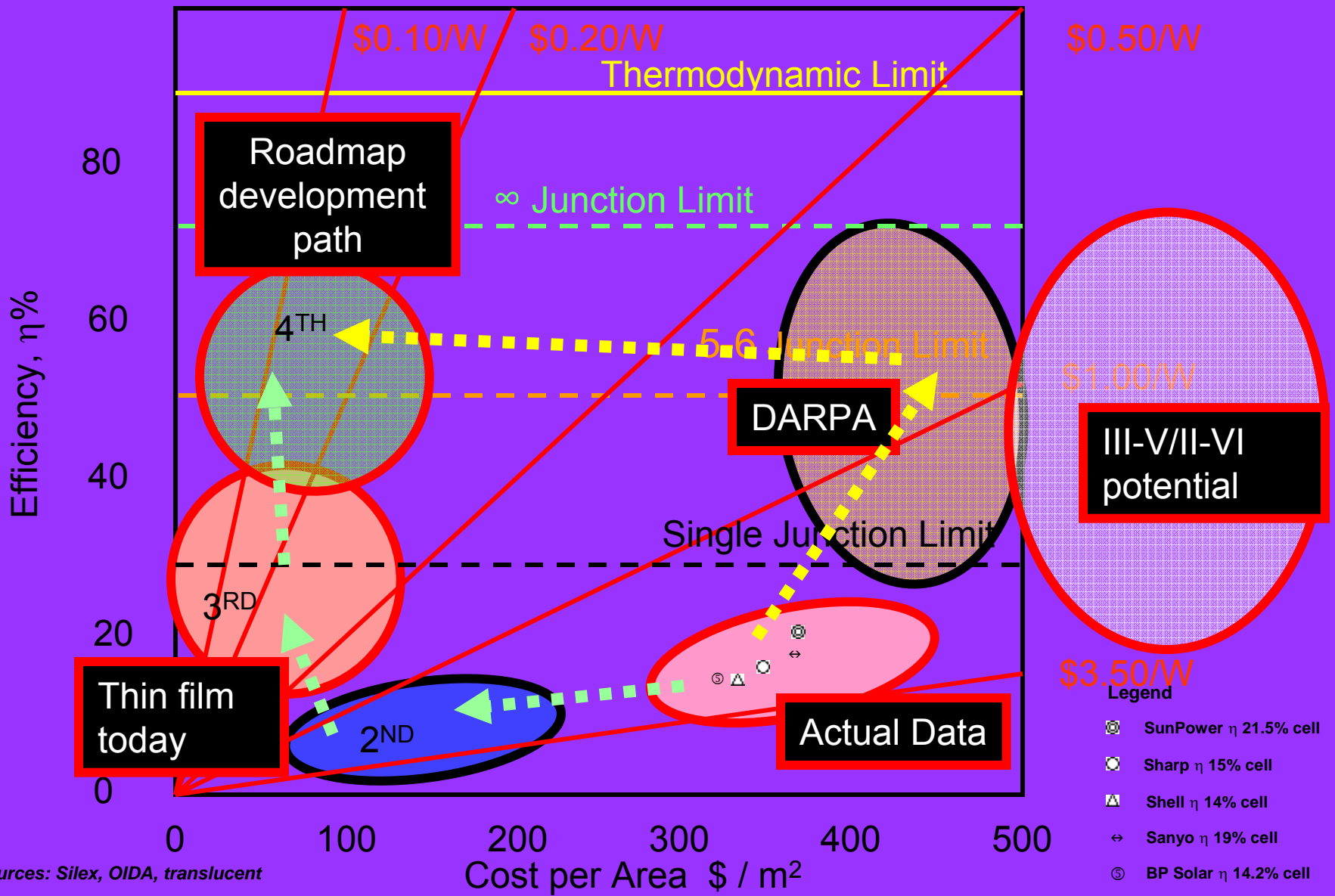
Sources: Silix, OIDA, translucent

- Legend**
- ⊗ SunPower η 21.5% cell
 - ⊙ Sharp η 15% cell
 - △ Shell η 14% cell
 - ↔ Sanyo η 19% cell
 - ⊕ BP Solar η 14.2% cell

OIDA solar roadmap 2007

OIDA

Solar cell platform roadmap



Sources: Silix, OIDA, translucent

***Can you remember
the 4 Grand
Challenges?***



4 Grand Challenges...

■ Terabit Photonics

- Video will be the killer app to drive bandwidth

■ Mobile Photonics

- Mobile living room will evolve

■ Plastics Photonics

- Roll to roll manufacturing with flex

■ Green Photonics

- Energy efficient, cleaner products



Moral of the story...summary

- Imagine our lifestyle in 10yrs
 - Focus on the needs (for the new lifestyle)
 - Look where the technology roadmaps fall short...
 - Better idea of where photonics will impact life, health and environment
- The 4 grand challenges help will enable that lifestyle...
 - Lots of challenging R&D...



Michael Lebbby (lebbby@oida.org)

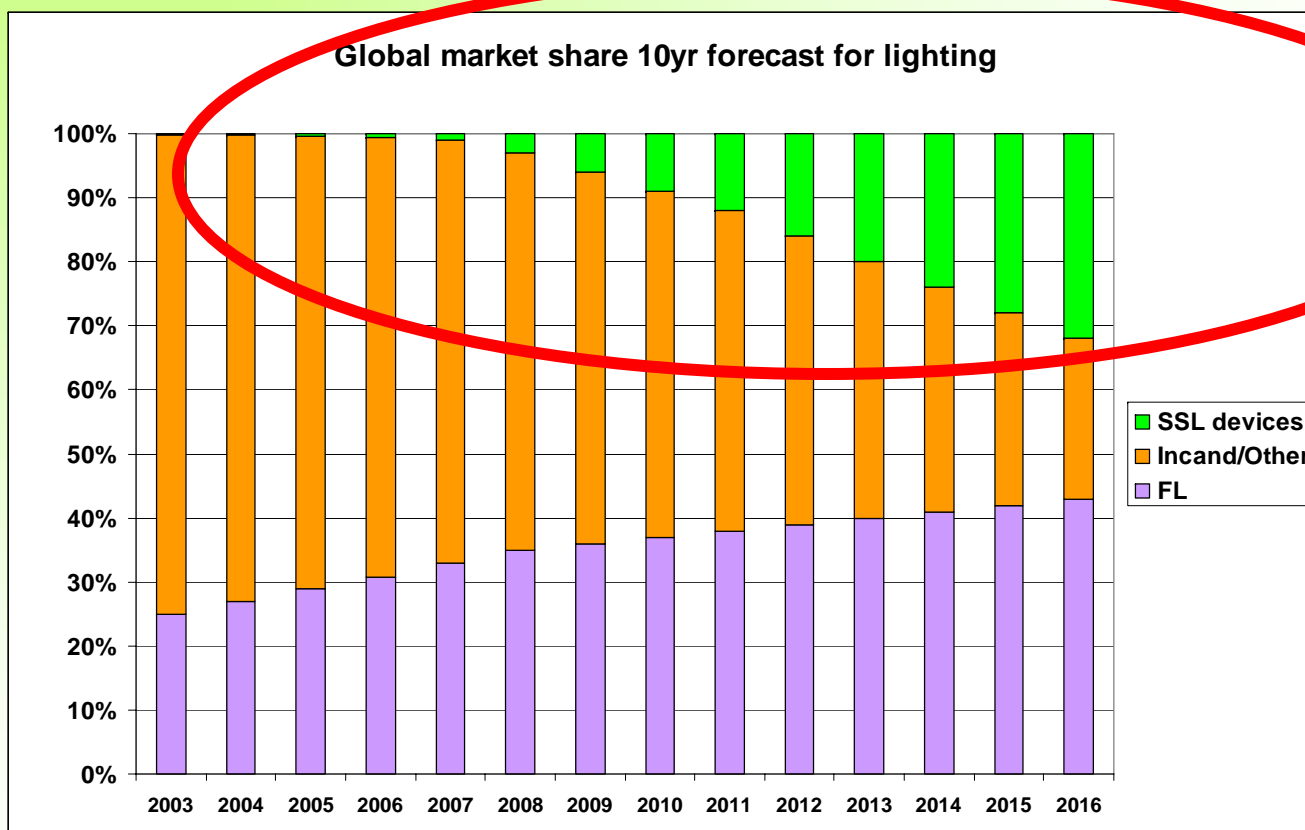
Photonics is key to our lifestyle...

End



Lighting market share forecast

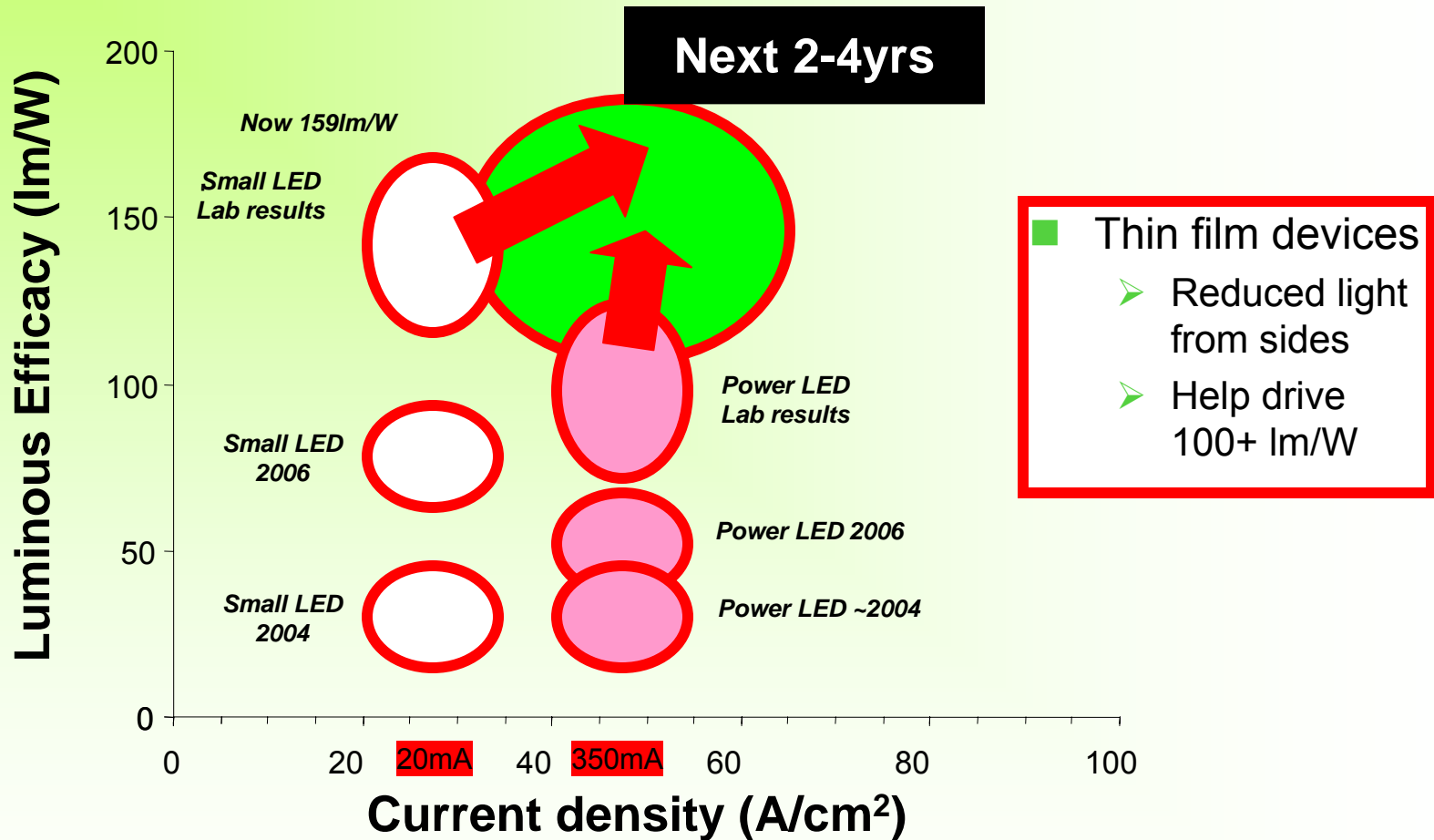
- SSL will grow to 32% of lighting market by 2016



Michael Leby (leby@oida.org)

Will the G7 ban Incand/Mercury in 5yrs?

White HBLED performance



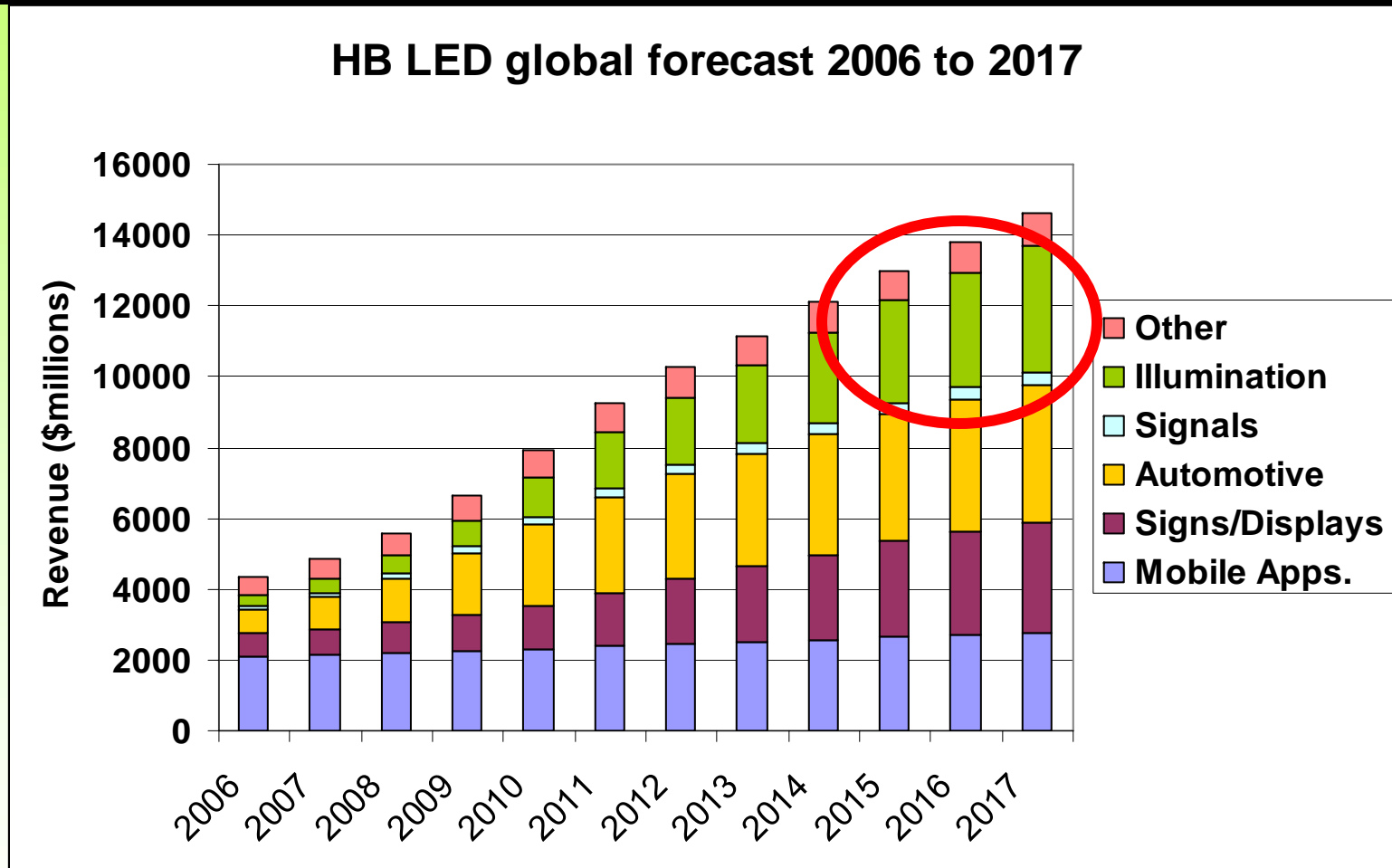
Sources: Philips Lumileds, CREE, Nichia, Osram, Tokoyda Gosei, OIDA

Michael Leby (leby@oida.org)



Converge: pwr devices > 100 lm/W soon...

Global HB LED over next decade



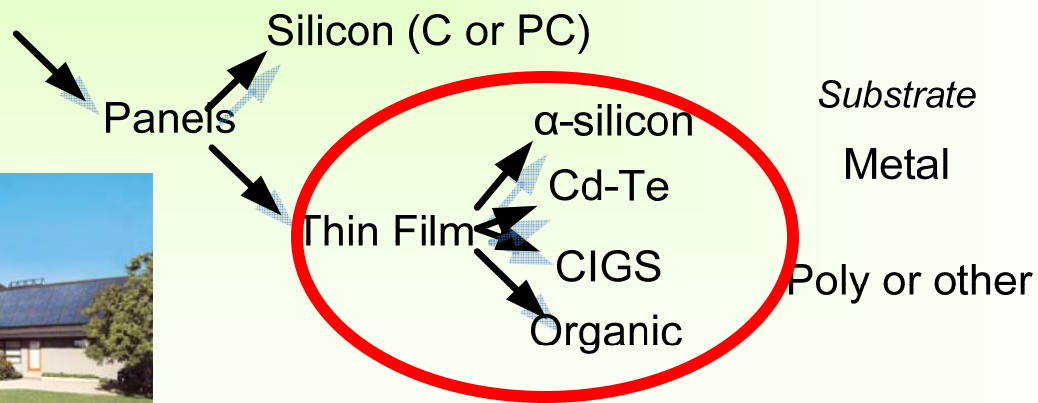
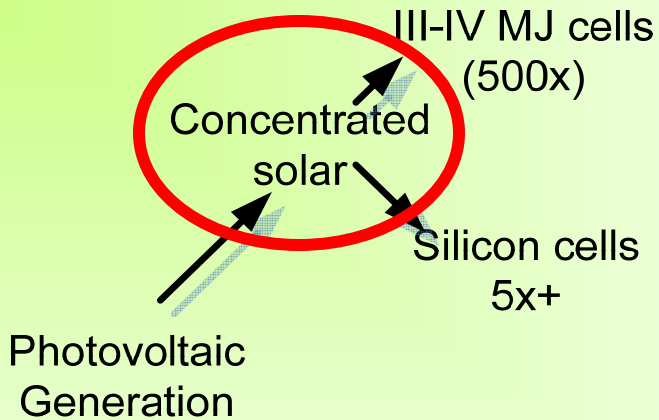
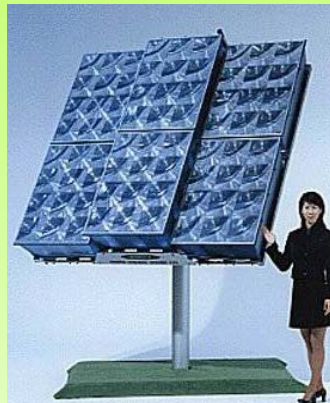
Sources: OIDA, Strategies unlimited, iSupply, Yole, OIDA members, IOA

Michael Lebbby (lebbby@oida.org)



Illumination will be strong for LEDs

A solar taxonomy

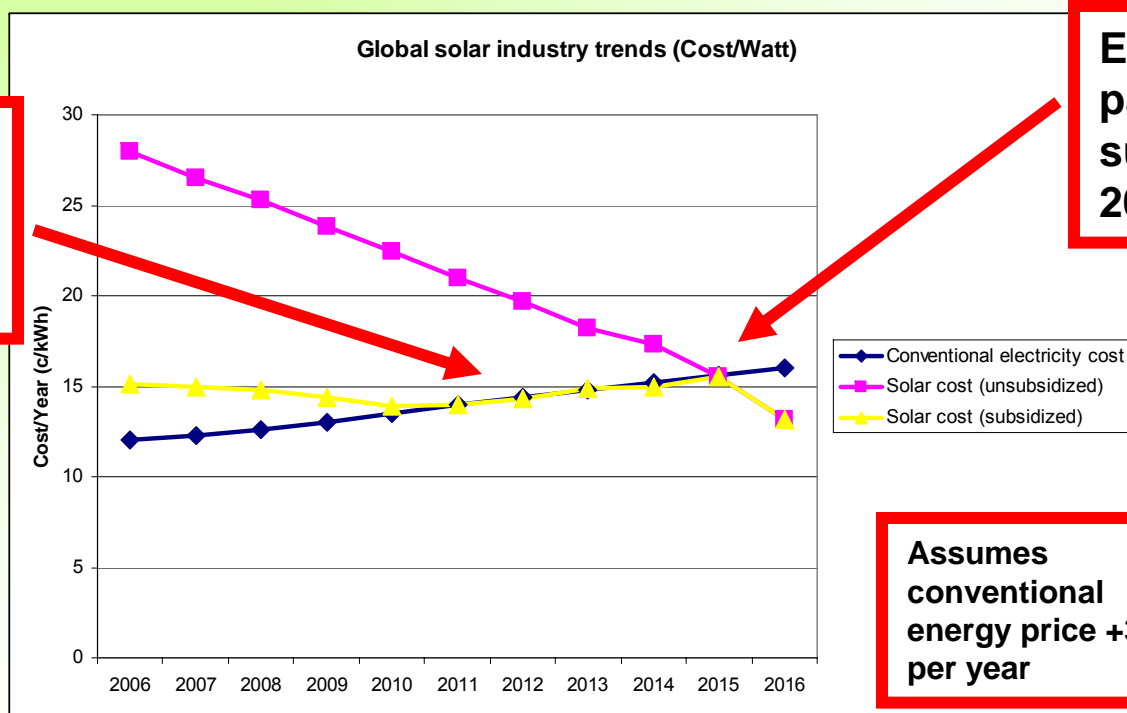


Michael Lebby (lebby@oida.org)

Scalability is the key with any technology

One view of solar industry cost trends

- Economies of solar in Cost/kWh → fundamental driver
- Today ~28c/kWhr (Ca) before subsidies (~14c after)
 - Verses ~11c-34c for retail electricity costs



Expect grid parity with subsidy around 2010-12

Expect grid parity without subsidy around 2014-16

Assumes conventional energy price +3% per year

Source: Morgan Stanley, Street Research

Michael Lebbv (lebbv@oida.org)



Issue: Generation vs transmission

Thin film solar cell innovations

- Challenge to the dominance of silicon by reducing manufacturing costs



Sources: Sharp

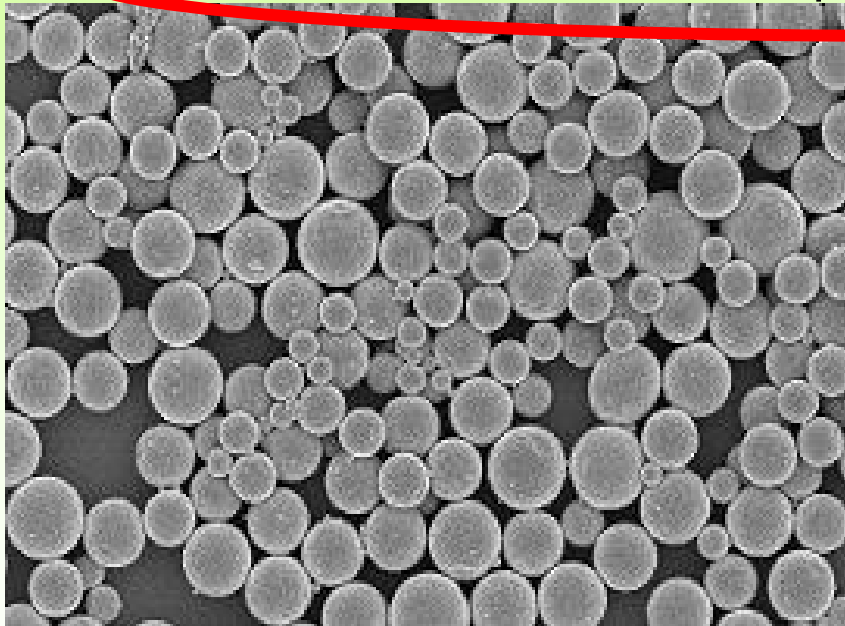


Michael Leby (leby@oida.org)

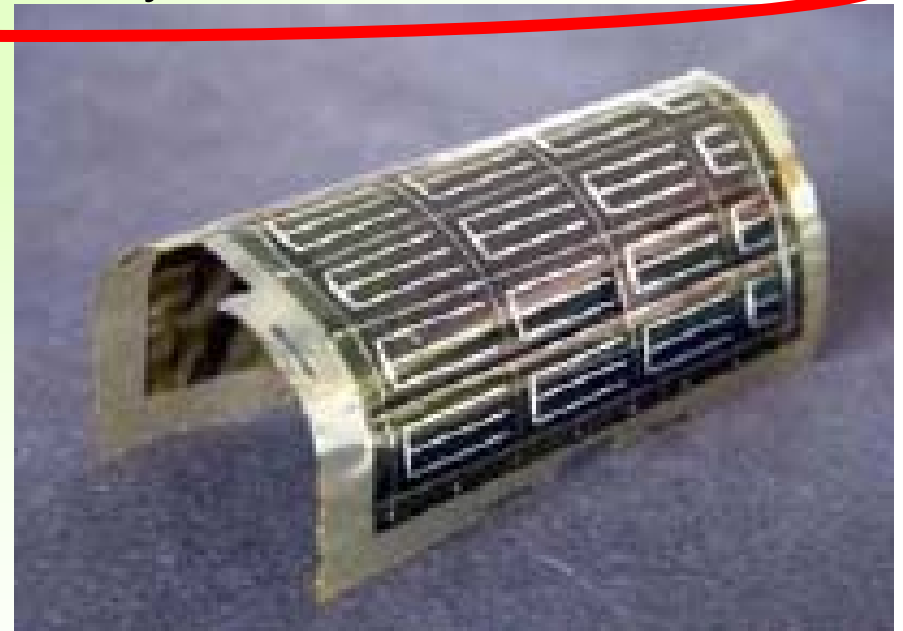
Efficiencies still hover ~10% today

Driving new innovations in solar

- Printing of CIGS thin films will extend to flexible substrates
 - Solution coated nano-composite material (ink)
 - CIGS thin film material deposited by vacuum onto s/steel



Source: Nanosolar



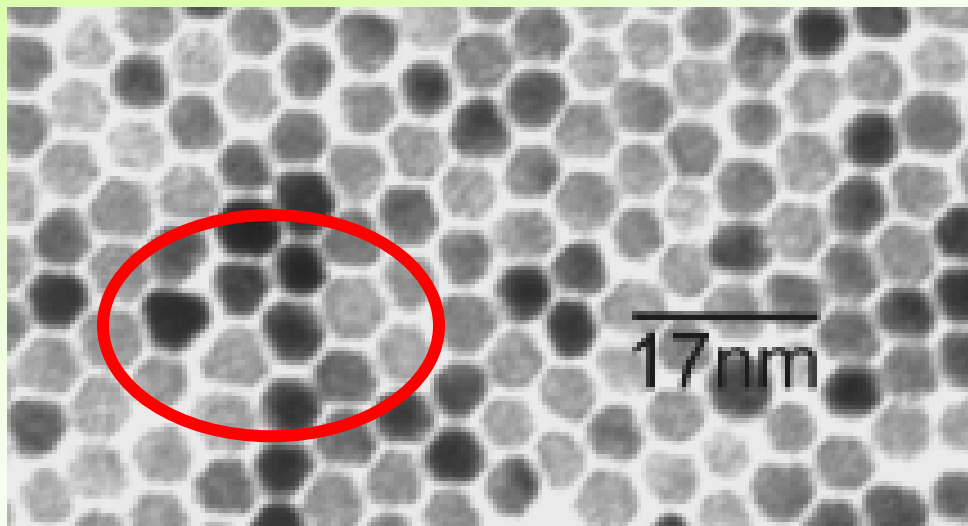
Michael Lebbv (lebbv@oida.org)



Printing cells opens new opportunities

Inorganic solar cells

- Ultra-thin solar cells from colloidal inorganic nanocrystals based on CdSe/CdTe
- Low-cost power generation, tunable absorption
- Polymer based manufacturing as semiconductor inks



Source: Ilan Gur, University of California, Berkeley

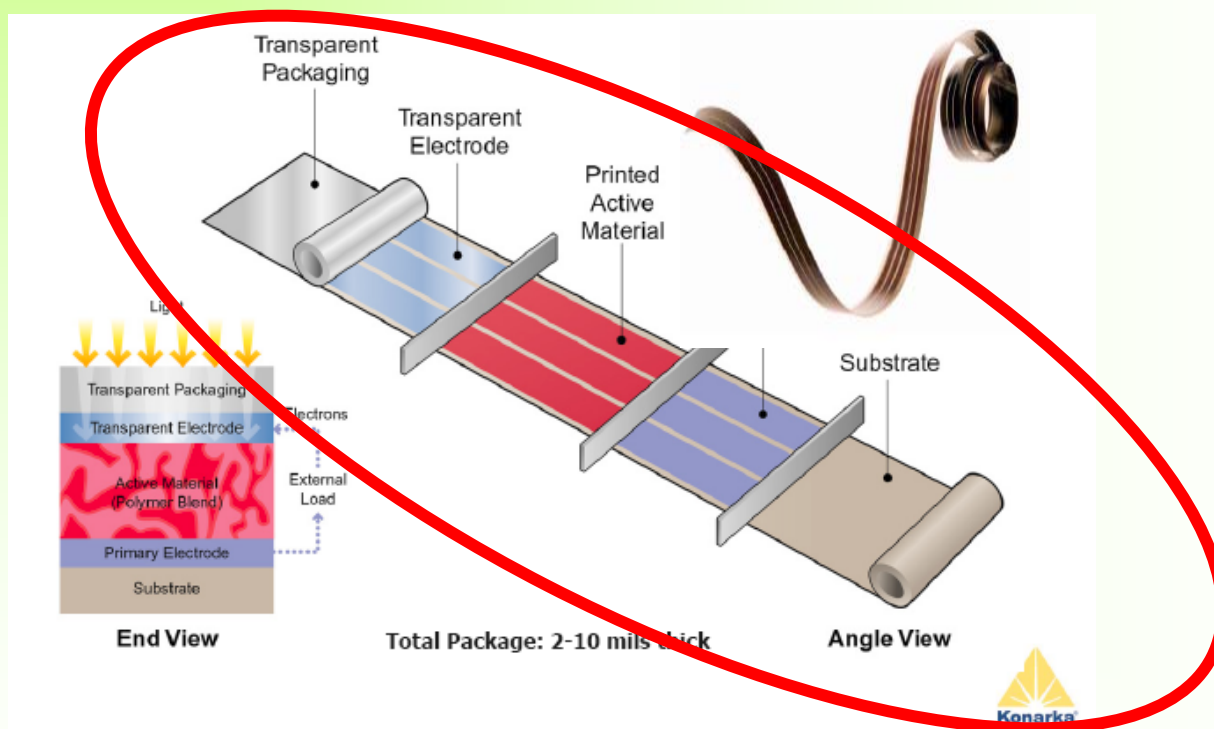
Michael Lebbv (lebbv@oida.org)



High potential for low cost manf

Printing approaches to solar cells

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



Source: Konarka

Michael Lebbv (lebbv@oida.org)



Capital investment in plant: big driver

Led/LCOS engine mobile projection

- LED-illuminated projection engine designed for integration into virtually any personal electronic device.
- Roughly the size of a wireless earpiece and less than half an inch thick, the 3M mobile projection engine delivers brilliant VGA resolution images
- When deployed in a host platform, such as a mobile phone, 3M's technology can project a 40-inch or larger image with no-speckle and a high-fill factor that ensures superior image quality.
- Each engine uses an advanced liquid crystal on silicon (LCOS) electronic imager in conjunction with proprietary 3M optics technology.
- Available today



Source: 3M



Michael Leby (leby@oida.org)

CES '08