

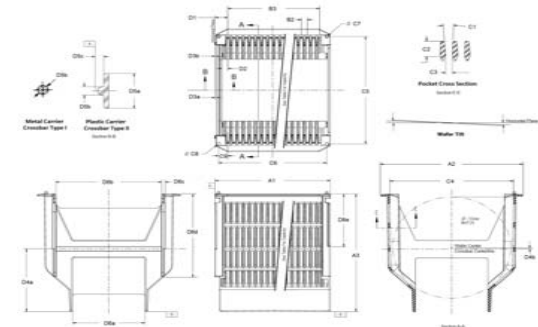
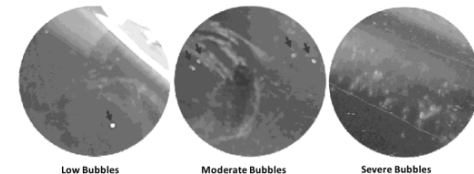


# LED Chip Manufacturing Outlook and Standards Update

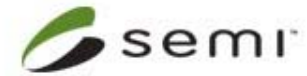
Tom Morrow, SEMI

# Agenda

- LED Manufacturing Outlook
  - Capacity by region
  - Equipment spending by region
  - China Manufacturing Update
- SEMI LED Standards Update
  - Wafer Geometries
  - Automation
  - Other
- How LED Industrial Development Compares with other Industries
  - Options and Policies



# SEMI & LEDs



- SEMI
  - Global Association for the Microelectronics Manufacturing Supply Chain
  - Established in 1971
  - ~2000 global members, primarily equipment and materials suppliers to the semiconductor, display, PV, LED, MEMS and related industries
- Exhibitions, Conferences, Forums in All Regions of World
- Industry Research-Opto/LED Fab Watch and Forecast
- Manufacturing Standards Development in LEDs
- Public Policy



LED Manufacturing Seminar, Taiwan



LED Manufacturing Forum, SEMICON China



LED Forum, SEMICON West



LED Korea, Conference and Expo



LED China Conference and Expo



LED Forum, Taiwan



# Manufacturing Outlook

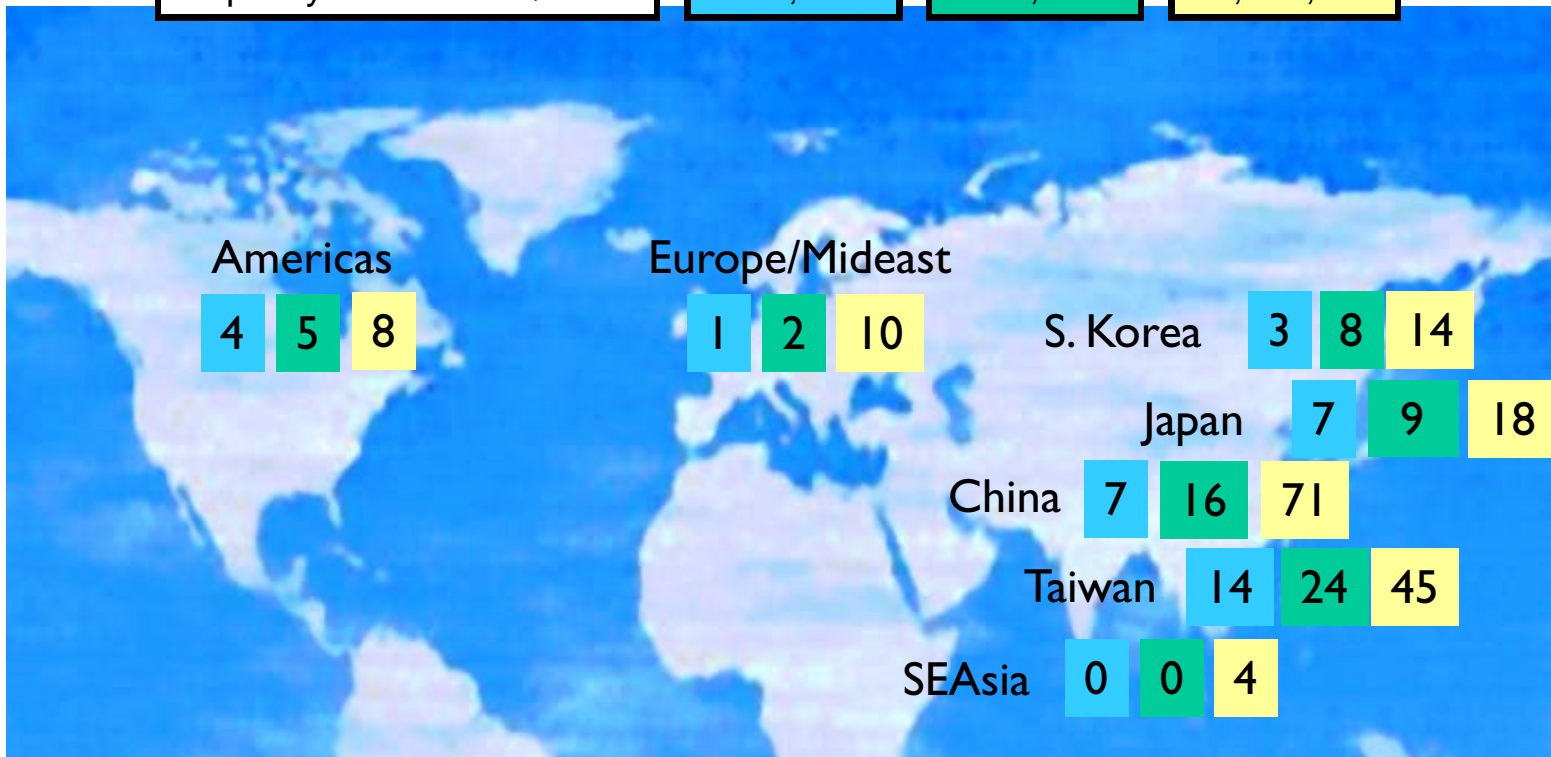


# LED Dedicated Fabs

## Changing LED Landscape



Year (begin operation)	2001	2006	2013 (est)
Total count of LED fabs*	36	64	170
Capacity in 4-inch EQs w/m	127,124	376,400	~2,400,000



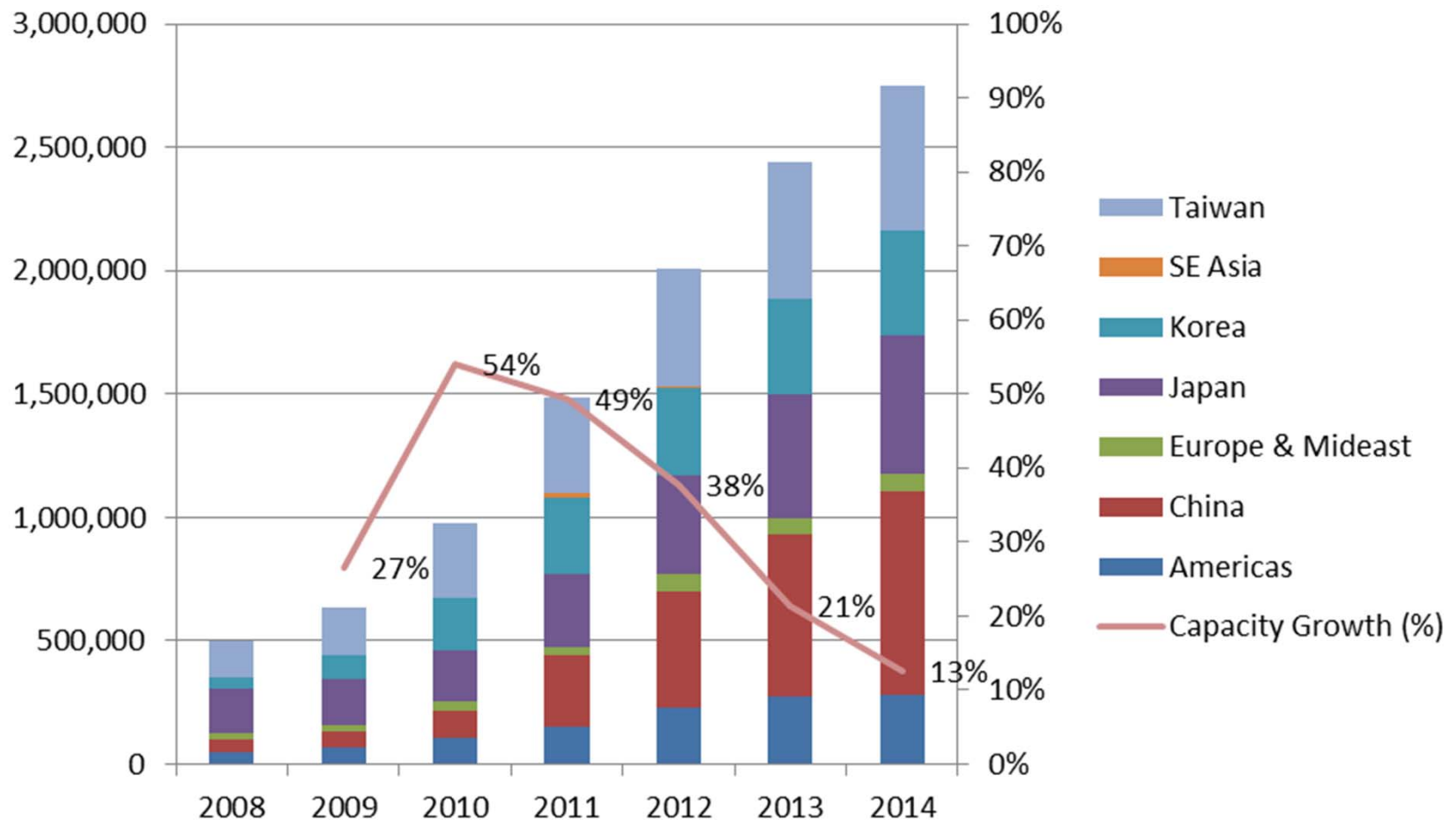
\*Fab number includes both LED epitaxy and chip facilities.

Source: SEMI Opto/LED Fab Forecast, Feb. 2013



# World LED Capacity Trend

LED Epitaxy capacity (4" equivalent per month)



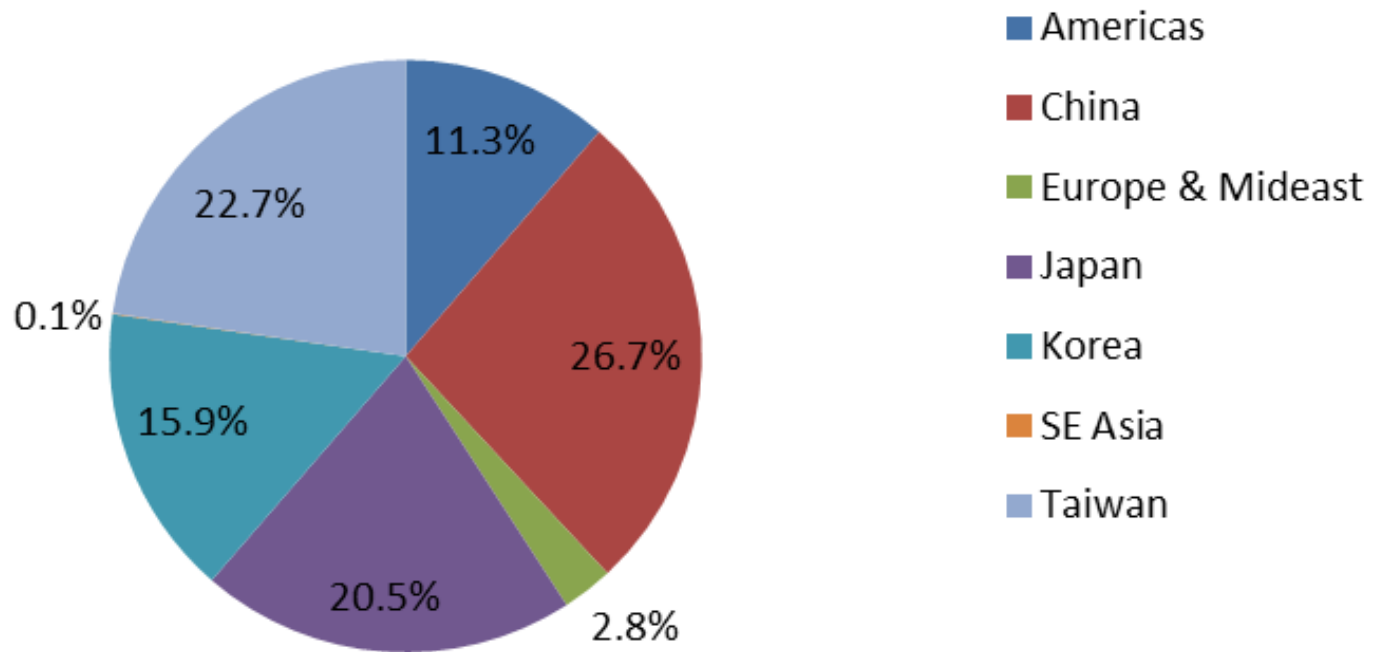
Source: SEMI Opto/LED Fab Forecast , Feb. 2013



# LED Fab Capacity by Region

Worldwide LED Epitaxy capacity to reach 2.4 M in 2013 (4" equivalent per month)

## 2013

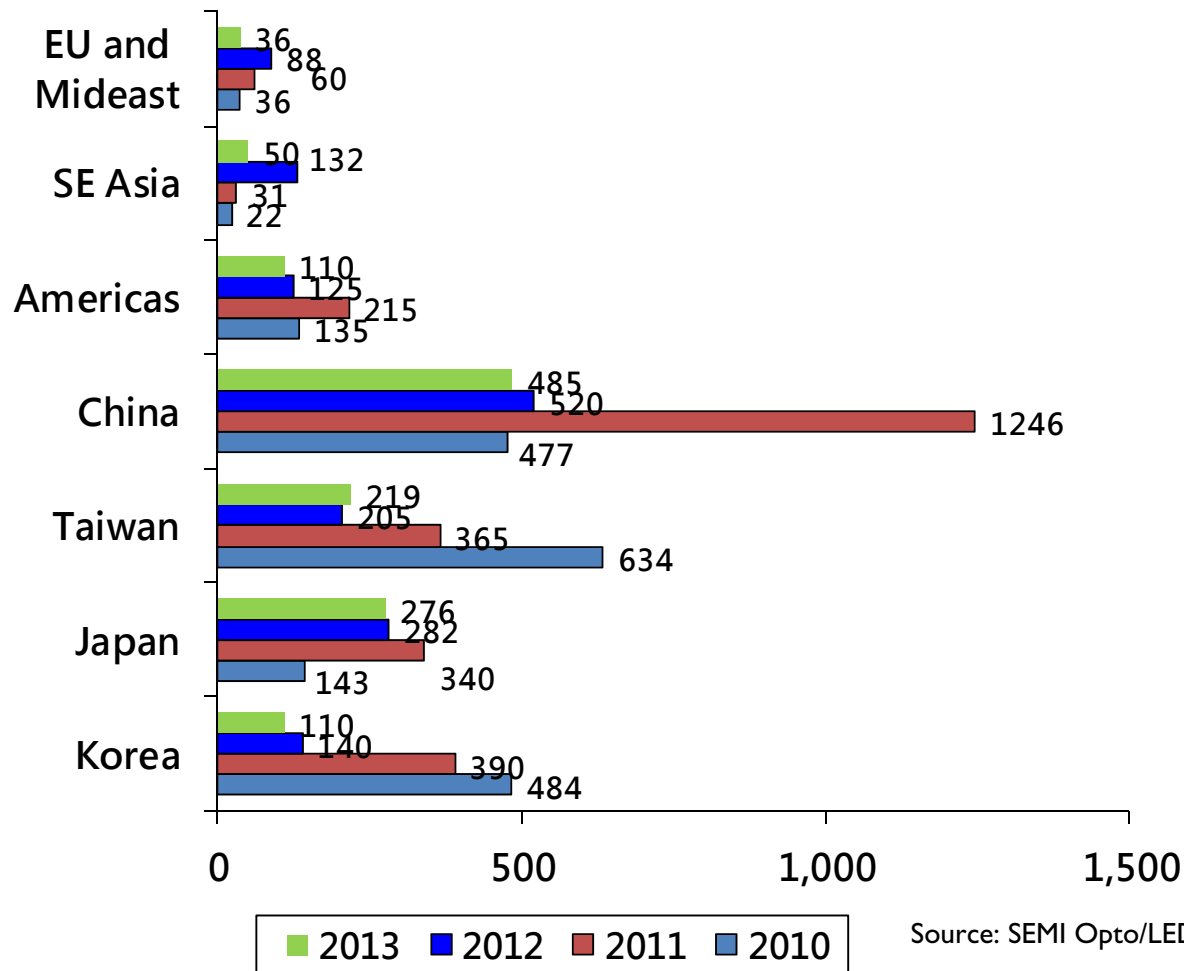


Source: SEMI Opto/LED Fab Forecast , Feb. 2013

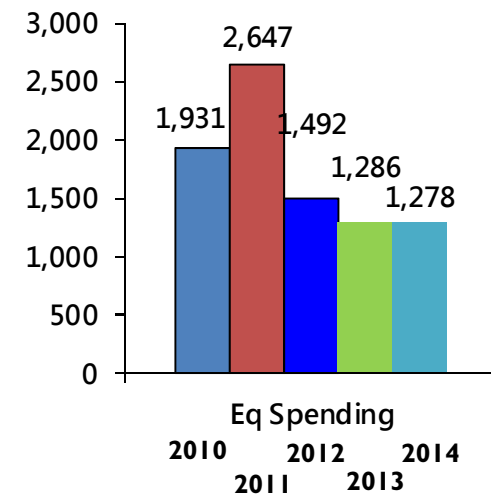


# LED Fab Equipment Spending

In \$US Million



In \$US Million

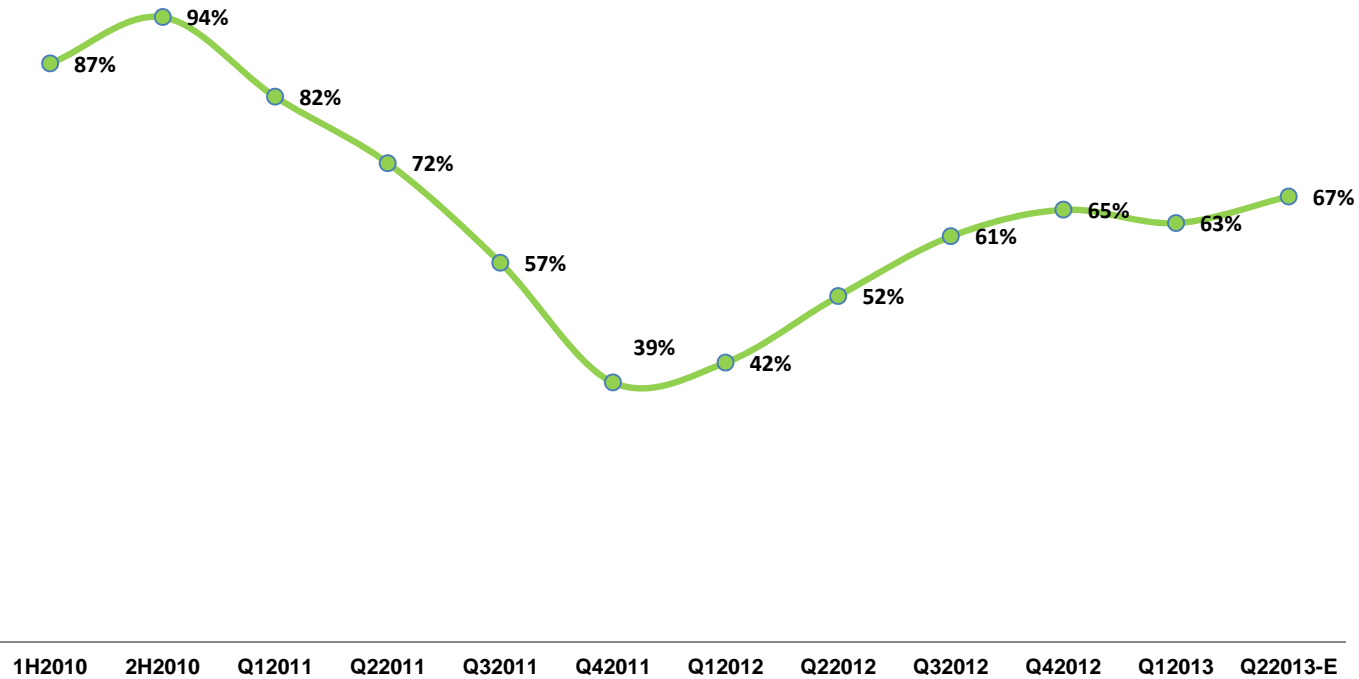
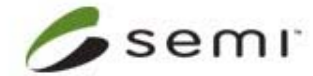


Source: SEMI Opto/LED Fab Forecast, April 2013 (prelim.)





# China LED Fab Utilization Rate

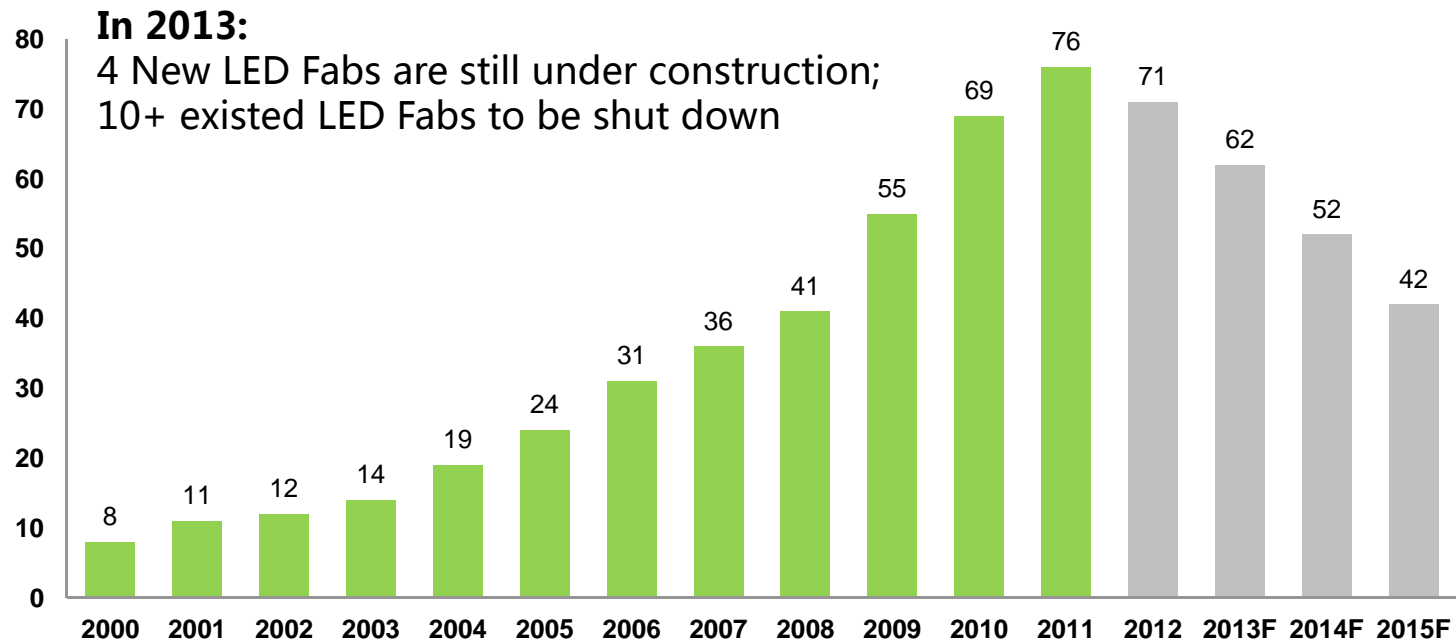


- China LED Fabs utilization (based on MOCVD tool) was down to 40% Q42011~Q1 2012.



# China LED Fabs Status

China LED Fabs Qty.



Source: SEMI China, 2013

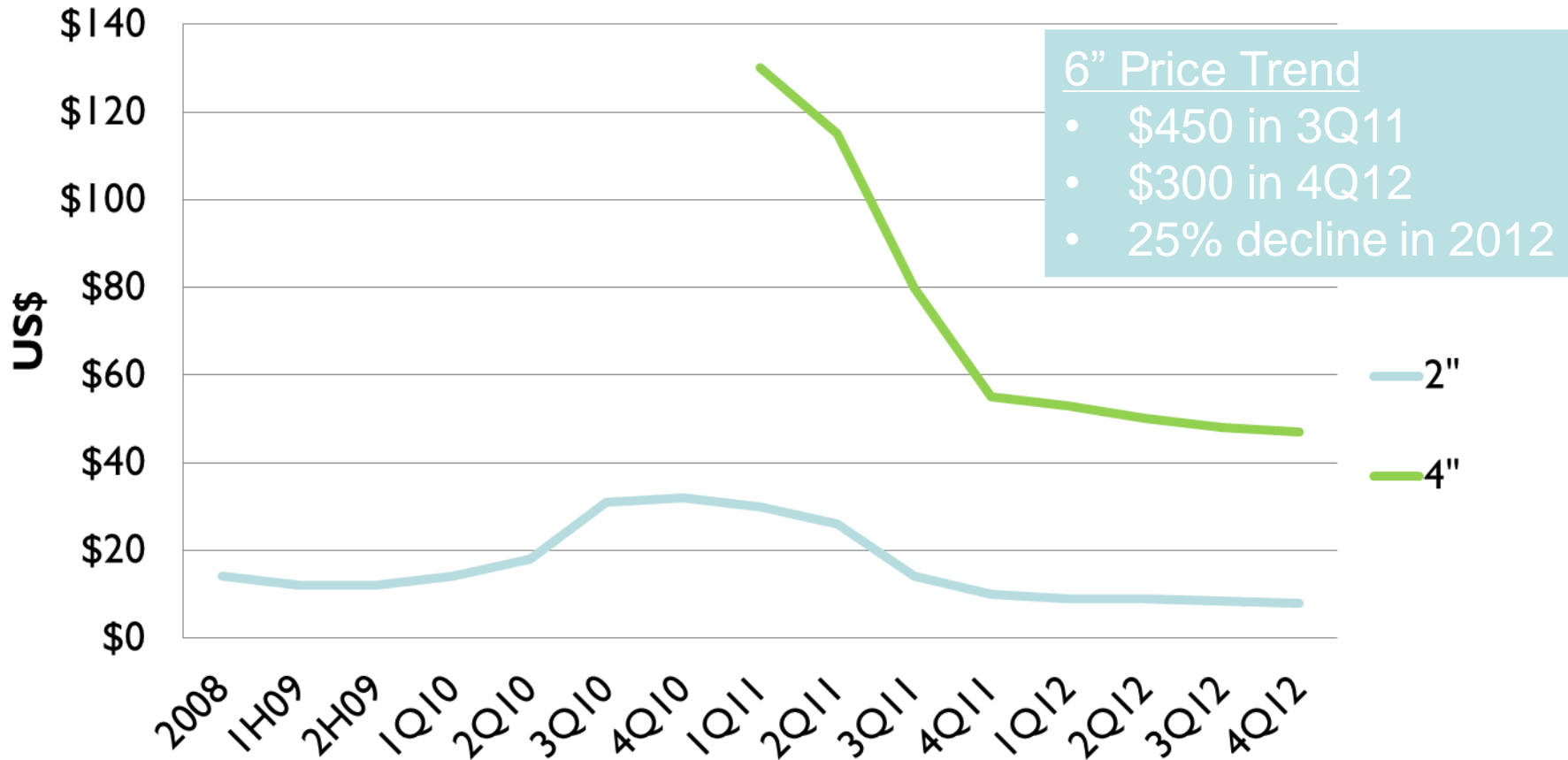
- China LED Fabs came to merging stage since 2012 .
- ~40% LED Fabs will quit or be acquired by 2015.



# Sapphire Pricing Trend

(Price refers to epi-ready polished wafer, not Pattern Sapphire Substrate)

## Sapphire Substrate Price



Source: Company data, Digitimes, SEMI IRS

# Manufacturing Outlook

- Overcapacity and margin pressure dampening investment incentives
- Industry awaits GaN-on-Si results; Skepticism Abounds
  - Toshiba/Bridgelux begins production of white LEDs using GaN on 200mm silicon in 2012
  - Toshiba acquires Bridgelux GaN on Si technology (April 2013)
  - Azzurro announced that Epistar has successfully migrated their LED structures to its 150mm GaN-on-Si templates and is working on 200mm
  - TSMC reportedly beginning GaN on 8 inch Silicon
- Industry consolidation, vertical integration continues
- Capex focus on yield, not scale



# SEMI Standards Update



# SEMI Standards

- Manufacturing Standards  
Development for over 35 years
  - Serving the semiconductor, LED, flat panel display, PV and MEMS industries
  - ~1800 standards
  - 3000 volunteers
  - Over 20 Technical Committees and 200 Task Forces
  - November 2010--**HB-LED Standards Committee** formed with strong industry support (VP-level device makers, key equipment manufacturers, material suppliers)



SEMI®  
International  
Standards



# Participating LED Companies\*



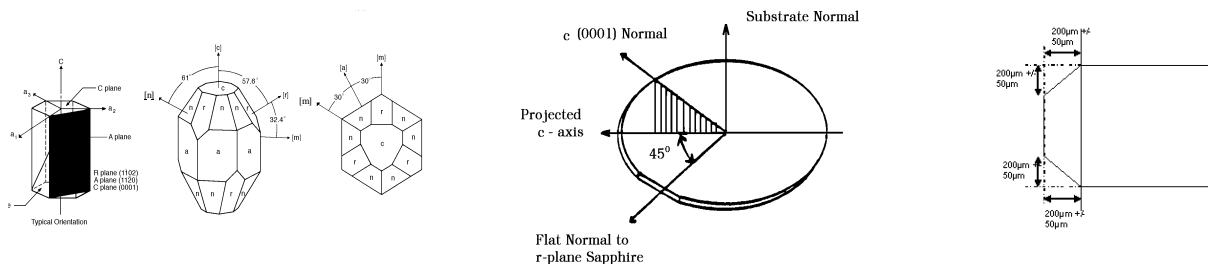
Over 120 registered Task Force members

AIS Automation	Hitachi High-Tech	Op-Test	Semilab
Aixtron	ILJIN Display	OSRAM	Silian Sapphire
Applied Materials	KLA-Tencor	Oxford Instruments	Sonoscan
ARC Energy	Kulicke & Soffa	Pall	Strasbaugh
Brooks Automation	Lam Research	PEER Group	Sumitomo
Cimetrix	LayTec	Philips Lumileds	SUSS Microtec
Daifuku	Meyer Burger AG	Quartet Mech	TOK America
Dow Corning	Miraial	Rubicon	Ultratech
Entegris	MKS Instruments	Rudolph Tech	Umicore
Epistar	Monocrystal	Samsung	Veeco
GT Advanced Tech	NIST	Sapphire Tech	Zeromicron

\* Partial List

# Published Standards

- **SEMI HBI-0113**, *Specifications for Sapphire Wafers Intended for Use for Manufacturing High Brightness-Light Emitting Diode Devices*
  - These specifications cover dimensional, wafer preparation, and crystallographic orientation characteristics for five categories of single-crystal single-side polished sapphire wafers used in HB-LED manufacturing as follows:
    - Flatted 100 mm diameter, 650  $\mu\text{m}$  thick, polished c-axis sapphire wafers
    - Flatted 150 mm diameter, 1,000  $\mu\text{m}$  thick, polished c-axis sapphire wafers
    - Flatted 150 mm diameter, 1,300  $\mu\text{m}$  thick, polished c-axis sapphire wafers
    - Notched 150 mm diameter, 1,000  $\mu\text{m}$  thick, polished c-axis sapphire wafers
    - Notched 150 mm diameter, 1,300  $\mu\text{m}$  thick, polished c-axis sapphire wafers
  - In addition, methods of measurements suitable for determining the characteristics in the specifications are indicated.

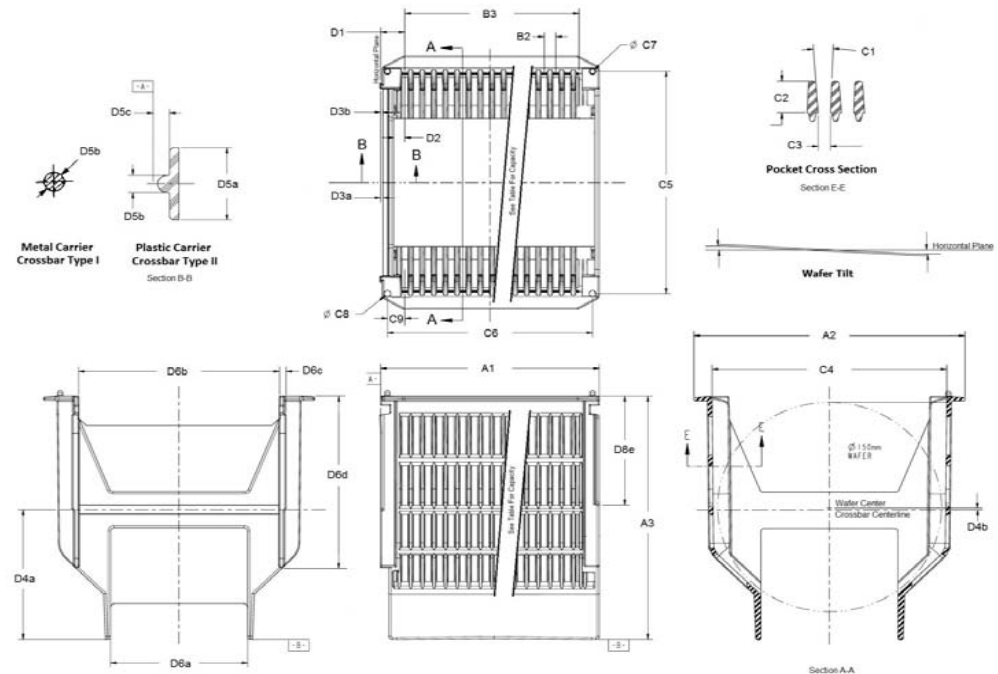




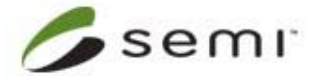
# Recently Approved Document

- **SEMI Draft Document 5420A**, *Specification for 150 mm Open Plastic and Metal Wafer Cassettes Intended for Use for Manufacturing HB-LED Devices*

This specification provides the dimensional requirements for plastic and metal wafer cassettes used for the processing and handling of 150 mm diameter HB-LED sapphire wafers conforming to the SEMI HBI.



# Current Activities

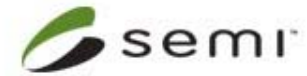


## Equipment Automation TF

- Equipment Automation TF – Hardware WG
  - [ [Doc. 5468](#) ] New Standard: Mechanical Interface Specification for 150 mm HB-LED Load Port
    - This Document will define the basic interface dimensions of a load port and their arrangements on HB-LED manufacturing equipment, where HB-LED 150 mm cassettes can be loaded and unloaded. These interface specifications include:
      - Location of physical interface between an HB-LED cassette and HB-LED manufacturing equipment.
      - Definition of load port volume and horizontal spacing on the equipment.
      - Ergonomic clearances for manual cassette handling.
      - RFID reader/writer volumes.
    - Document development in progress, to be submitted for the Cycle 3, 2013 voting period.



# Current Activities

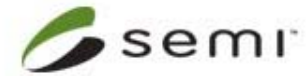


## Equipment Automation TF

- Equipment Automation TF – Software WG
  - [ [Doc. 5469](#) ] New Standard: Specification for High Brightness LED Manufacturing Equipment Communication Interface (HB-LED ECI)
    - Document development in progress, to be submitted for the Cycle 4, 2013 voting period.
  - New Activity:
    - [ [5529](#) ] New Standard: Specification of Job Management and Material Management for High Brightness LED Manufacturing Equipment (HB-LED JMMM)



# Current Activities



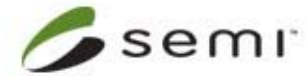
## HB-LED Wafer TF, Impurities & Defects TF

- HB-LED Wafer TF, Impurities & Defects TF
  - Working on next set of revisions to SEMI HBI, including:
    - laser marking and identification specification;
    - definitions and specifications of impurities and defects;
    - patterned sapphire substrate (PSS)-ready specification for 100mm and 150mm;
    - double sided polished wafers specifications;
    - updated surface roughness parameters & test methods; and
    - reclaimed wafer specifications
  - Ongoing: Phase 2 of the wafer marking experiment to characterize mark survivability, mark width, and depth



# LED Safety Task Force

## Taiwan EHS Committee



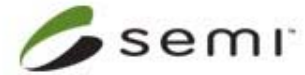
- Formation Date: October 25, 2011
- Charter
  - The objective is to develop EHS (Environmental health and safety) technical standard specifications and guidelines related to LED manufacturing equipment.
- Scope
  - The activities of the task force will result in the development of an EHS industry standard which equipment suppliers, raw material suppliers, module makers and other involved parties can find conformity.
  - Initial work will focus on:
    - Determining if current LED equipment is covered by SEMI S2 or not
    - Developing EHS guidelines for manufacturing equipment for the LED industry
  - Future activities may include:
    - Establishing equipment safety event database
    - Collecting and analyzing the data of safety notice and SEMI reports which were certified by third party
    - Developing SEMI EHS guidelines for LED manufacturing



# LED Manufacturing and Today's Microelectronics Industry



# Comparisons with the Solar Industry



**PV**



**LED**



**Demand Event**

German Feed-In  
Tariffs

LED TVs

**Supply Chain Gaps**

Low scale mfg.  
Polysilicon Shortages

Low scale mfg.  
Sapphire Shortages

**Global Race is On**

WW cap. increases  
400% 2007-2011

WW cap. Increase  
288% 2008-2012

**China Investments**

~65% of world  
capex (2011)

~40% of world  
capex (2012)

**Overcapacity**

Rapid price declines;  
widespread financial  
losses

Rapid price declines;  
widespread financial  
losses

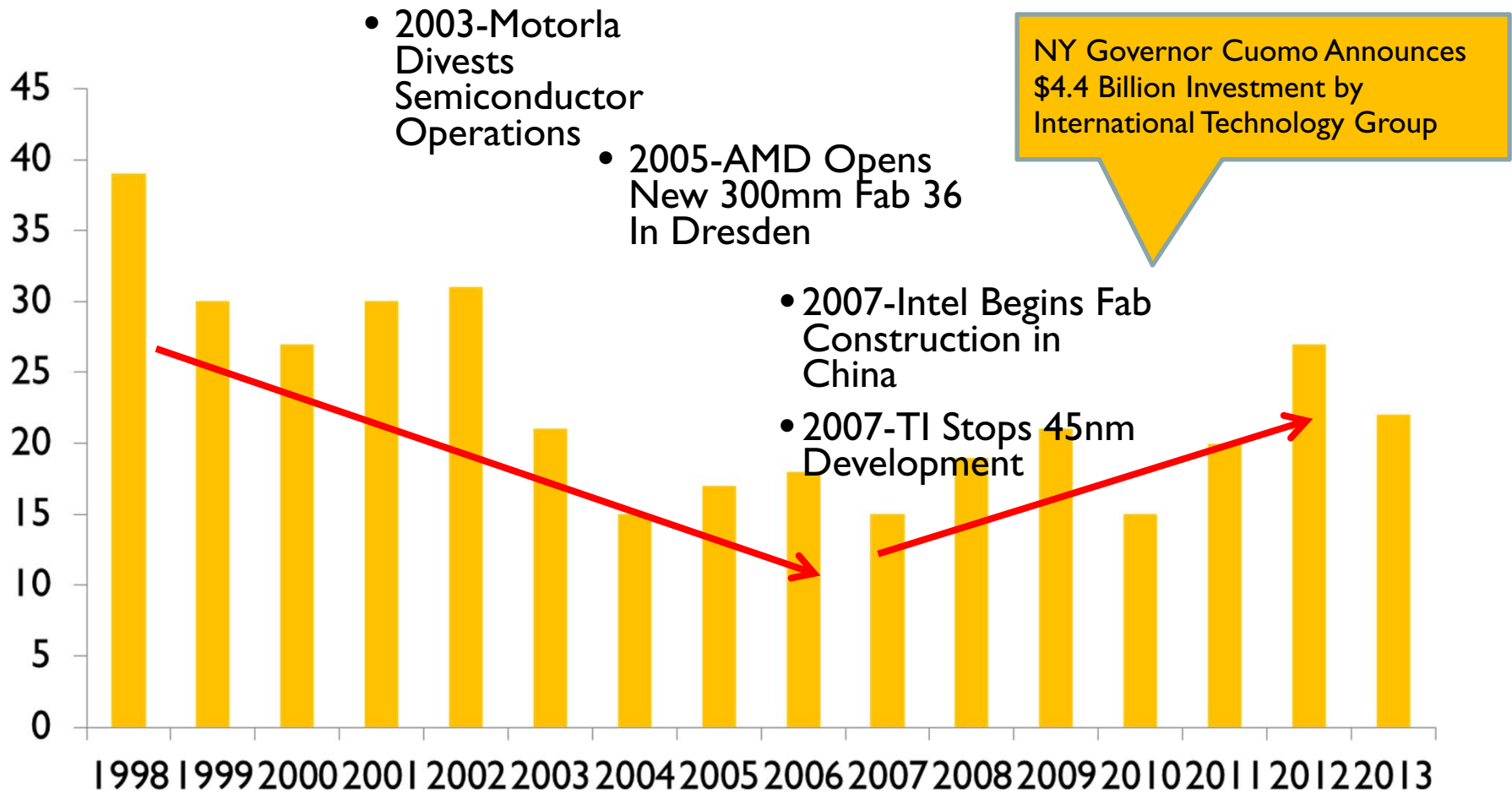
**Global Trade Impact**

Trade Wars  
Quality Gaps

???



# US Share of Semiconductor Fab Equipment



Source: SIA, SEMI





# Solid State Lighting Policy

- SEMI supports increased funding for the DoE and EERE in particular
- SEMI supports SSL manufacturing and market support programs and prefers a clear, transparent SSL budget line, not just “Emerging Technologies”
- SEMI supports an accelerated solid state lighting adoption through a partnered manufacturing program between LED and lighting and equipment suppliers.
- SEMI supports DoE programs that retain and grow existing industries, not just try and create new ones.



# Thank You

Tom Morrow, SEMI

Questions and Comments: [tmorrow@semi.org](mailto:tmorrow@semi.org)

