平面顯示技術概論

平面顯示器製程設備

主講人： 郭怡之

講授日期： 2005年12月21日

Process Equipment Development for TFT-LCD Manufacturing

YT Kuo (郭怡之)

AKT, an Applied Materials Company

Dec. 21, 2005

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Outline

- **Introduction to AKT**
  - AKT's history & present
- **TFT-LCD Technology**
  - Investor's Point of View
- **Technologies of AKT**
  - Plasma-enhanced chemical vapor deposition (PECVD) process system
  - Process Capability
  - Electron Beam array Tester
- **Challenges and solutions to the large-size substrate processing**

AKT Overview

Applied Materials

- Founded: 1967
- Employees: 13,000
- Net Sales FY04: $8B

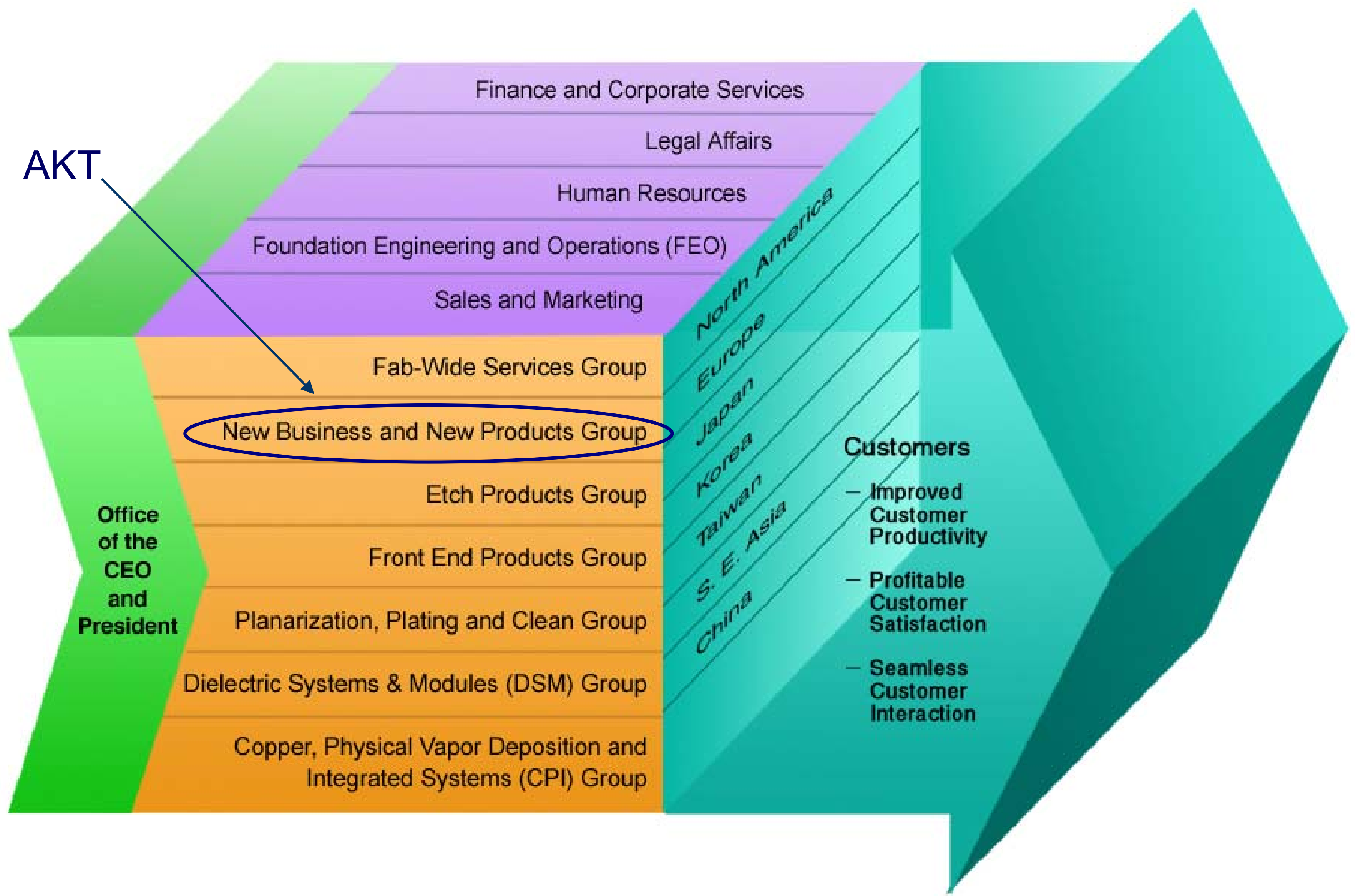
- Manufactures systems for processing silicon wafers, Flat Panel Displays, Mask Pattern Generation, Etch & Inspection Systems, and designs software for semiconductor manufacturing

AKT

- Founded: 1993
- Employees: ~ 450

- Manufactures systems for Flat Panel Display production, with processing glass substrate up to ~ 2100x2400 mm^2

AKT is one of the key growth engines of AMAT



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AKT

"Be the Leading Supplier of Display Manufacturing Equipment and Service through Innovative Technology and Continuous Improvement of Products Enhancing Customers' Productivity."

Envisioning the Future

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Company History

AKT

- Started PE-CVD Development in AMAT – ADT — 1991
- Joint development program with Japan — 1992 -1993
- Shipped the first AKT-1600 CVD to Japan — Feb. 1993
- Formed 50:50 JV Applied Komatsu Technology — Sep. 1993
- Established AKT Korea Branch — May 1994
- Shipped first AKT-1600 CVD to Korea — Sep. 1994
- Shipped the first system to Taiwan — Feb. 1996
- AMAT bought 50% share from Komatsu — Oct. 1999
- Established AKT Taiwan Branch — Dec. 1999
- Acquired EBT organization in Germany — Jan. 2000
- Shipped the 400th PECVD system to China — Sep. 2004
- Opened 1st AKT office in P.R. China — Sep. 2004
- 450th PECVD system shipped — May. 2005

AKT's Current Focus

AKT

Products

Gen 8 PECVD

-System / Process Development

-Beta System Manufacturing

Gen 6 – 7.5 PECVD

-Fab start-up/Production Support

Gen 2 - 4 PX PECVD for LTPS

-Process Enhancement

-R&D/Production Support

Gen 6 - 7 EBT (Array Tester)

-Fab start-up/Production Support

Gen 8 EBT (Array Tester)

-Concept Design

Technology

Continuous Development

-Throughput Enhancement

-COO Reduction

-Innovative Future Technology & Product Development

-PECVD:

- -a-Si / LTPS Superior Process
- -Lower Chamber Cleaning Cost
- -Particle Reduction
- -Low Temperature Deposition

-EBT:

- -Detectability Enhancement
- -IPS / LTPS / OLED Test Capability

Customer Support

Global Focus

-Rapid and Smooth Start-Up

-On-time Spare Parts Delivery

-Productivity Improvement

-Post-Warranty Contracts

-Total Support Package

-Used System Support

-Customer Training

-Local Manufacturing Capability

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AKT Systems Installation Base

(As of Q4/FY 2005 End - Estimation)

Region	Count
Taiwan	208
Japan	163
Korea	157
US & EU	13
China	5
Total	546

Product	Count
CVD	480
PVD	18
Etch	15
EBT	33
Total	546

480th PECVD shipped in Oct 2005

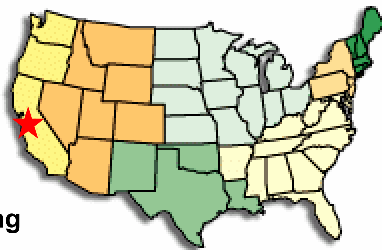
AKT's products are used for mass production at major LCD fab's in the world

AKT Worldwide Locations for Customer Support

AKT

United States

Santa Clara
- RD& E
- Manufacturing
- Engineering
- Customer Demo Facility
- Product Marketing
- Strategic Marketing
- Product Support & Training
- Spare Parts



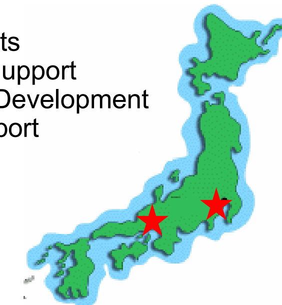
Japan

Osaka
- Sales and Marketing
- Customer Service Center

–Spare Parts
–Process Support
–Software Development and Support

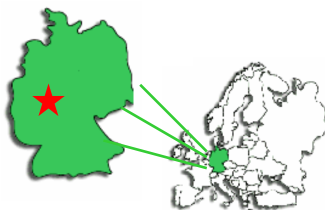
Tokyo
- Customer Service Center

Service Offices
- Tokyo
- Osaka



Germany (AKT EBT)

Feldkirchen
- Engineering
- Manufacturing Array Tester



China

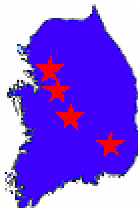
Beijing
- Sales and Service

Spares Depot: Beijing
Service office: Beijing

Korea

Seoul
- Sales
- Customer Service Center
- Spare Parts
- Product Support

Service Offices
- Kihueng
- Kumi
- Chonan
- Tangjung
- Paju



Taiwan

Hsin-Chu
- Sales and Service

Spares Depot: Taoyuan
Service office: Tainan
Taichung

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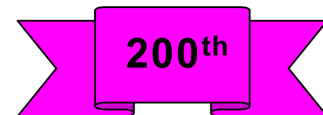
AKT Taiwan Summary

- Formed in 1996 under Applied Materials Taiwan
- Legal Entity established in 1999
- Hsinchu main office and 3 site offices
  - Taoyuan (spare operations, 2000)
  - Taichung (2004)
  - Tainan (2000)
- YTD: 60 RFT and 35 contractors.



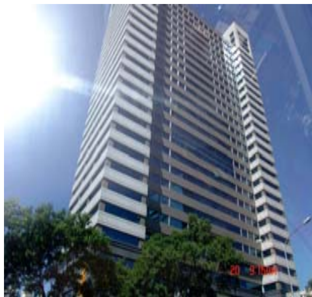
- More than 200 AKT systems Installed in Taiwan by August '05.
- Asia R&D Center (ARDC) established in Taiwan in 2004

AKT Taiwan Offices

Hsinchu office

ARDC

Taoyuan Spare Center



Taichung Site office

台北
桃園
新竹
宜蘭
苗栗
台中
彰化
南投
花蓮
雲林
嘉義
台南
高雄
台東
屏東

Tainan Site office

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Strategic Advantages of ARDC

- Close proximity to all customers in Asia
  - Fast demo cycles and lower cost
  - Rapid testing & implementing of continue improvement programs to customers
  - Close to customers eager for new technology demo & beta-site test
- Strategic partnership with ITRI
  - Exploiting ERSO processing capability for TFT device characteristics study and advanced technology
  - Exploiting MIRL's precision machinery engineering capability for future machine parts/ modules/ sub-system OEM/ ODM manufacturing , which provide high quality, lower cost, fast deliver speed to support all customers in Asia
  - Close collaboration with ERSO for Join Develop program- AM, AdOx, pass-SiN,.. etc.
  - Utilizing ITRI's overall advanced capabilities

- Intending to cover all R&D areas which may generate significant technology advancement and/or productivity enhancement
- Focusing on TFT-LCD sector, while vigilantly monitoring other emerging sectors (e.g., OLED, FED, etc.)
- Leveraging existing strong R&D resources, manufacturing experiences and global intelligence network in Taiwan
  - Advanced process capabilities
  - Advanced integration capabilities
  - Advanced testing / analysis capabilities
- Large cleanroom space in ITRI for multiple projects
  - Large area substrate processing capability – Gen 5, Gen 6 and beyond
  - Both wet and dry processing capability

Win-Win Strategy – Joint R&D Effort

AKT

- R&D focus
  - Large area substrate processing
  - Advanced CVD process technology
  - Advanced metalization technology
  - Other innovative new applications
- Joint research force – AKT and ITRI
  - Talented engineers
    - Hardware engineers
    - Software engineers
    - Process engineers
    - System engineers
  - Versatile technicians
- Located inside ITRI – close proximity to ERSO
- Facilities and Equipments – jointly provided by ITRI and AKT

ARDC - Facilities & Projects

AKT

- Process tool
  -15KA (Gen.5) Test Stand

- Measurement tools
  - Stress meter
  - FTIR
  - RI/thickness
  - Digiscreen
  - Alpha step

- Glass cutter

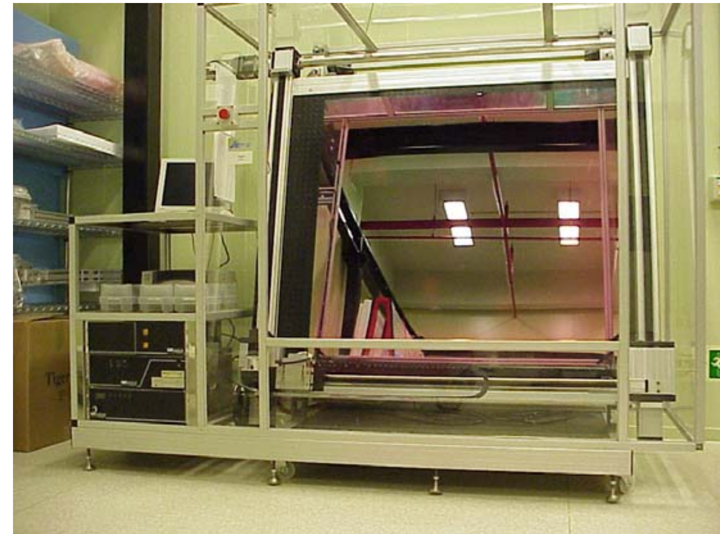
- Resources in ERSO
  - WER
  - Ellipsometry
  - SEM/EDX
  - CV
  - Device

- Thin film processes
  - Cleaning process cost reduction
    a. Feasibility of F2 recycling
    b. NF3 usage optimization
  - LC alignment layer process

- Automation parts refurbishment
  - Vacuum robot refurbishment

- Parts localization
  - 1600 Process chamber
  - E-gun

ARDC - Photos



AKT Santa Clara Campus

AKT

- January, 1996 AKT occupied 170,000 ft^2 (15,800 m^2) campus
- Manufacturing & Spare Center
  - 12 Manufacturing Final Test Bays
- Engineering Lab Space:
  - 9 R&D Product / Process Development Bays
  - 4 R&D Product Development/Reliability (Mfg type) Bays
  - Mechanical Reliability, Wet Chemistry Lab, Analytical/Metrology Lab, and Other Engineering Labs

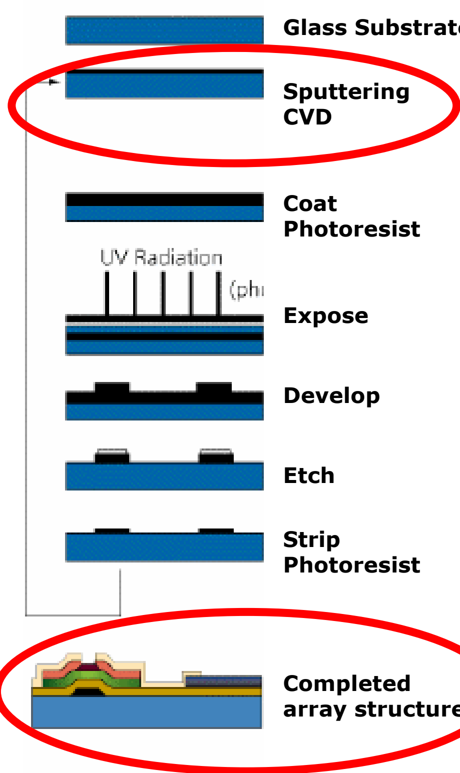
Envisioning the Future

LCD & TFT-LCD

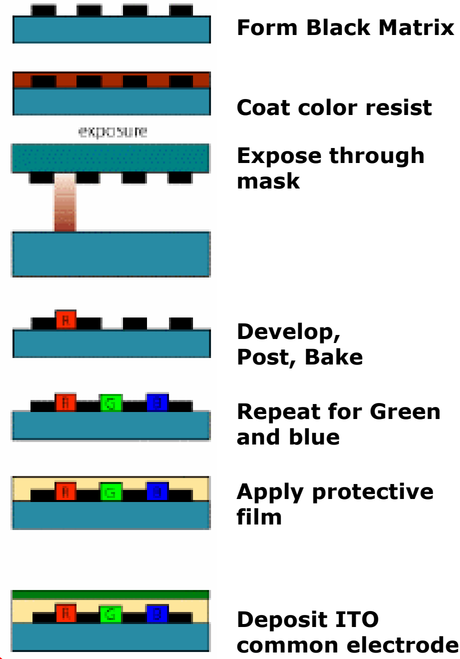
Conventional LCD-TFT assembly processes

AKT

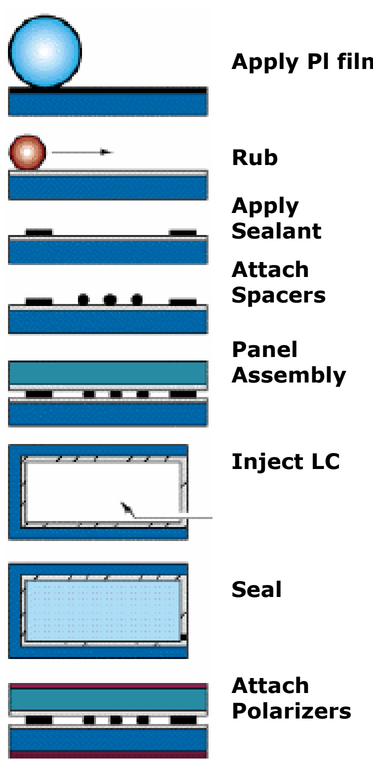
Array Process



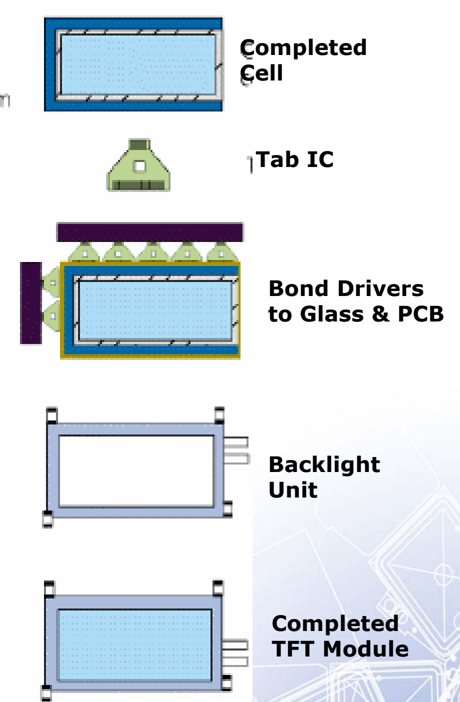
CF Process



Cell Process



Module Process



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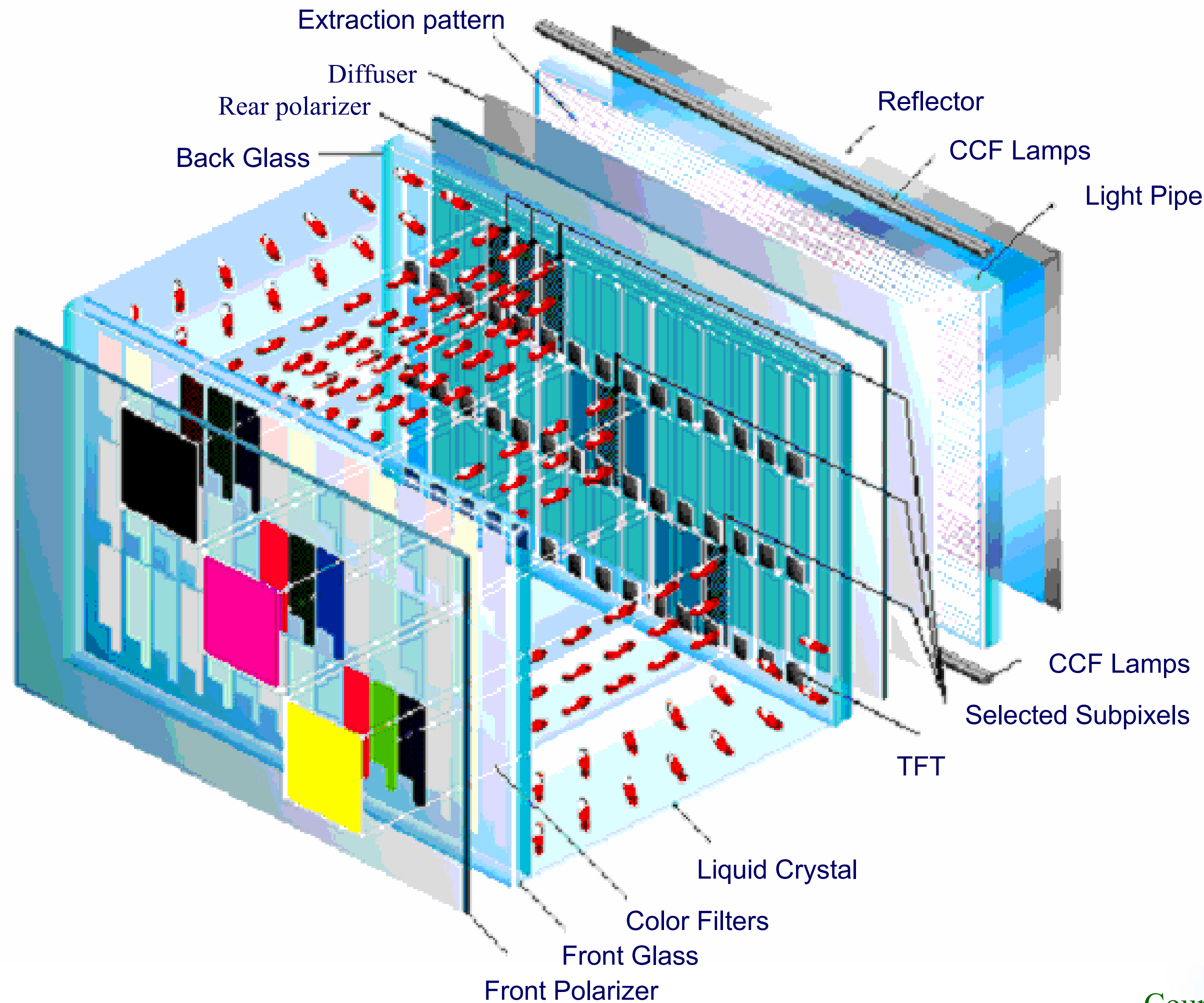

Courtesy of Silicon Graphics

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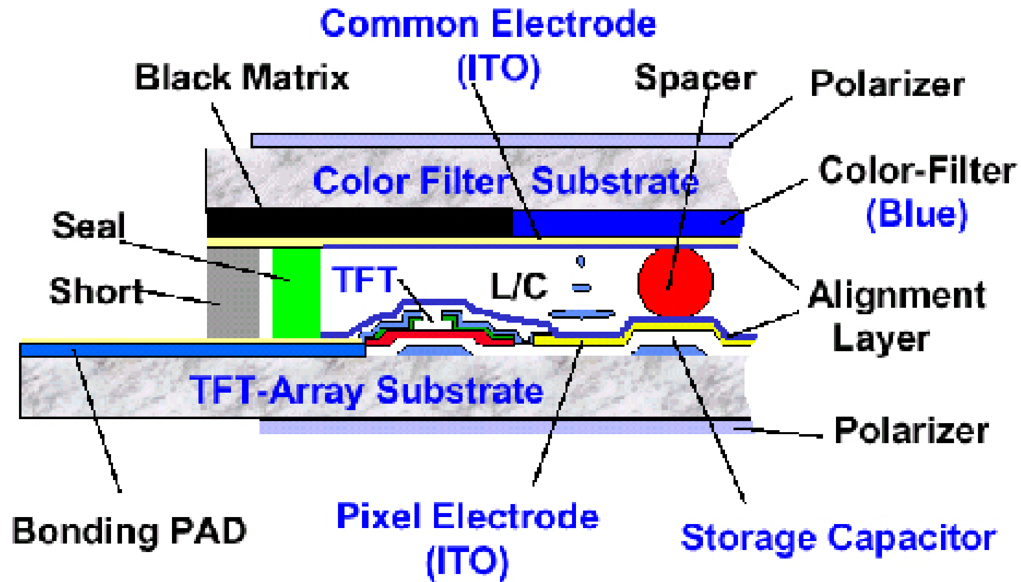
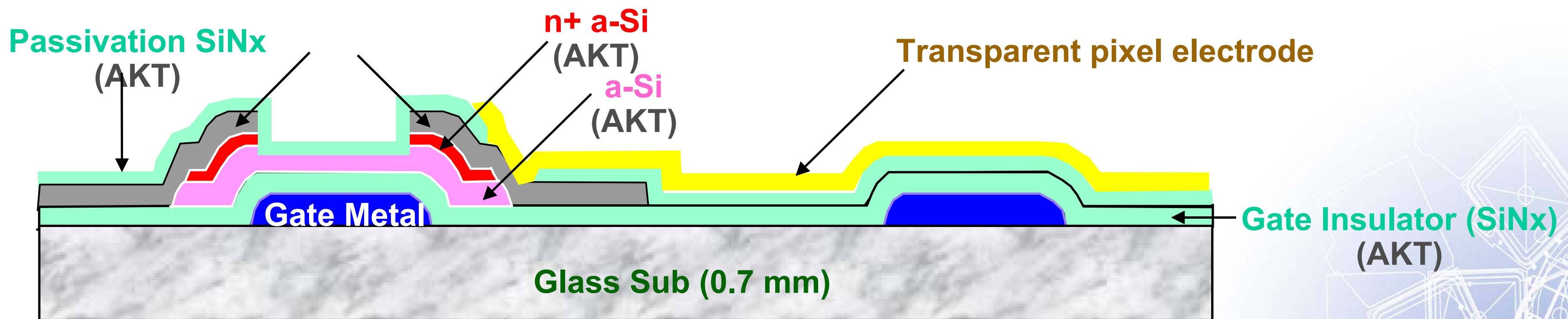
TFT Switching ON/OFF of Each Sub-Pixel



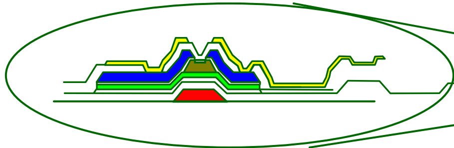


Ref Ex.: http://www.netbored.com/classroom/tft_device_design.htm

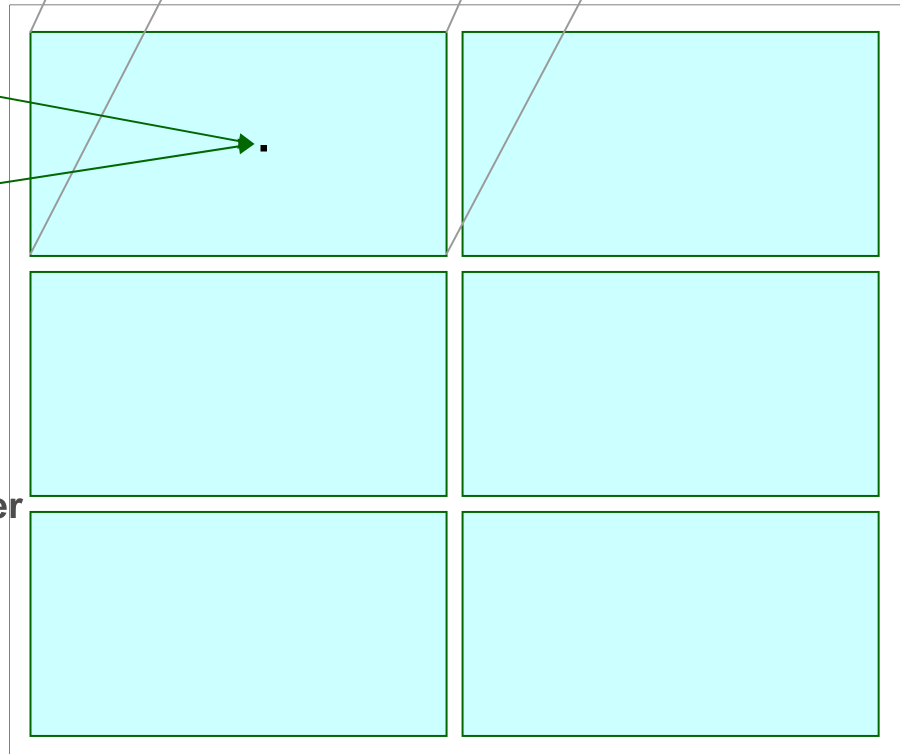
37" LCD TV

6,220,800 Thin Film Transistors (TFT's); on/off switch's; control the display of each 37" LCD TV.

One TFT →

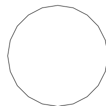


Glass Substrate*



*1500mm x 1800mm glass produces six 37" TV panels

AKT successfully transferred Chemical vapor deposition (CVD) technology FROM 200MM WAFERS TO LARGE SIZE GLASS
Gen. 6 sub area ~ 86x 200 mm wafer



200MM WAFER

Actual size comparison with substrate.

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Large-size LCD-TV is booming …

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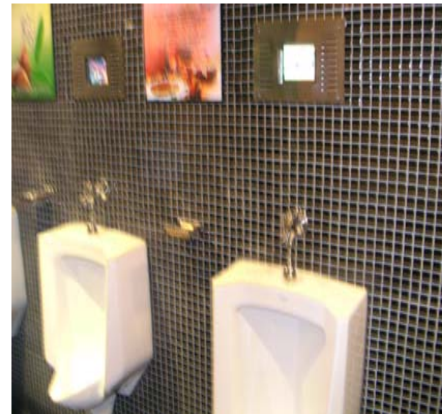
65" LCD-TV – SHARP

82" LCD-TV – SAMSUNG

Philips *Chameleon*
Mirror-Display

?? Even in WC ??



新聞中心

Date: 2005年4月26日

友達啟動次世代投資計劃 基板尺寸**1950mm x 2250mm**

月產能規劃三萬片 投資金額將達350億

- (2005年4月26日)

友達廠房 (世代)	玻 璃基板尺寸(mm)	地點	主要產 品
L3A (G3.5)	610 x 720	新竹科學園區	中小尺寸 / 筆記型電腦面板
L3B (G3.5)	610 x 720	新竹科學園區	中小尺寸
L5 (G3.5)	600 x 720	新竹科學園區	桌 / 筆記型電腦面板
L6 (G4.0)	680 x 880	龍潭渴望園區	筆記型電腦 / 電視面板
L8A (G5.0)	1100 x 1250	龍潭渴望園區	桌 / 電視面板
L8B (G5.0)	1100 x 1300	龍潭渴望園區	桌 / 筆記型電腦 / 電視面板
L8C (G5.0)	1100 x 1300	中部科學園區	桌 / 筆記型電腦
L10 (G6.0)	1500 x 1850	中部科學園區	桌 / 30 ~ 40 吋 板
L11 (G7.5)	1950 x 2250	中部科學園區	40 吋 以上電視面板

奇美電:第二季成長5-10% 首季EPS-0.52元 宣布再擴建1座5代廠 並跨入7.5代面板廠

【王宗彤 / 台北報導】

奇美電(3009)昨公布第一季季報，營收為267.01億元，稅後淨損1 9.71億元，每股稅後淨損0.52元。另外，**奇美**電也宣布投入次世代生產線，包括再投資新台幣200億元，將現有5.5代面板廠月投片量由原訂12萬片提升至18萬片，以及投資350億元再擴建1座5代廠，並跨入 7.5代面板廠投資。

同時，**奇美**電預估第二季出貨量較第一季成長5-10%，ASP微幅上揚或持平，成本下滑5-10%，今年全年TFT-LCD景氣為審慎趨樂觀。

奇美電財務處長陳彥松表示，為因應新投資案需求，**奇美**電今、明兩年資本支出各約達700億元，除將動撥金融機構聯貸額度支應外，今年股東會也將提出私募特別股及辦理現金增資兩項籌資案。

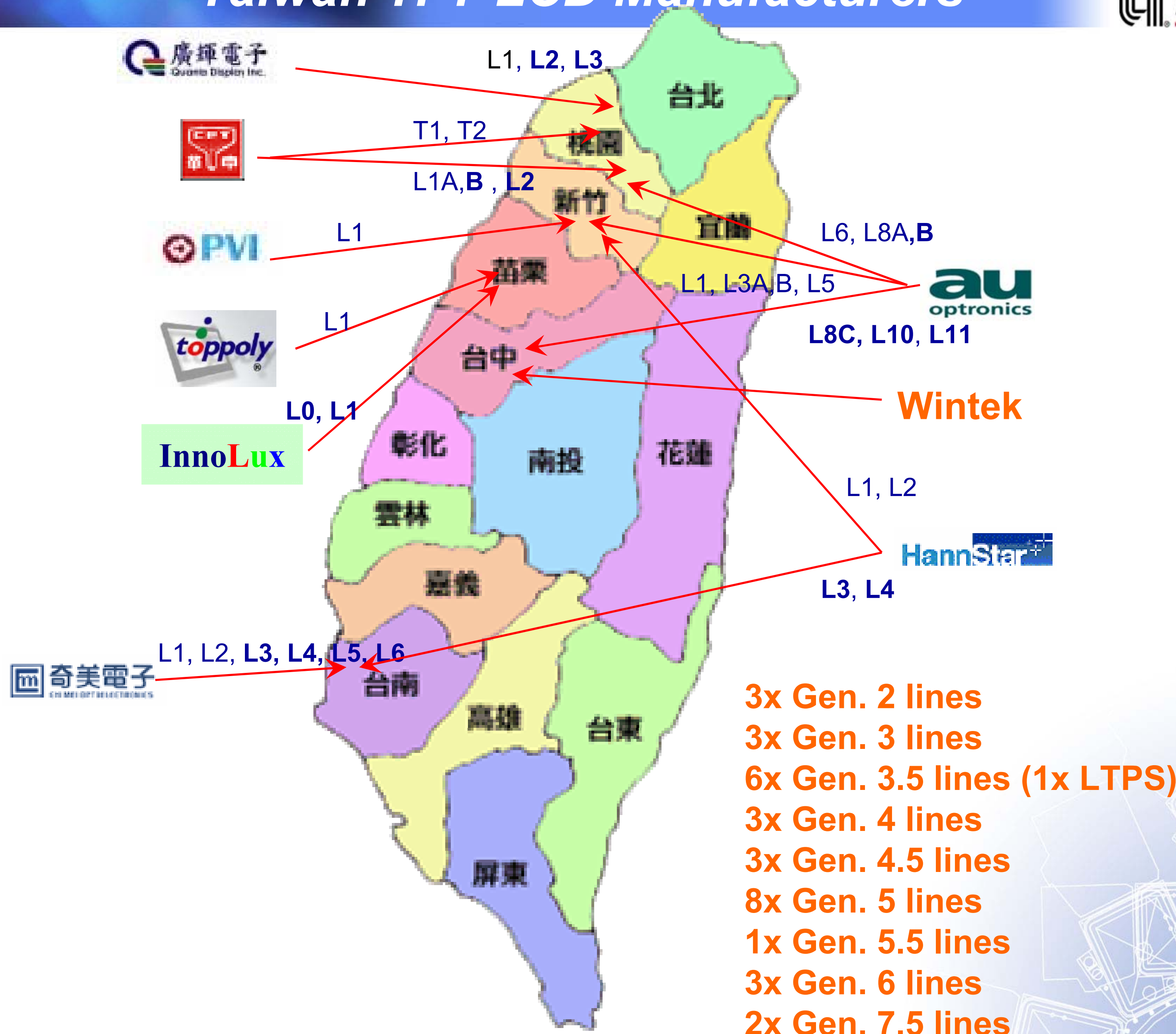
奇美電是繼友達(2409)日前宣布7.5代面板廠投資案後，為台灣第二家面板廠宣布跨入更新次世代生產線，**奇美**電預計今年6月進行7. 5代面板廠土建工程，預計2007年第二季投產，初期投片量為每月3萬片基板產能。

奇美電5.5代面板廠原投資金額750億元，昨宣布再投資200億元將投片量提高至18萬片後，5.5代廠總投資金額將提高至950億元。**奇美** 電決定再投資一座5代廠，該廠廠房將在下週起進行土建工程，預計 2006年第二季移入設備、第四季量產。

陳彥松並宣布 7.5代廠建廠計劃重新啟動，原以停建的廠房硬體工程將在下周復工，首期投片量為3萬片，預計量產時點比5代新廠量產晚6個月，將在2007年第2季量產，以生產42吋及47吋TV面板。**奇美**電總經理何昭陽表示，**奇美**電認為LCD TV市場已起來，目前正是擴充的大好時機?

From: China Times, April 30, 2005

Taiwan TFT-LCD Manufacturers



3x Gen. 2 lines
3x Gen. 3 lines
6x Gen. 3.5 lines (1x LTPS)
3x Gen. 4 lines
3x Gen. 4.5 lines
8x Gen. 5 lines
1x Gen. 5.5 lines
3x Gen. 6 lines
2x Gen. 7.5 lines

Envisioning the Future

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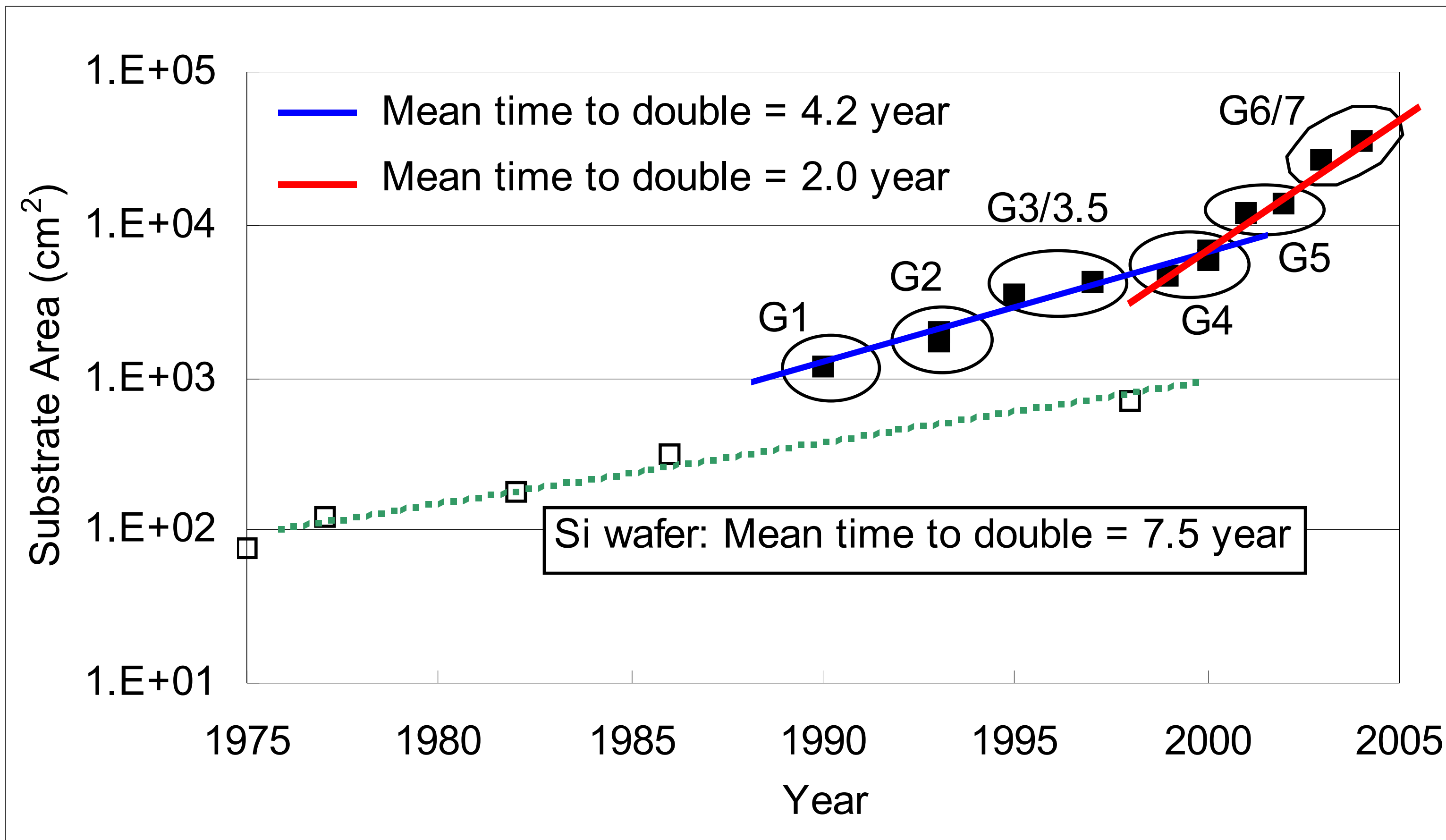
Growth of Substrate Area



	Gen 1	Gen 2	Gen 3/3.5	Gen 4	Gen 5	Gen 6	Gen 7
size (inch)	10.4	10.4	12.1	15 ~ 17	19 ~ 24	36W	42W
# of panel	2	4	6	6	6	6	6

- ***Why TFT-LCD Manufacturers always Invest New Generation Size?***

- New application requires larger size, such as LCD-TV

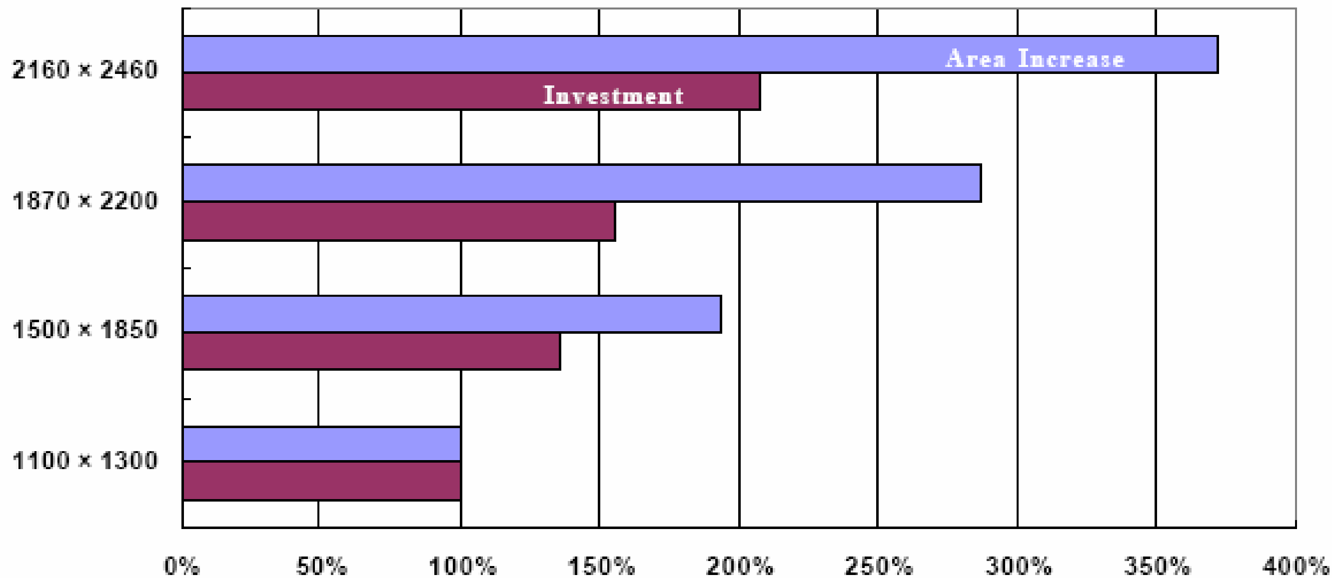
- LCD-TV, a consumer product competing with conventional CRT & other FPD TVs, needs faster Price reduction to gain the market share. **Larger size which means new generation brings the cost down more feasible**.

Envisioning the Future

Rapid Growth of Substrate Size

4 up 10.4"	6 up 12.1"	6 up 15.0" ~ 17.0"		6 up 19.0" ~ 24.0"	6 up 37.0" Wide panels	6 up 46.0" Wide panels
				CUSTOMER SUPPLY	CUSTOMER SUPPLY	CUSTOMER SUPPLY
AKT-1600 370x470 mm2 400x500 mm2	**AKT-4300** 600x720 mm2 620x750 mm2	**AKT-5500** 680x880 mm2 730x920 mm2	**AKT-10K** 1000x1200 mm2	**AKT-15K** 1100x1250 mm2 1200x1300 mm2	**AKT-25K (25KA)** 1500x1800 mm2 (1500x1850 mm2)	**AKT-40K** 1870x2200 mm2
2/93	4/95, 2/97	1/00	8/01	6/02	5/03	7/04
G2	G3/3.5	G4	G5	G5	G6	G7

Investment vs. Substrate size

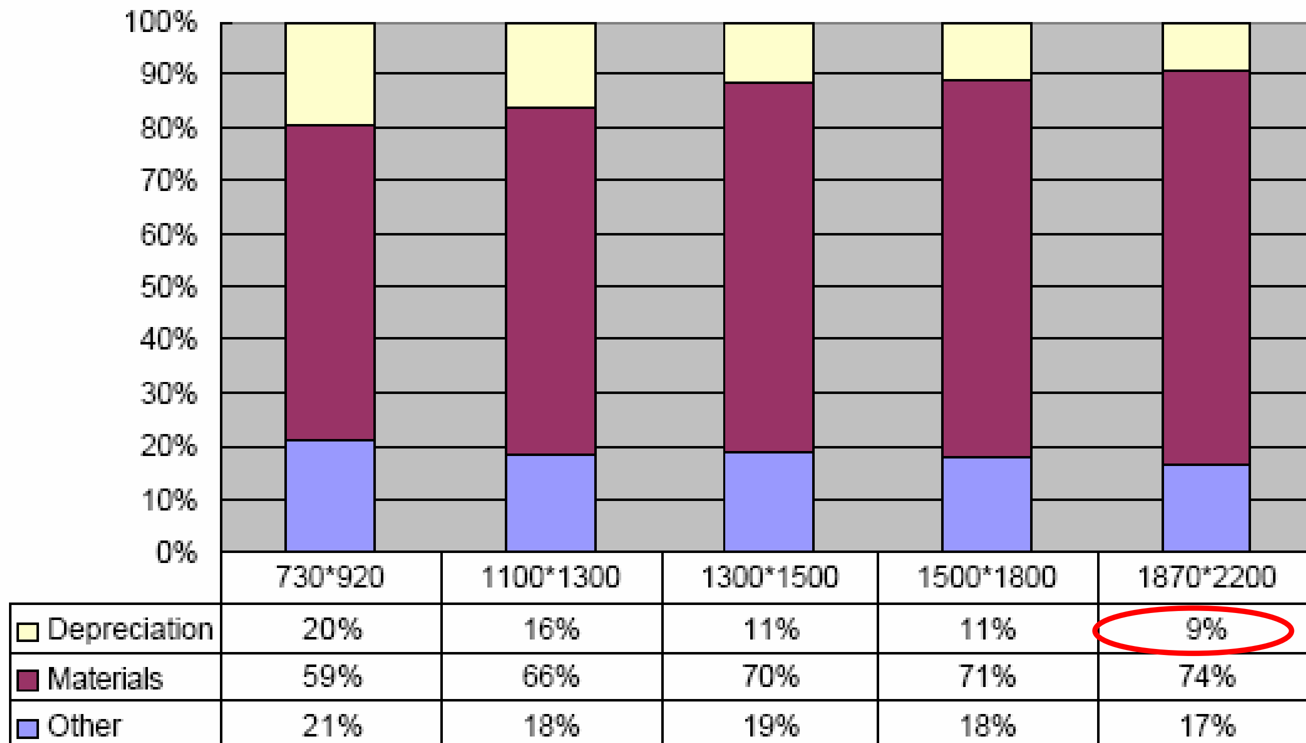


Gen	Glass Size	Area (m2)	Area Increase	Equipment	Facilities Land	Total Investment	Investment Increase
5	1100 × 1300	1.43	100%	$887	$577	$1,464	100%
6	1500 × 1850	2.78	194%	$1,180	$802	$1,982	135%
7	1870 × 2200	4.11	288%	$1,362	$926	$2,288	156%
7.5	2160 × 2460	5.31	372%	$1,808	$1,229	$3,037	207%

Note: 60,000 substrates per month fab, 5-mask process. Equipment includes array, cell, color filter and module tools. Actuals will vary significantly by process type, manufacturer, timing, location, etc. Indexed to G5.

Ref: 7th Annual DisplaySearch US FPD Conference, Charles Annis, page 16, w/ permission

with equipment depreciation ↓ and materials ↑



	730*920	1100*1300	1300*1500	1500*1800	1870*2200
Depreciation	20%	16%	11%	11%	9%
Materials	59%	66%	70%	71%	74%
Other	21%	18%	19%	18%	17%

Note : Forecast 32" WXGA LCD TV "Total Sales Cost" of $720.1 for G4 to $598.8 for G7 in 2005. "Others" includes Personnel, Indirect, R&D, and Overhead/Sales expenses.

Ref: 7th Annual DisplaySearch US FPD Conference, Charles Annis, page 17, w/ permission

Cost Of Ownership Modeling

AKT

ITEM	units		SYSTEM
Number of Chambers			**5**
System Price	$		**400,000,000**
System Quantity			**1**
Throughput			48
Gross Throughput		sub/mon	34,560
Adjustments To Throughput:			
System Uptime		%	85%
Line Yield rate		%	99.5%
Net Yearly Capacity (not incl. yield)		**subs/mon.**	**29,376**
Net Yearly Capacity (incl. yield.)		**subs/mon.**	**29,229**
Fixed Costs			
Equipment Depreciation	$	/mon	6,666,667
Incidental EQ cost: ACLS			9,091,500
Pump			13,800,000
Local Scrubber			4,350,000
Insurance Cost: Main EQ shipping ins. cost			121,000
Cleanroom (Floorspace) Depreciation	$	/mon	116,451
Total Fixed Costs	**$**	**/mon.**	**7,161,472**
Fixed Costs/ per sub.	**$**	**/sub**	**245.01**
Variable Costs			
Consumable Parts (Average)	$	/mon.	300,000
PM Kit for system and PC	$	/mon.	201,331
Electrical/Utility	$	/mon.	919,670
Process Gases	$	/mon.	672,417
Clean Gases	$	/mon.	1,739,353
Labor cost	$	/mon.	58,676
Total Variable Costs	**$**	**/mon.**	**3,891,446**
Variable Costs/ per sub.	**$**	**/sub**	**133.14**
Total Cost of Operation	**$**	**/yr.**	**11,052,918**
Cost Per Substrate (By EQ process capacity)	**$**	**/sub**	**378.15**

More cost conscience at each new generation

AKT

For equipment suppliers, **Production Worthiness** is the key.

– System throughput depends on both process time and mechanical transfer, and the latter gets more significant.

– Down time reduction for higher productivity requires better system reliability and easier & more flexible service (PM); against the increasing chamber size and weight.

Technologies of AKT

Plasma Enhanced Chemical Vapor Deposition (PECVD)

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Development Key Strategy

LOW RISK & QUICK DEVELOPMENT

Field proven System Construction
The First Introduced to Industry

AKT PECVD

PROCESS QUALITY

Reliable Process Scale Up
& Development

RELIABILITY

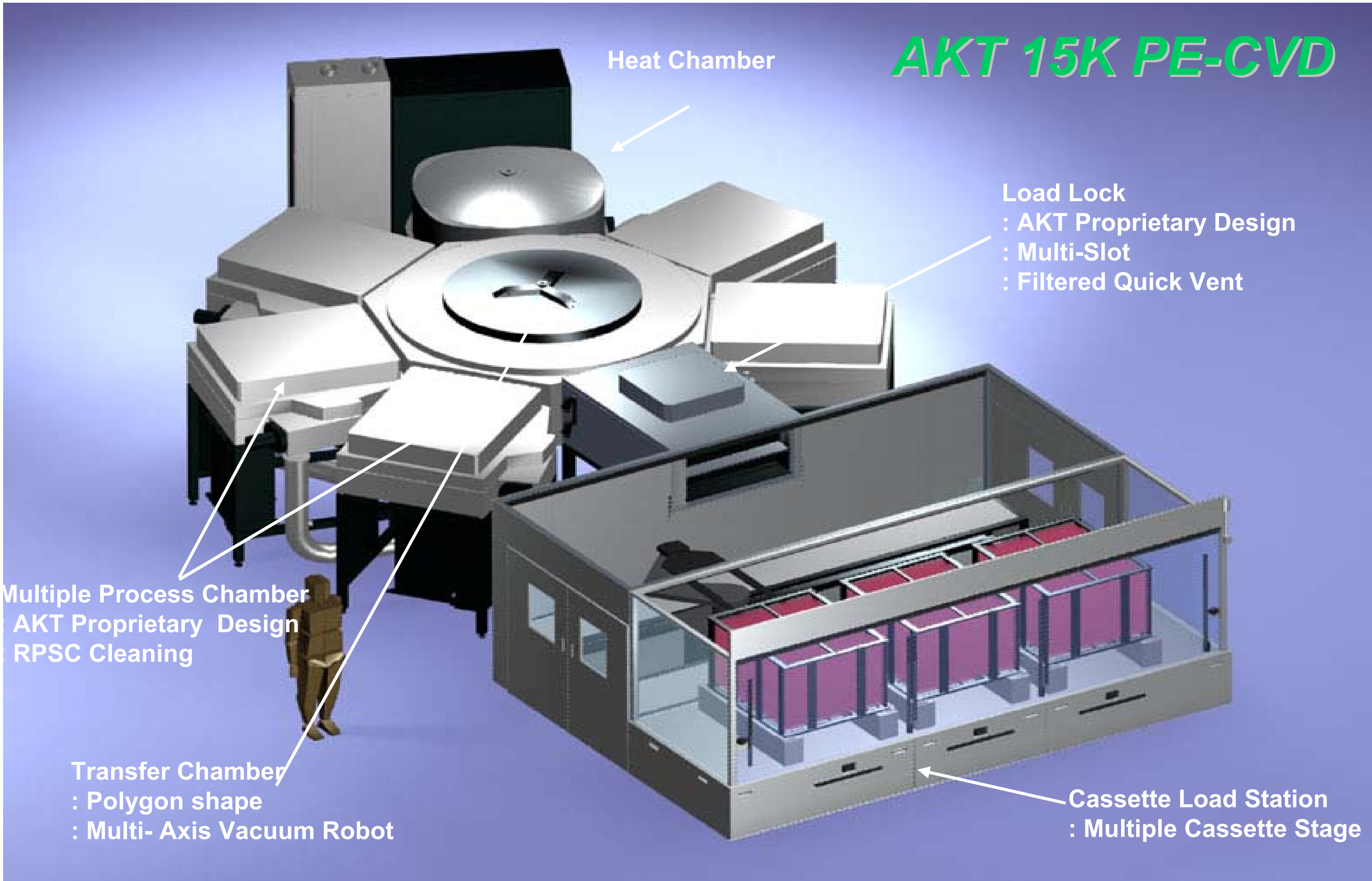
Reliable Substrate Handling
Compensate Thermal Expansion

CAPITAL PRODUCTIVITY

Minimize Cost of Ownership
Small Foot Print Cluster Tool
System HW Throughput ≥ 65 sub / hr

Single Substrate, Multi-Process Chamber Cluster Tool

AKT



AKT PECVD System Configuration

Remote Process Pump Module

RF Generator Module (3500 & 4300 Only)
Deep: 915mm (36")
Width: 1423mm (56")
Height: 1829mm (72")

Heat Exchanger
Deep: 966mm (38")
Width: 1004mm (39.5")
Height: 1397mm (55")

Overhead Gantry Crane (optional for 3500 and 4300)

CVD Chamber

Mainframe

Hoist (standard)

Operator Control Station

Remote Mainframe Pump Module
Deep: 1145mm (45")
Width: 1465mm (58")
Height: 1915mm (75.5")

Gas Panel

Automated Cassette Loading Station

I J K G F H A B C D E

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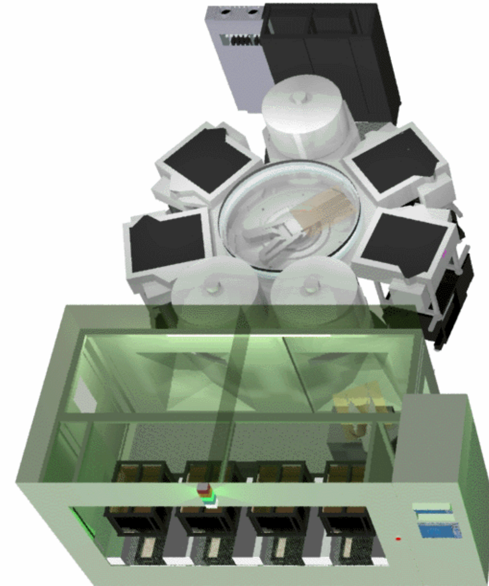
Advantages

Higher Performance

- Single loadlocked vacuum environment for multiple films
- High throughput through batch pumpdown and pre-heat
- High throughput using up to 5~6 process chambers in parallel

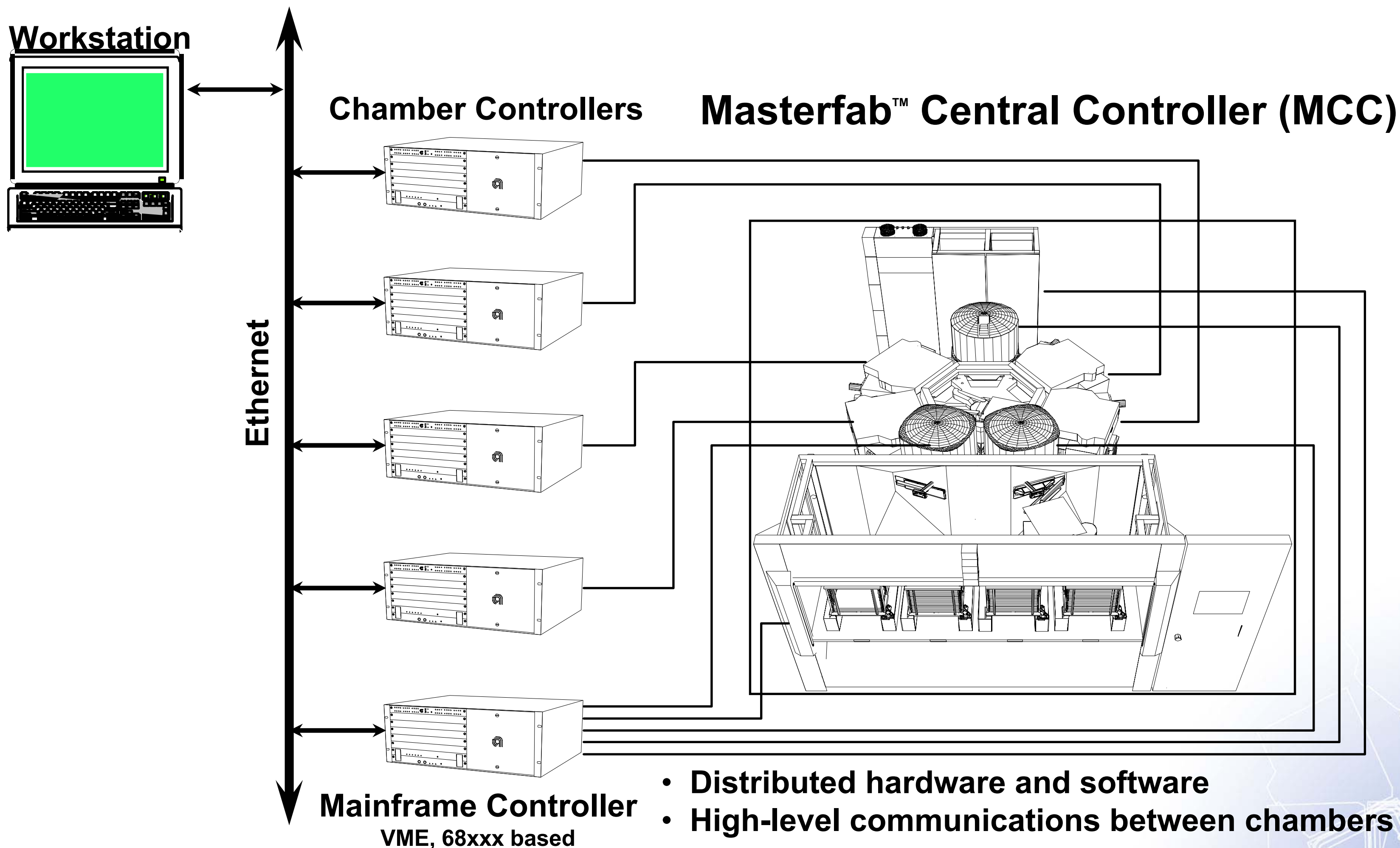


Compared to Inline Tools

- Small system footprint
- Does not require trays
- Horizontal substrate handling avoids edge rubbing and reduces particle
- Higher system uptime and quicker maintenance

AKT PECVD Cluster Tool

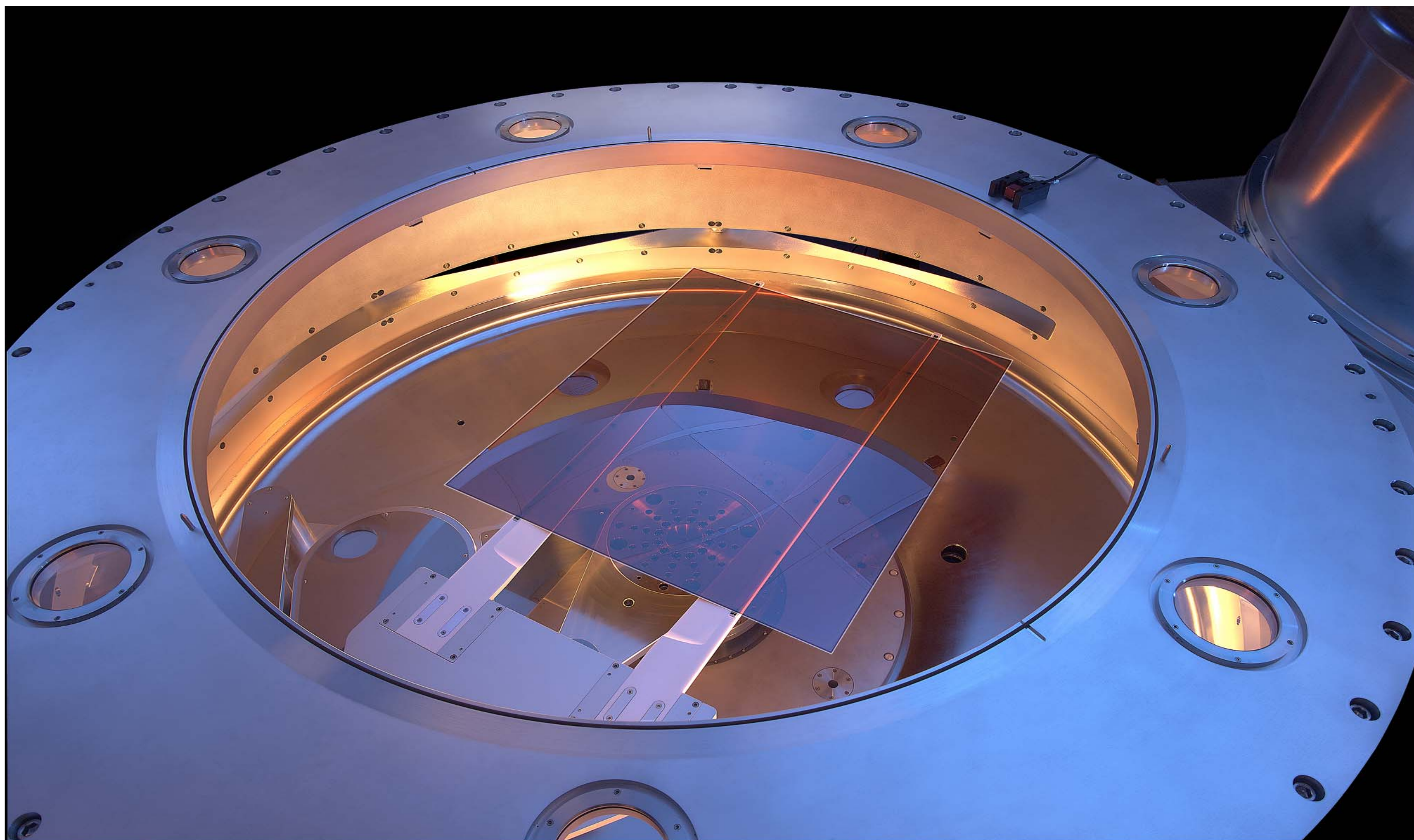
System Control



- Distributed hardware and software
- High-level communications between chambers

AKT-15K PECVD Transfer Chamber with Vacuum Robot

AKT



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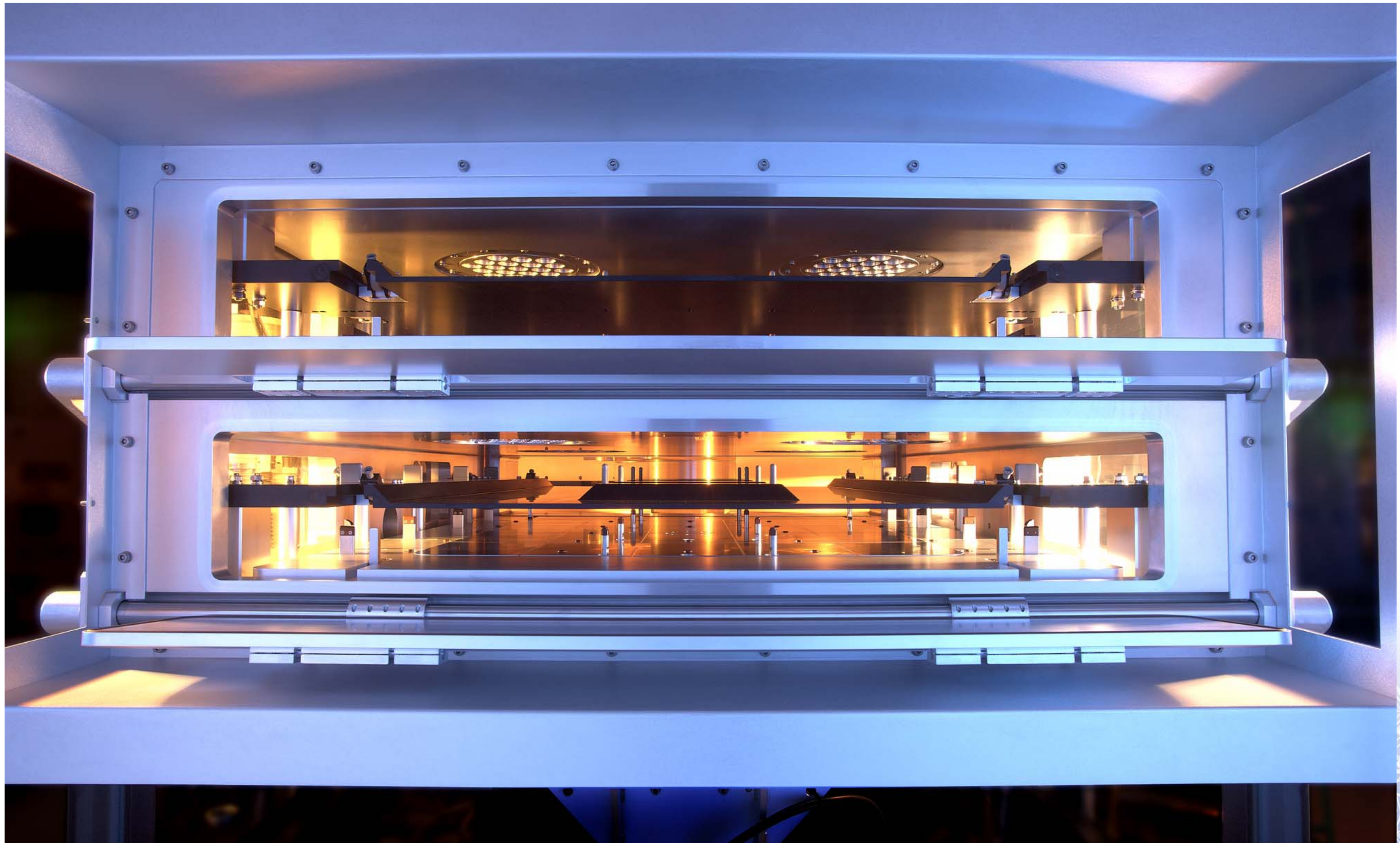
AKT-15K PECVD DDSL



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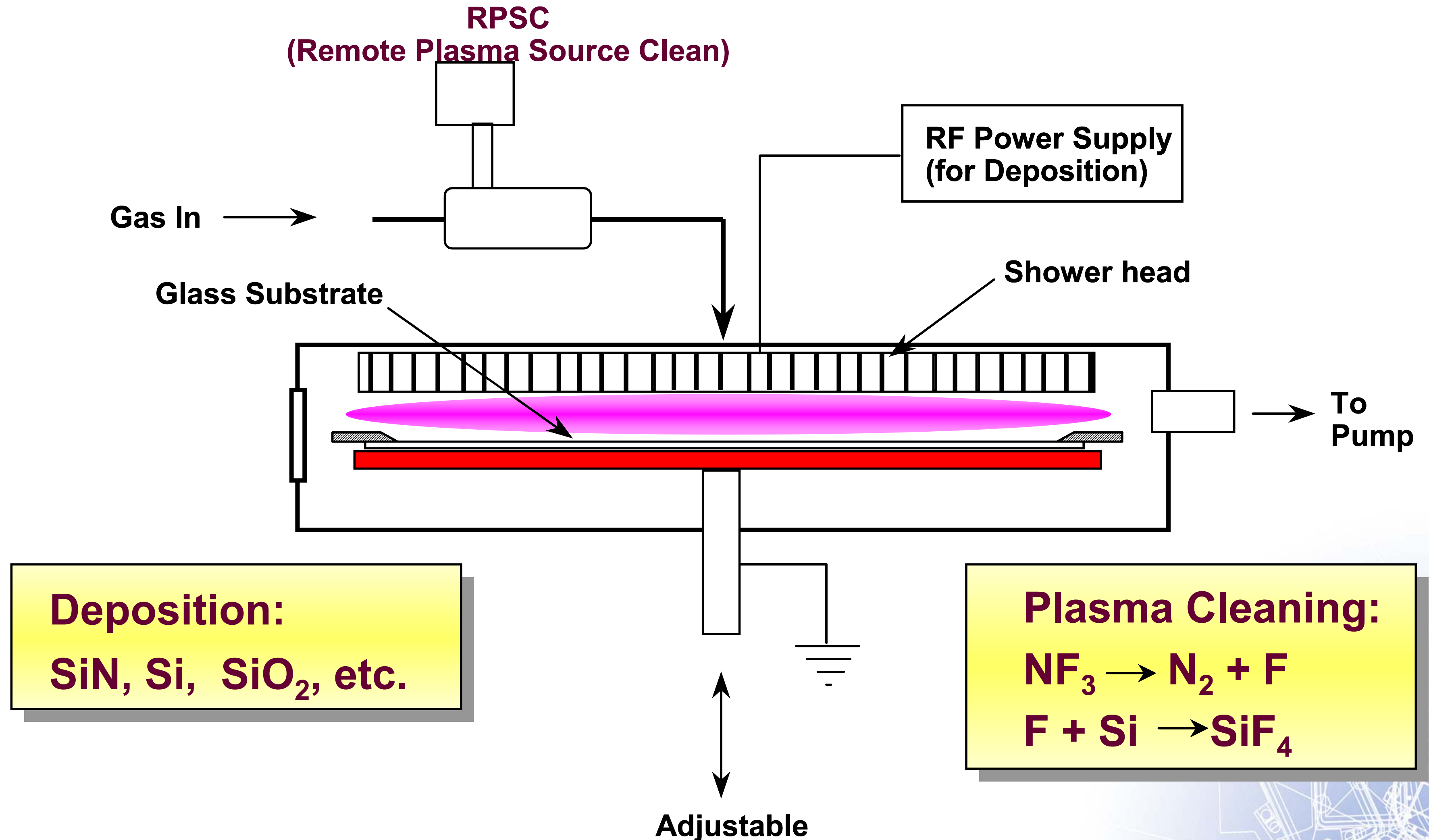
Capacitively-Coupled Parallel Plate Plasma Reactor



Deposition:

SiN, Si, SiO_2, etc.

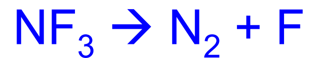
Plasma Cleaning:

$NF_3 \rightarrow N_2 + F$

$F + Si \rightarrow SiF_4$

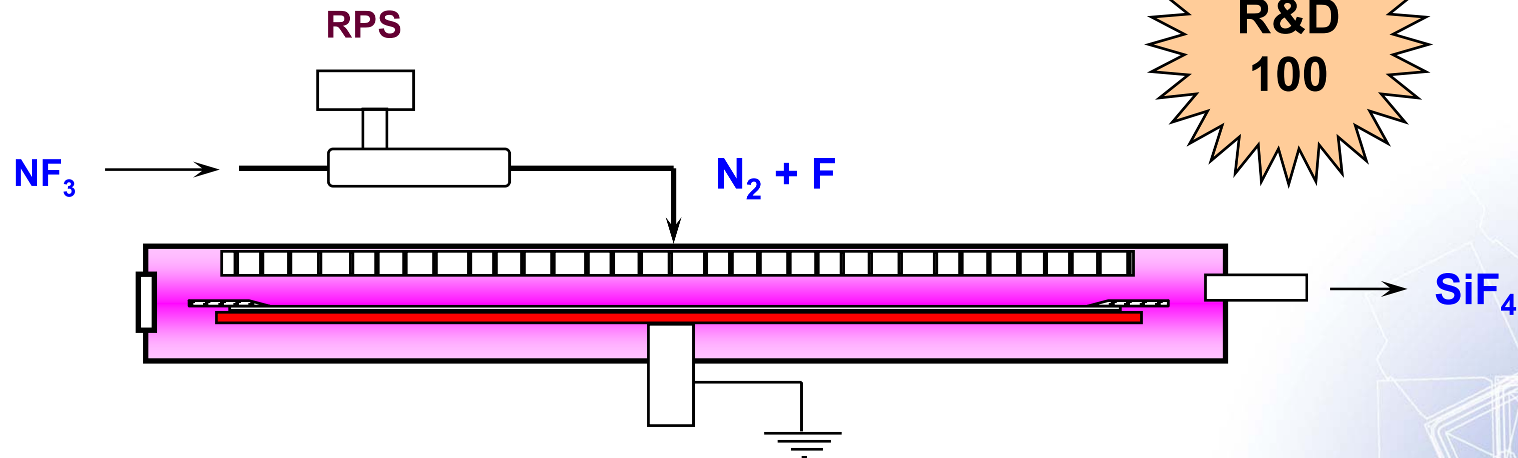
Remote Plasma Source (RPS) Chamber Cleaning

- Used to clean deposited film residues from process chamber components
- RPS fully dissociates cleaning gas remotely from process chamber:



$NF_3 \rightarrow N_2 + F$

- Active species (F radicals) directed to process chamber where cleaning reaction occurs: $F + Si \rightarrow SiF_4$
- Extends lifetime of chamber components, reduces cost-of-ownership
- Environmental friendly – **Green Technology**
- **R&D 100 Award in 1999**



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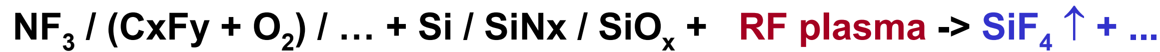
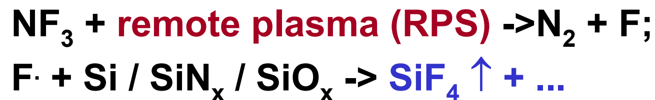
- **In situ plasma cleaning**



Productivity greatly improved, but potential plasma damage to chamber parts, and the cleaning gas not fully utilized.

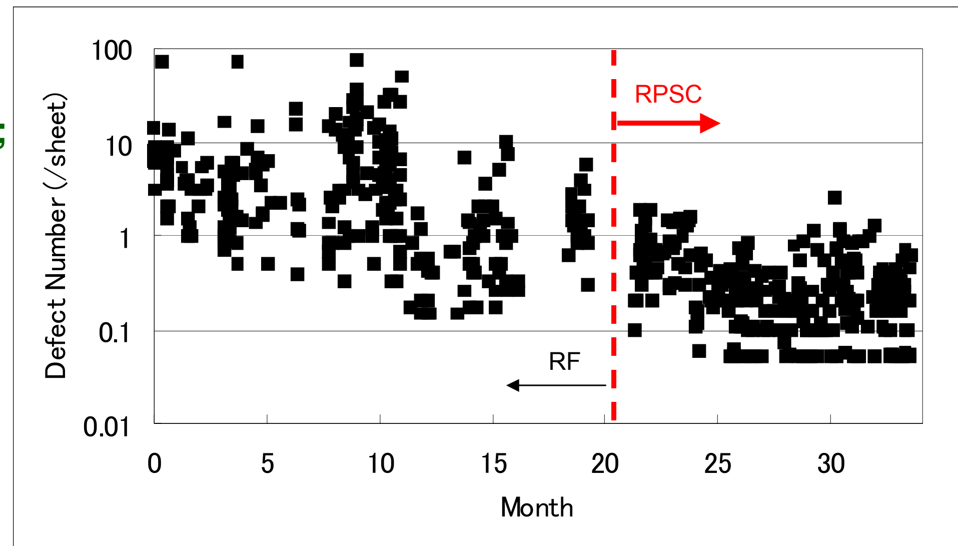
- **Remote Plasma Source Cleaning (RPSC)**



Further improved yield and productivity;

- Reduced Cost of Ownership (COO) with extended chamber parts lifetime;
- Clean gas dissociation > 97%
  virtually full utilization
  and environmental friendly

(Customer Data with permission)



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Gen.7 AKT-40K PE-CVD System

AKT

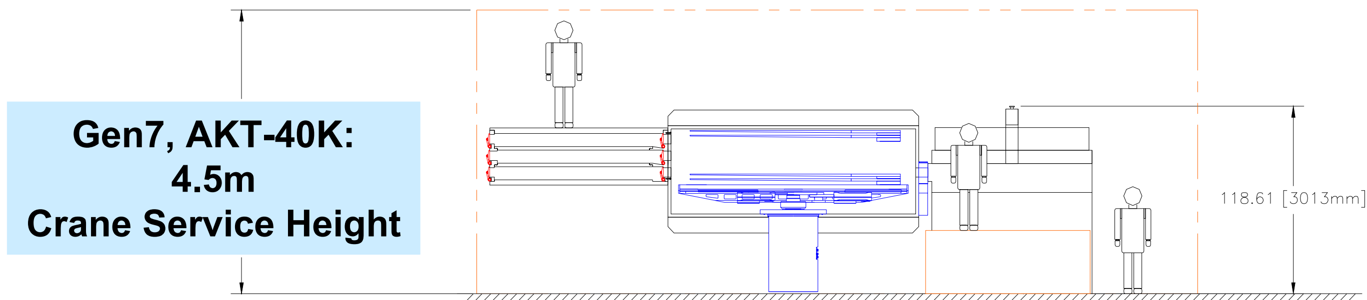
Handling 1.87x2.2m² Substrate

Load Lock

Process Chamber

Transfer Chamber

Vacuum Robot



Envisioning the Future

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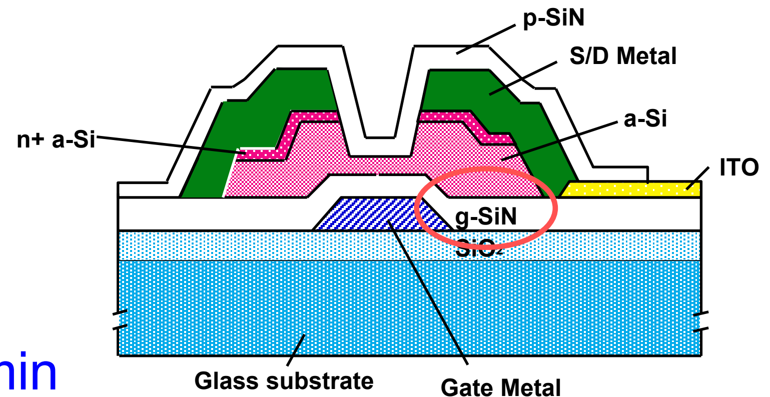
AKT-40K PECVD System

AKT PECVD Process Capability

g-SiN_x

Applications and Advantages

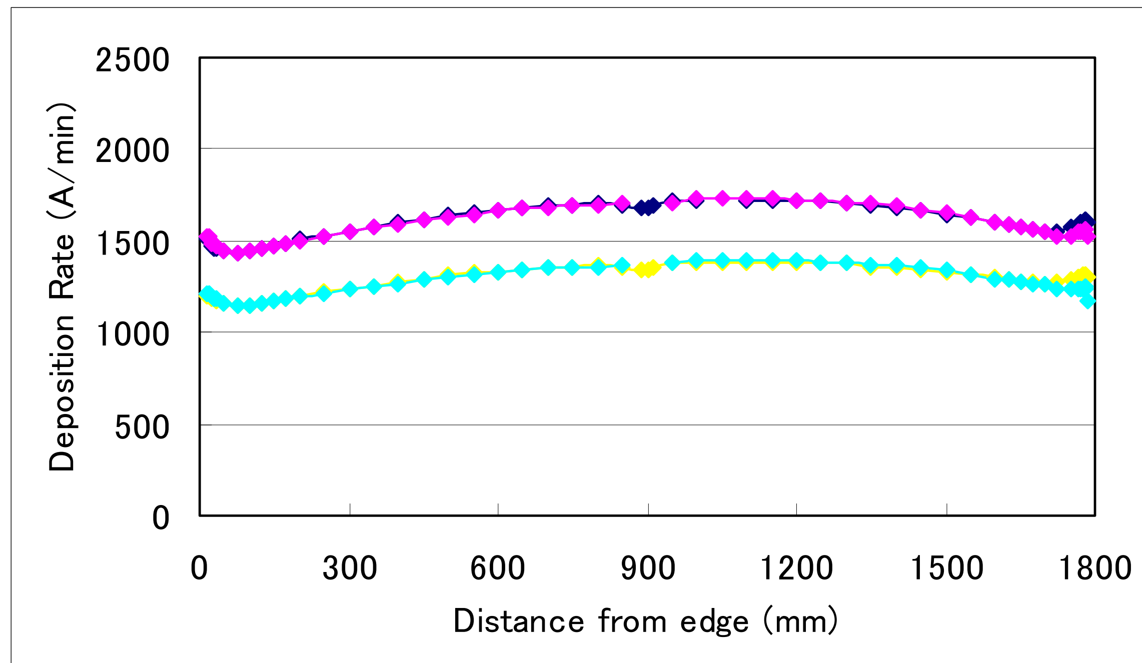


Process Performance

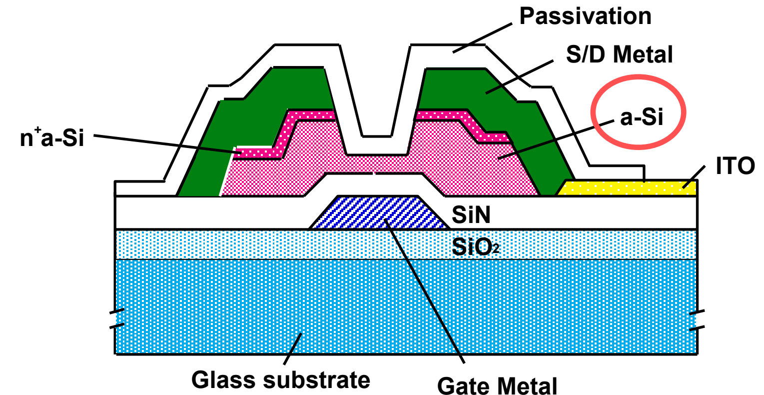
Deposition Rate	2000 Å/min
Thickness Non-Uniformity	± 10% at 15mm EE
Refractive Index	1.9 ± 0.1
Stress	± 7E9D/cm^2
Wet Etch Rate	300-600 Å/min (10:1 BHF)
Breakdown Voltage	5-8MV/cm
Dielectric Constant	6-7
Si-H Content	3-8E21/cm^3
N-H Content	9-12E21/cm^3
Stable H Bonding	Up to 600 °C

Example of Gate SiNx - GH

Film	DR A/min	Stress E9D/cm2	WER(6:1) A/min	R.I.
GL	1300	C3.3	598	1.9
GH	1600	C2.7	485	1.93



Applications and Advantages



Process Performance

Deposition Rate	500-1000 Å/min E/S type 1500-3000 Å/min BCE type
Thickness Non-Uniformity	± 10% at 15mm EE
Stress	6-9E9D/cm^2 (C)
Si-H Peak	2000 cm^{-1}
Si-H Peak FWHM	95-100 cm^{-1}

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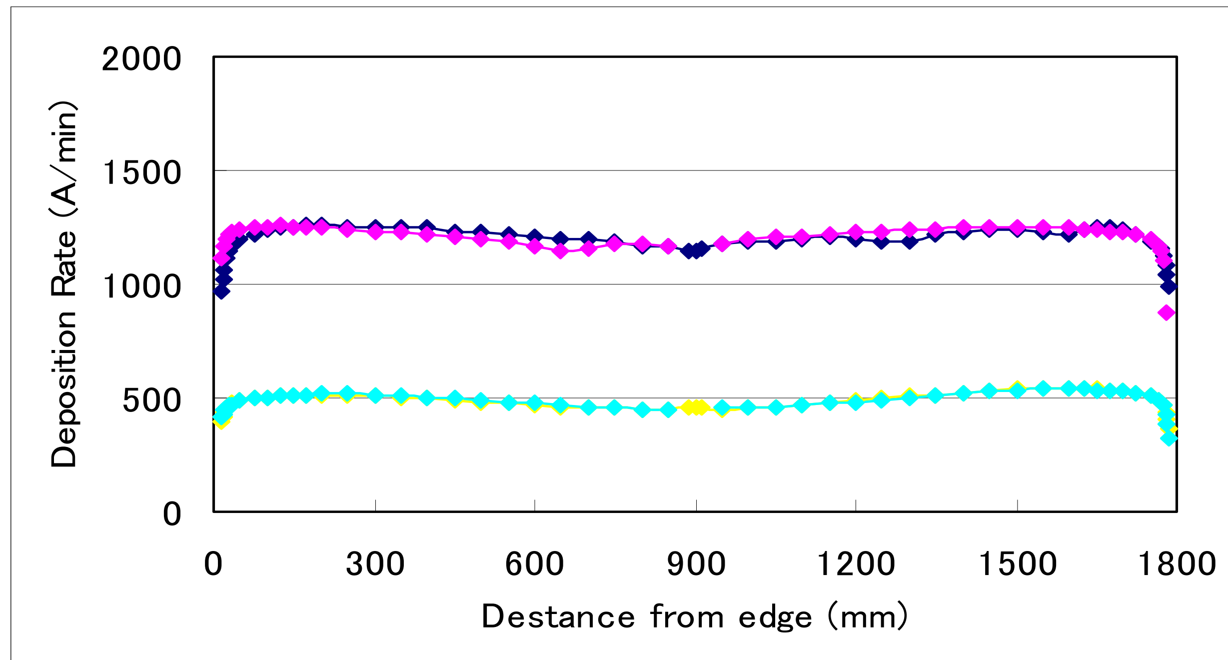
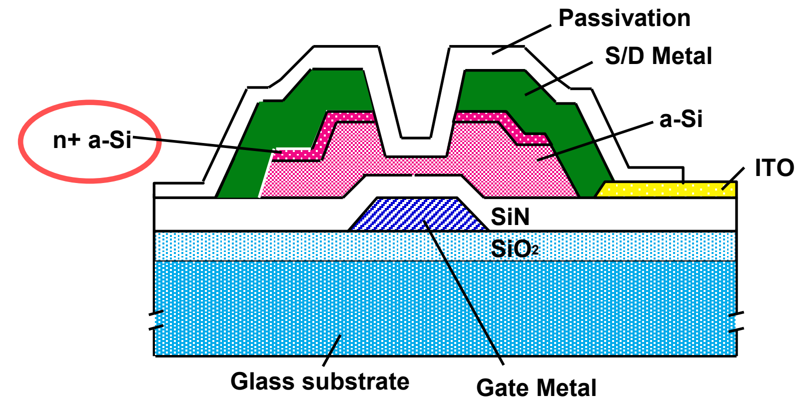
Example of a-Si

Film	DR	Stress	Peak Pos.
	A/min	E9D/cm2	cm-1
AL	500	C3.1	1994
AH	1200	C3.6	1994



n+ a-Si

Applications and Advantages



Process Performance

Deposition Rate	500-1000 Å/min
Thickness Non-Uniformity	± 10% at 15mm EE
Stress	6-9E9D/cm^2 (C)
Resistivity	≤ 200 Ω-cm

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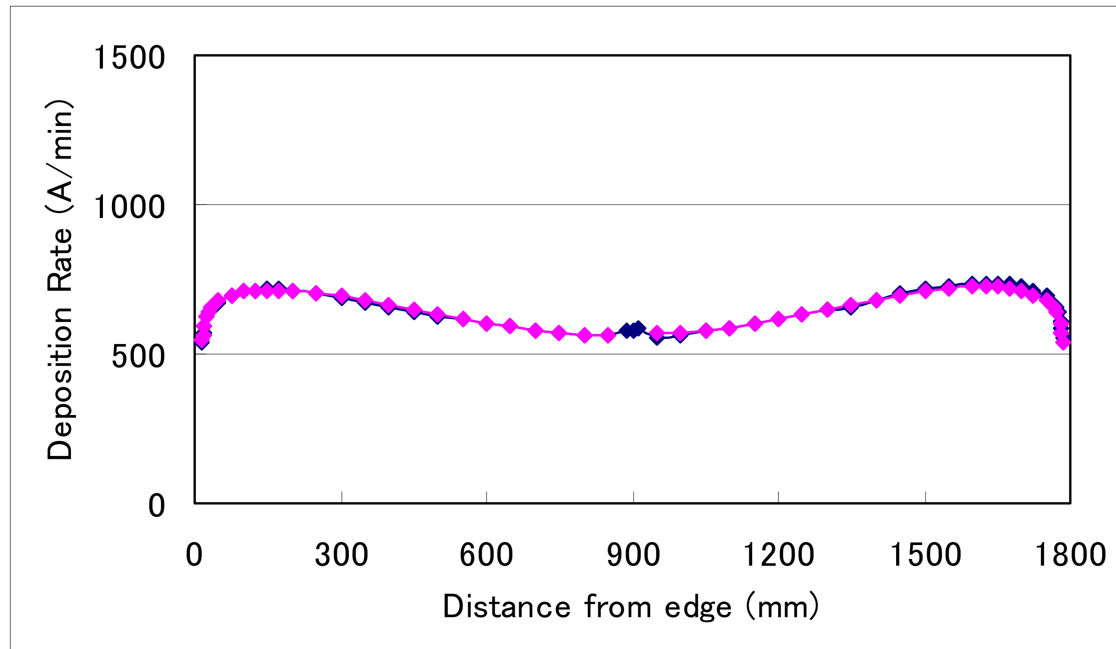
Example of n+ a-Si

Film	DR A/min	Stress E9D/cm2	Peak Pos. cm-1	Rsistivity Ohm cm
n+ a-Si	650	C1.2	1994	56

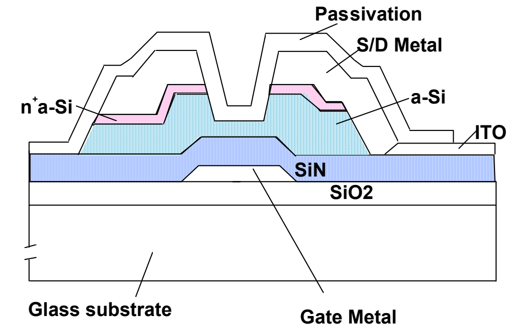


Envisioning the Future

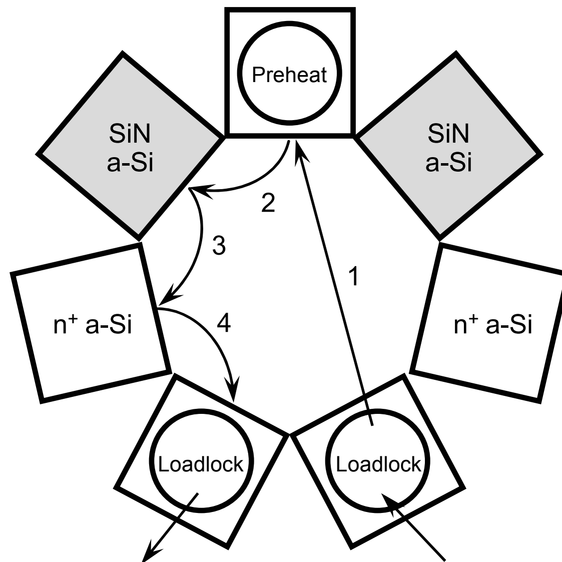
Multi-layer Deposition
Applications and Advantages

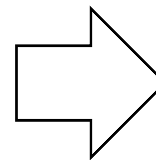
- **Throughput improvement**
- **Particle reduction**
- **Yield improvement**

- **Stress control**
  Substrate temperature
  RF power
  Electrode spacing
  Gas flow ratio
  Processing pressure
  SiNx : +5E9 ~ -5E9 D/cm²



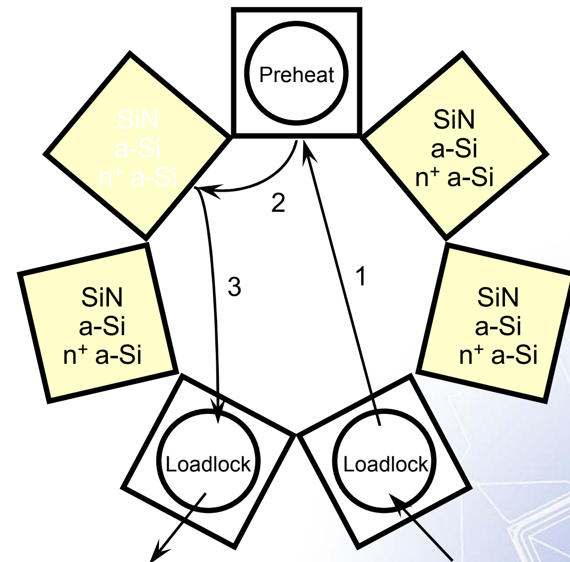
Two Chamber Process





High Throughput and Low Particle

Single Chamber Process



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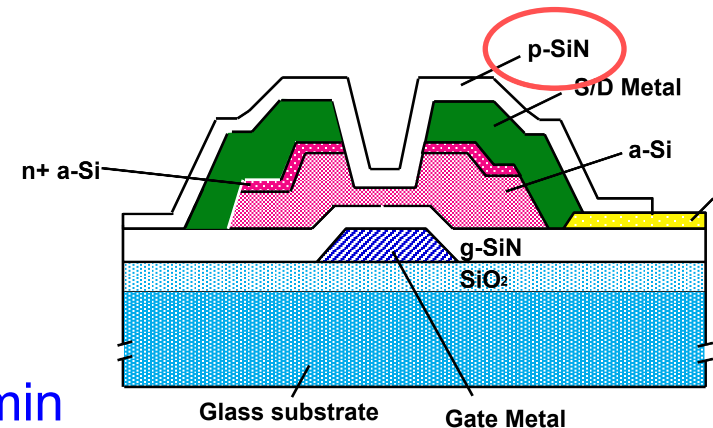
p-SiN_x
Applications and Advantages

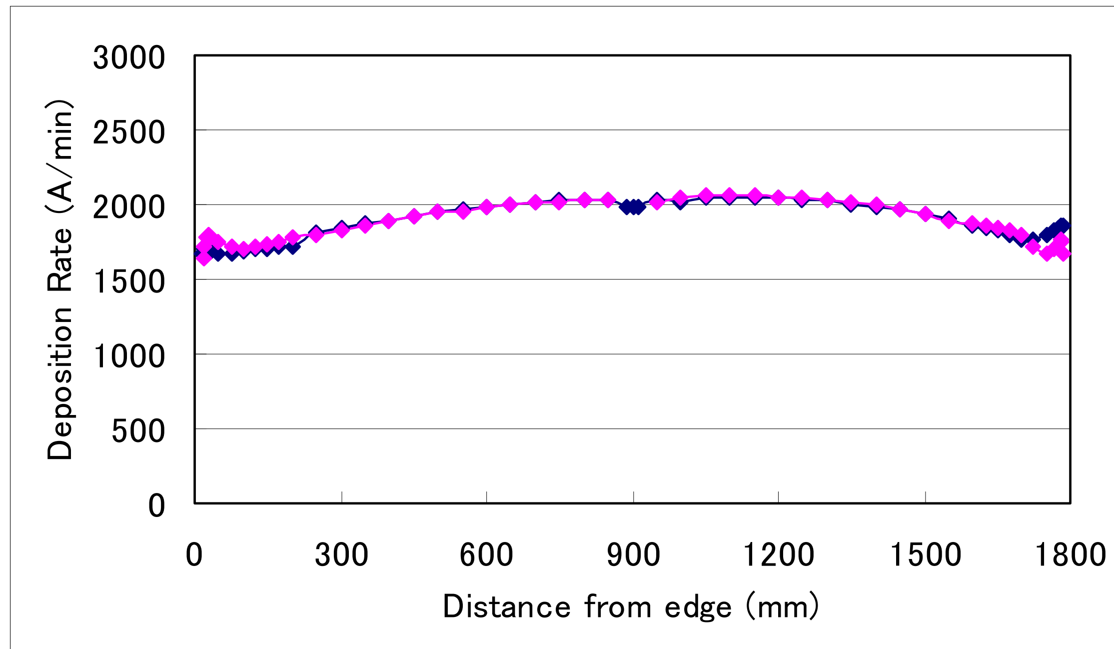


Process Performance

Deposition Rate	2000 Å/min
Thickness Non-Uniformity	± 10% at 15mm EE
Refractive Index	1.9 ± 0.1
Stress	± 7E9D/cm^2
Wet Etch Rate	600-1200 Å/min (10:1 BHF)
Breakdown Voltage	5-8MV/cm
Dielectric Constant	6-7
Si-H Content	3-8E21/cm^3
N-H Content	9-12E21/cm^3

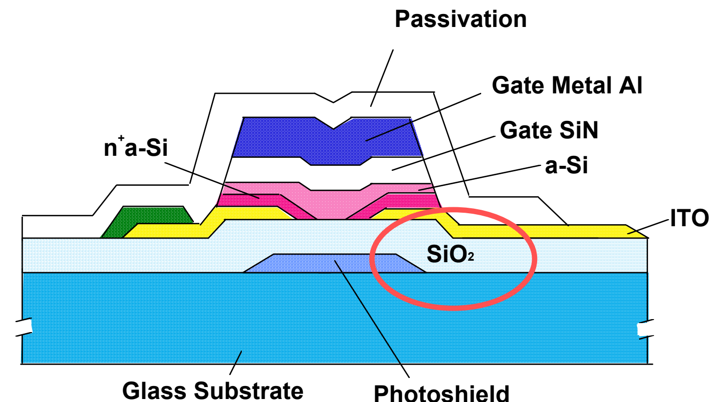
Example of Pass SiNx

Film	DR A/min	Stress E9D/cm2	WER(6:1) A/min	R.I.
Pas	1900	C2.4	1464	1.9



SiO_2

Applications and Advantages



Process Performance

Deposition Rate	500 to 3000 Å/min
Thickness Non-Uniformity	± 10% at 15mm EE
Refractive Index	1.46 ± 0.02
Stress	1-3E9D/cm^2 (C)
Wet Etch Rate	900-1800 Å/min (10:1 BHF)
Breakdown Voltage	5-10MV/cm
Dielectric Constant	4-5

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Technologies of AKT

E-beam Array Tester (EBT)

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German Site

History - long term continuation of team and technology

All key employees have stayed with the team under different company names since the early beginning, resources have continuously been added.

1982	**Started in Siemens research with circuit board test technology**
1991	**First e-beam tester or PCB installed at Siemens Augsburg**
1992	**Group and technology transferred to ICT GmbH - co-operation with MRS Technology inc.**
1994/95	**Co-operation with Hitachi to demonstrate test capability**
1996	**Prototype LCD matrix tester installed at ADT (Bosch)**
1997	**Spun off as EBETECH and acquired by Etec**
1998	**Co-operation with DTI to demonstrate test capability relative to "charge sensing technology"**
1999	**First commercial systems installed in Korea at Samsung, SECS integration**
2000	**Etec acquired by Applied materials, EBT to continue operation within AKT organization as an Applied Materials Company, re-named AKT Electron Beam Technology,**
Present	**Continue to work within AKT, increasing installed base, next generations under development**

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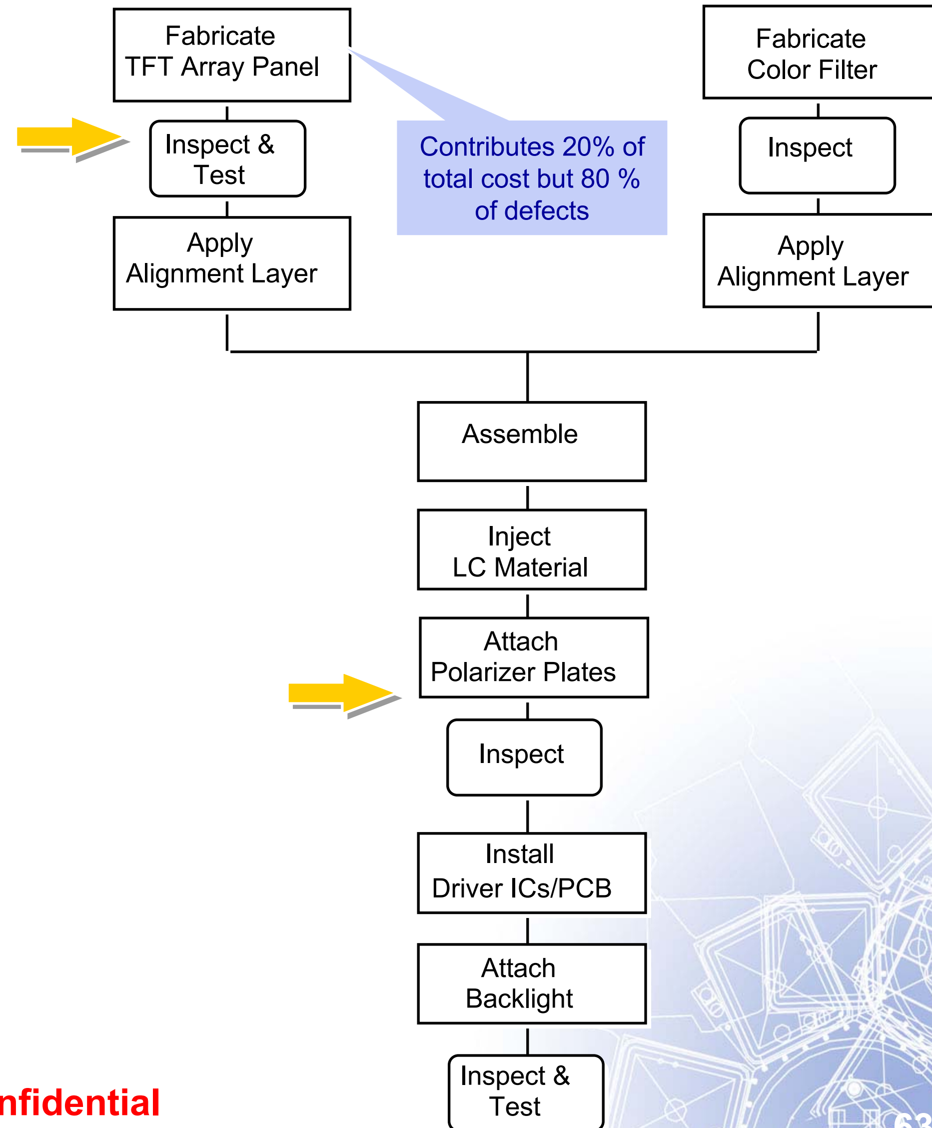
- Yields cost savings:
  - Color filters and other materials by repair or scrap of array matrix
  - Several full production lots in case of process problem
  - Driver ICs in case cell test is skipped
  - Reduced production ramp



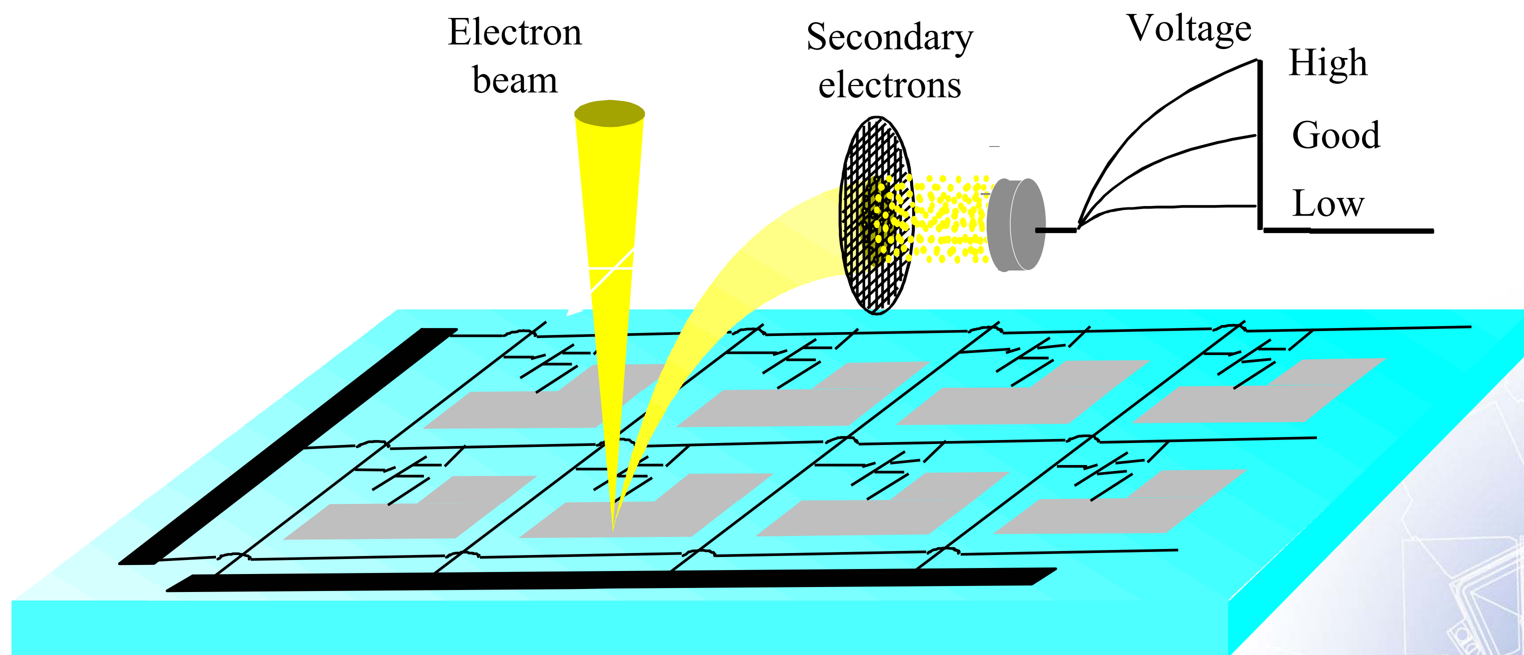
Increasing Importance of Testing

AKT

- Larger displays - e.g. TV - with higher cost of added components but demand to reduce overall cost
- Demand to drive cost down and take advantage of any cost saving possibility such as repair increasing demand for low or no pixel defects smaller pixels with higher risk for defects
- Short life time of each product requiring new product ramp up with initial yield problems

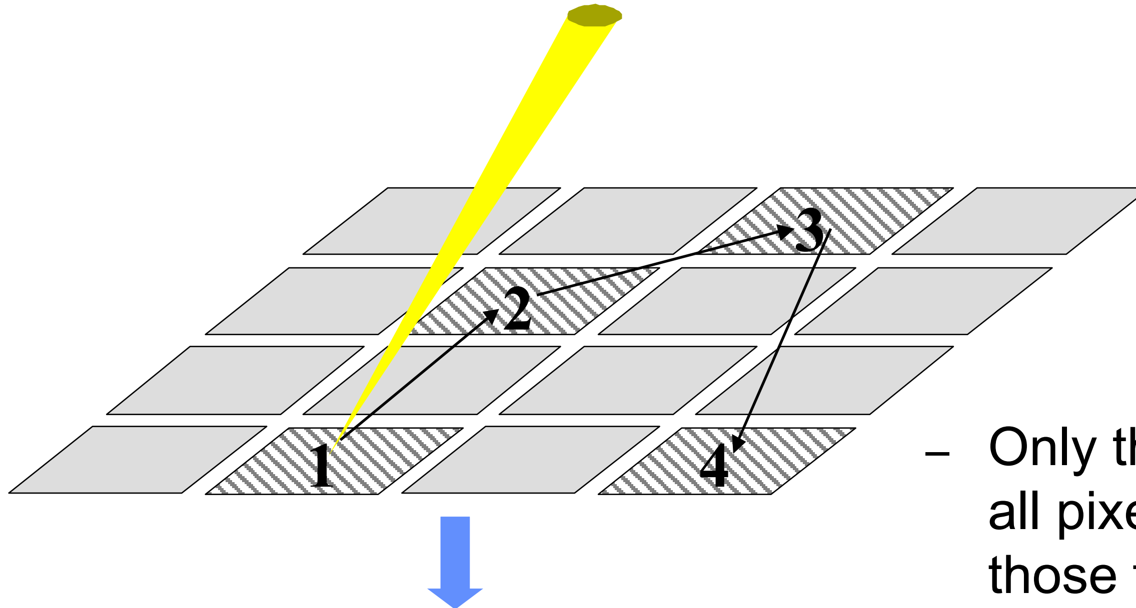
Electron Beam Technology

- Use electron beam to address individual pixels for test and re-test
  - Analyze emitted secondary electrons to sense pixel voltages
  - Inject current to charge each pixel - voltage limited to transistor threshold voltage. No additional charging.



AKT

→ high test accuracy, detailed classification



pixel	data			
	first test	re-test a	....	retest f
1	m1	a1	....	f1
2	m2	a2	....	f2
3	m3	a3	....	f3
4	m4	a4	....	f4

- Only the first test addresses all pixels, the re-test only those found in the first test
- Adds only low additional test time - only few pixels are re-tested (1000 x 10 µs = 10 ms)
- Result data of all re-tests are evaluated for full characterization

EBT Benefits

Detectability

- High S/N (signal/noise) ratio from vector-addressed (not raster scan) high voltage beam operation
- Retest functionality offers compelling detection advantages with less impact on total throughput

Defect characterization

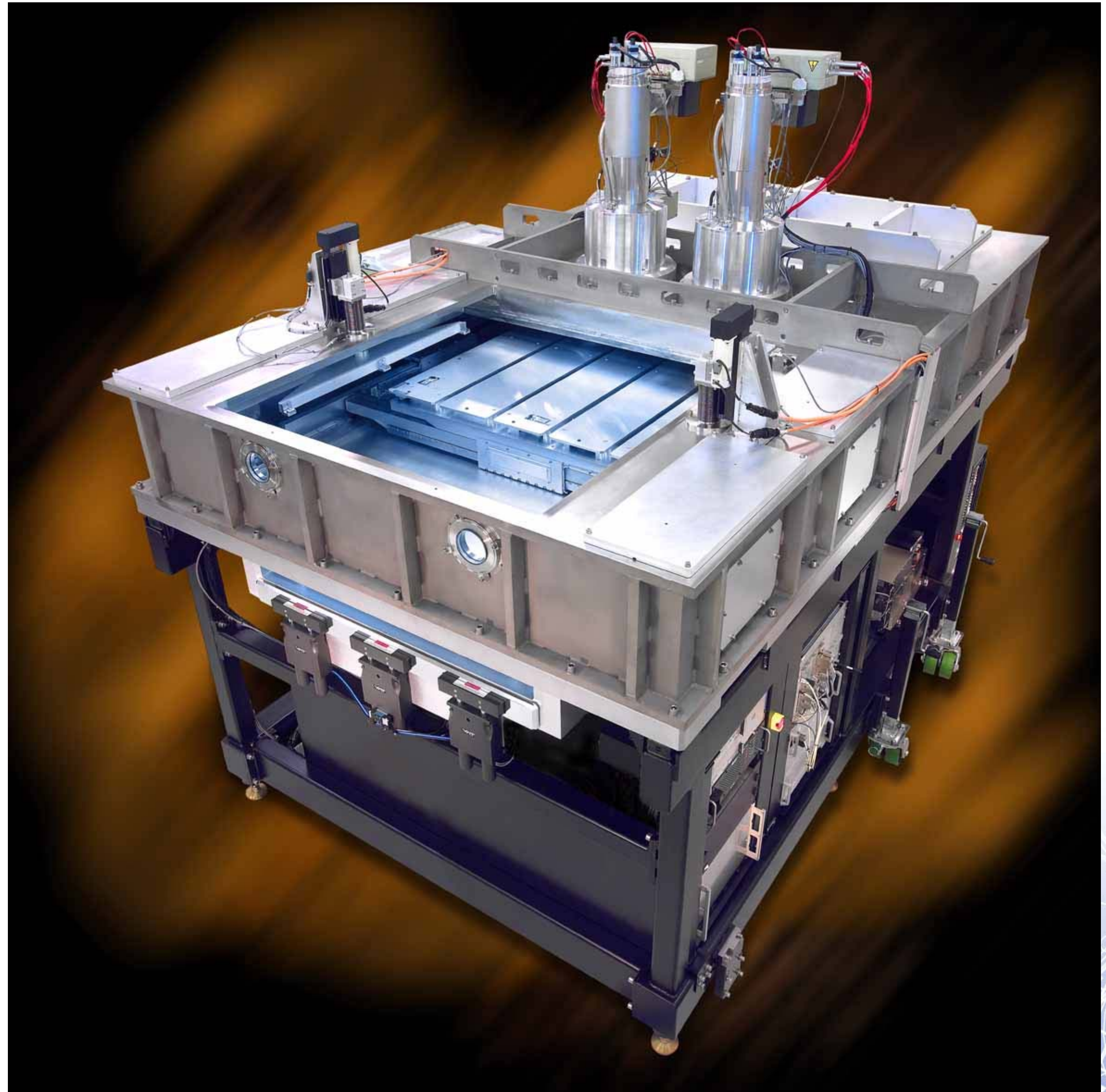
- Identify candidate defects with narrow testing thresholds
- Perform additional tests only on candidate defects using new test recipes to isolate defect types and improve detection → small impact on throughput

COO

- Throughput advantage of 20%-100% depending on substrate and panel size and pixel density → reduce system number particularly for LCD TV fabs
- Gun lifetime > 12 months
- High reliability systems with uptime > 95% achieved

Gen.5
AKT-15K
EBT

Up to 1200x1300mm Glass Substrate



15K EBT Development Scope

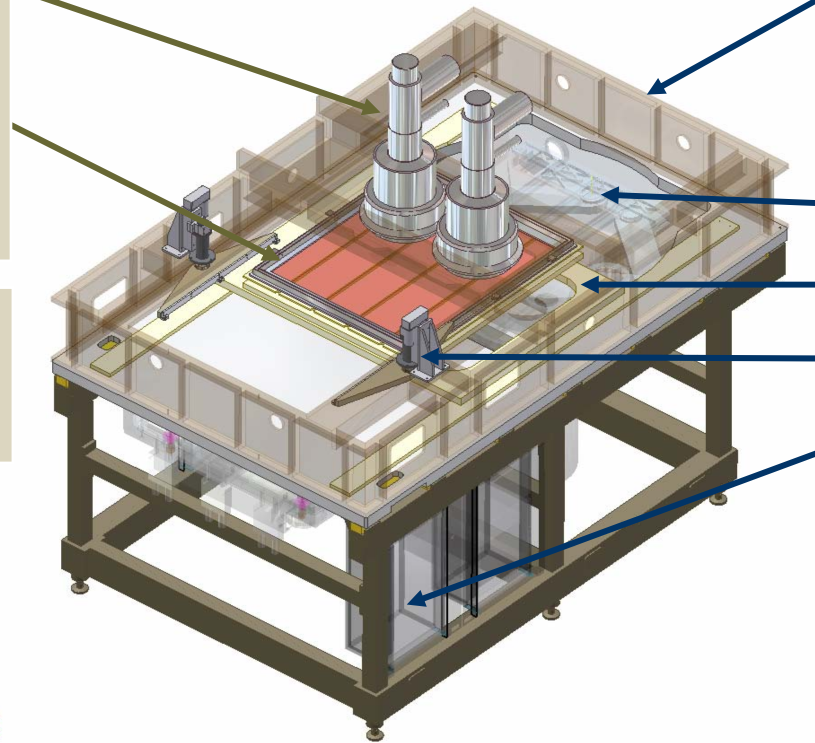
AKT GERMANY

EBT Column
(Column, Controller, SW)

Prober
Substrate Alignment

Microscope Option

EB Test Performance
Microscope Function



AKT SCLA

Vacuum Chamber & Frame

Vacuum Component

Power & Signal Distribution

Transfer Module (Robot)

XY Table & Stage

Prober Lifter

System Control

Service Tool

Substrate Handling Reliability
Vacuum System Performance

Envisioning the Future

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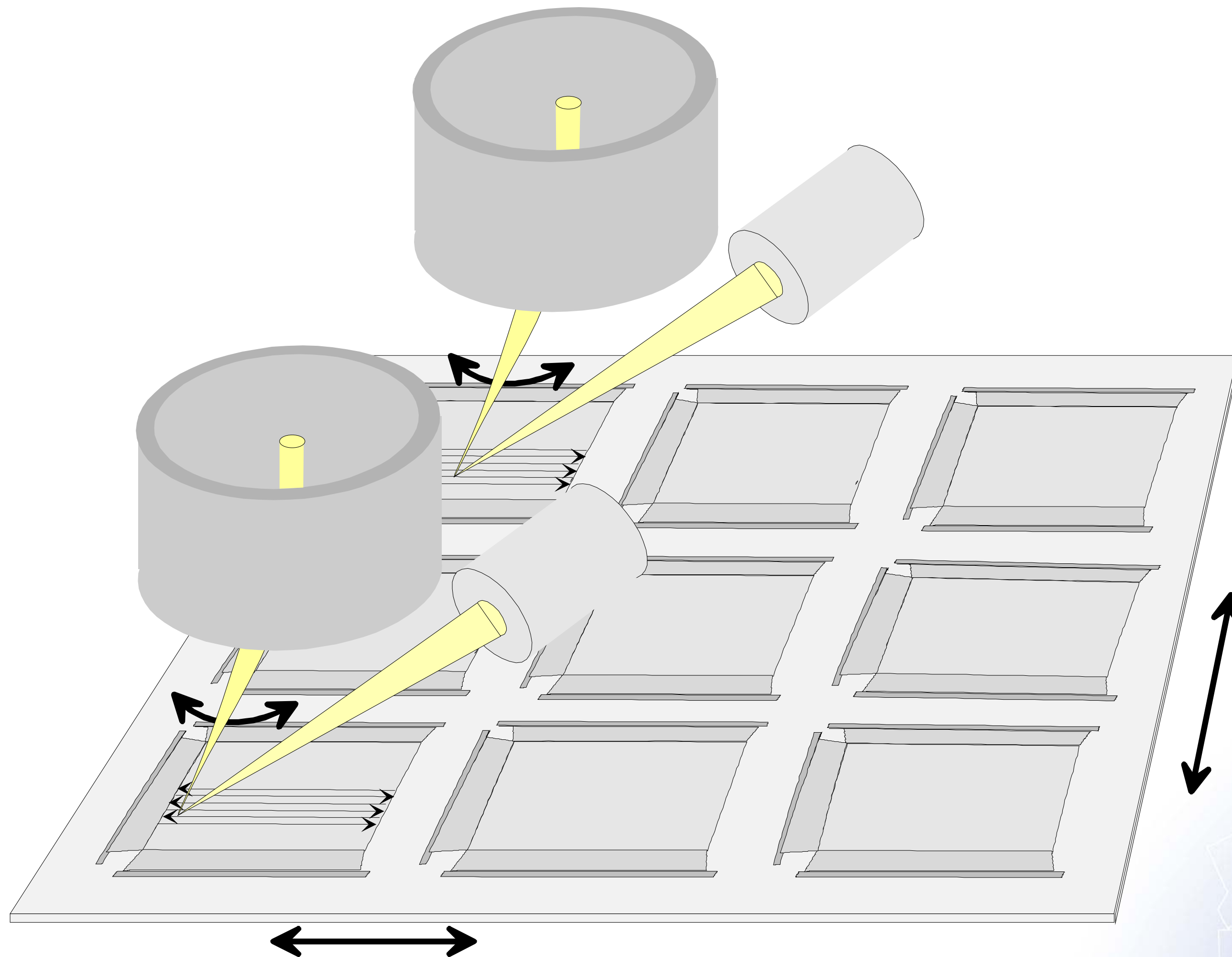
2X Throughput By 2 Columns



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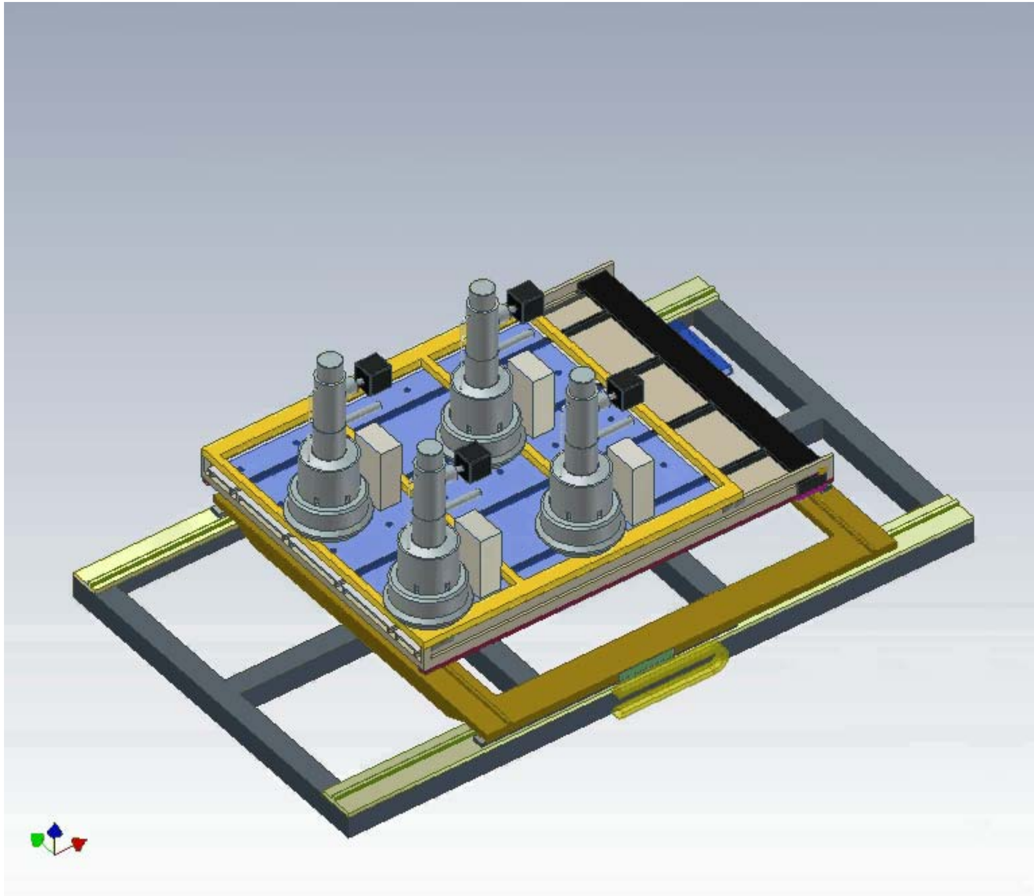
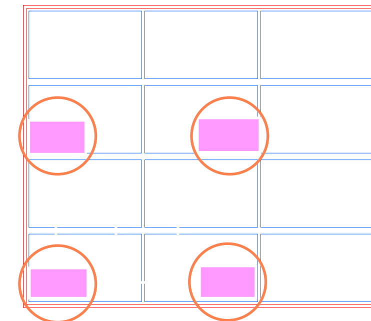
Four Column & XY Table Concept





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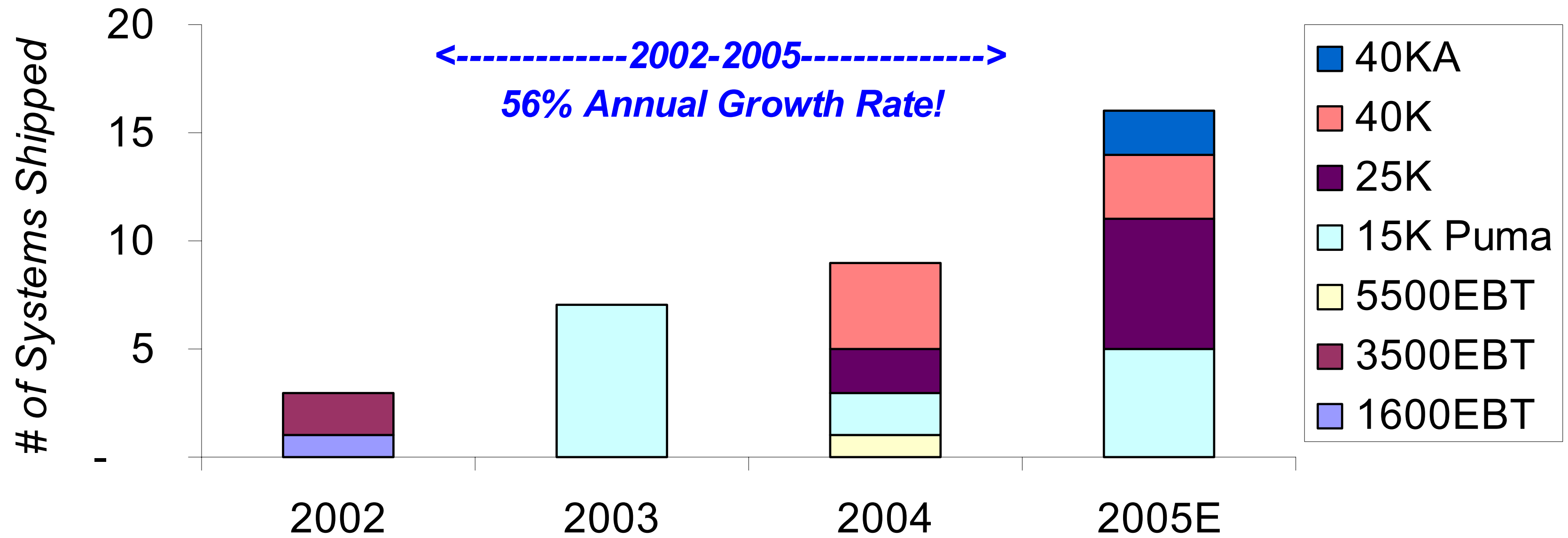
EBT Shipment History



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Challenges and solutions to the

large-size substrate processing

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- Have to Compete with Time
- How to maintain process uniformity within a “bed”
- Hardware reliability
  - Glass become larger and heavier
- How to maintain similar or even higher productivity despite of larger substrate

AKT

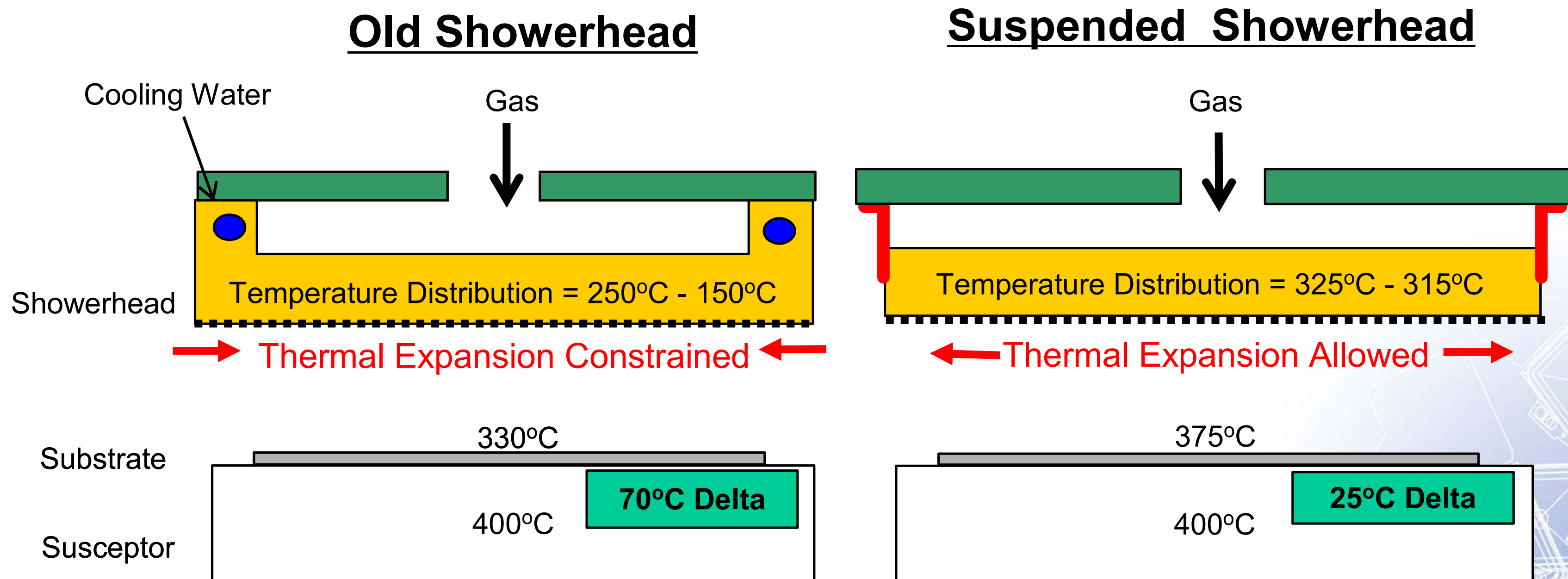
Example: Suspended Showerhead Diffuser Design

Challenges

- Diffuser damage due to thermal expansion (up to 1 cm @ G.5 size)
- poor showerhead and substrate temperature uniformity

Solution: Suspended Showerhead Diffuser

- Reduces diffuser/substrate and susceptor / substrate temperature delta
- Accommodates diffuser thermal expansion



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Example: Center Supported Showerhead Diffuser Design

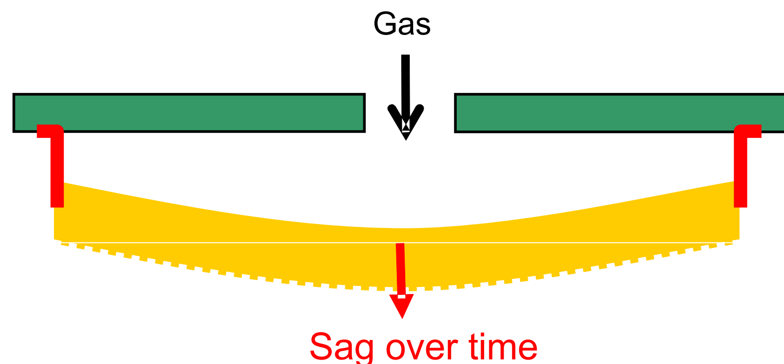
Challenge

- At larger generations, showerhead diffuser sag over time due to the heat and weight

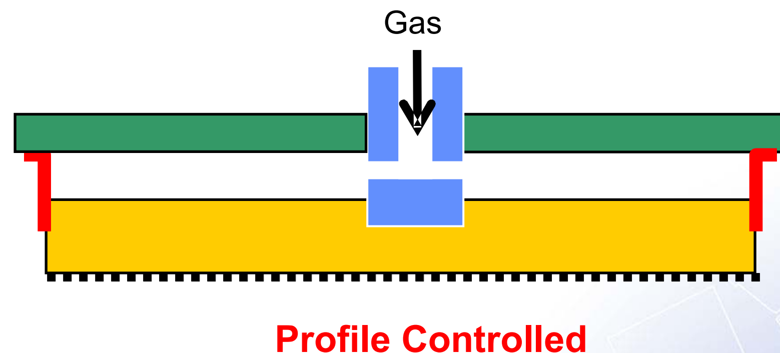
Solution: Center Supported Showerhead Diffuser Design

- One or more adjustable supports at a center region to prevent diffuser sagging
- Allows control of diffuser profile to any shape (flat, concave, convex)

No Center Support



Suspended Showerhead



Profile Controlled

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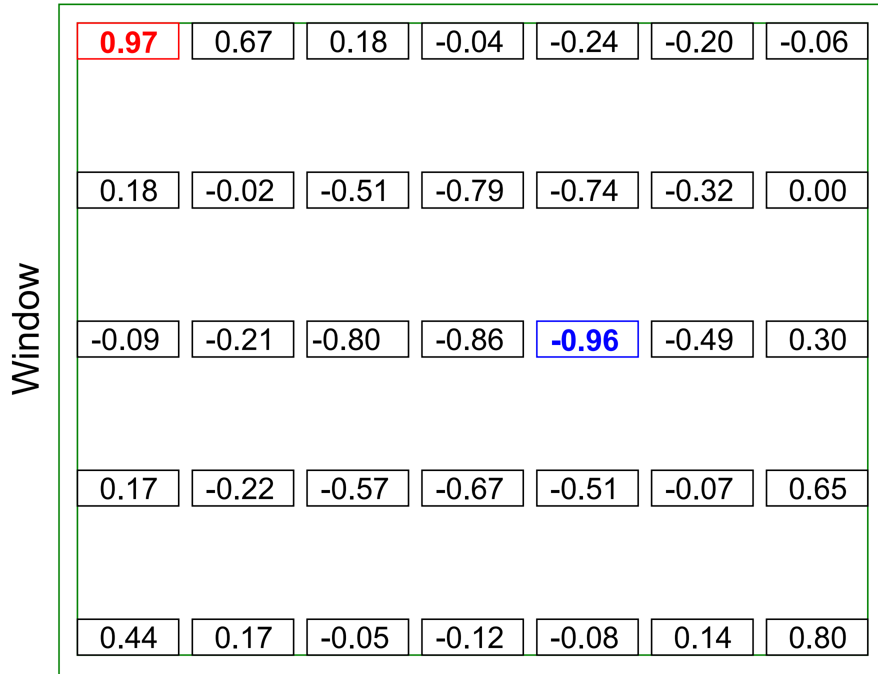
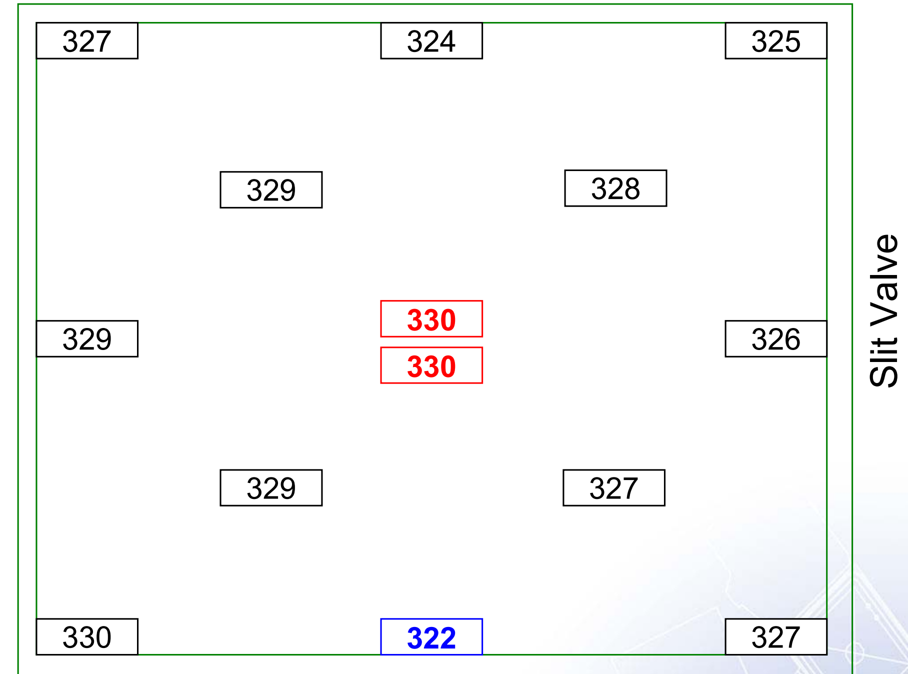
Hardware Performance





Parallelism less than +/- 1mm over the whole electrode area

Tsusc = 340/350C
Tsub (ave.) = 327C
Range = 8C

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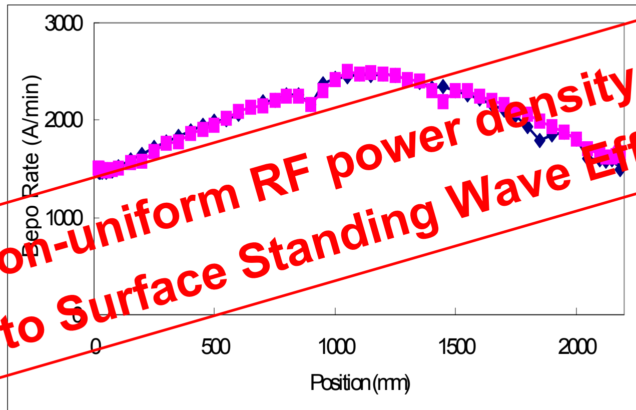
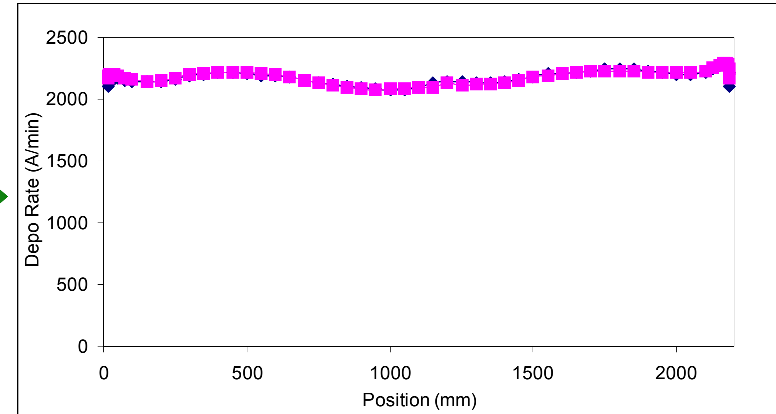
Plasma Surface Standing Wave Effect – making film center-dome non-uniformity





RF Frequency (MHz)	Wavelength λ_0 (m)
13.56	**22.11**
27.12	11.05
40.7	7.37
60	5.00
81.38	3.68

Generation	Substrate Size (mm^2)	R (half diagonal) (m)	$2.6(L/s)^{1/2}R$
5	1100X1300	0.85	5.7
6	1500X1850	1.19	8.0
7	1870X2200	1.44	**9.7**

assuming spacing ~ 800 mil, 2L = 20 mm, s ~ 1.5 mm

Surface standing wave effects criteria :

$$\lambda_0 >> 2.6\,(L\,/\,s)^{1/2}\,R$$

AKT

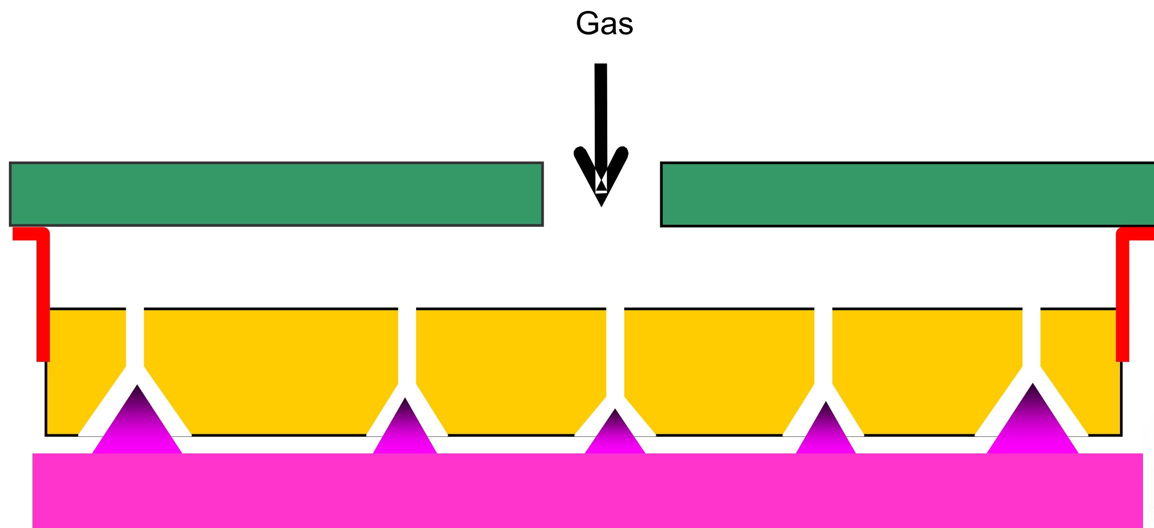
Example: HCG Showerhead Diffuser Design

Challenges

- At larger generations, CVD film properties becomes non-uniform with center dome thickness profile
- Root cause is the plasma density non-uniformity – Standing Wave Effect

Solution: Hollow Cathode Gradient (HCG) Showerhead Diffuser Design

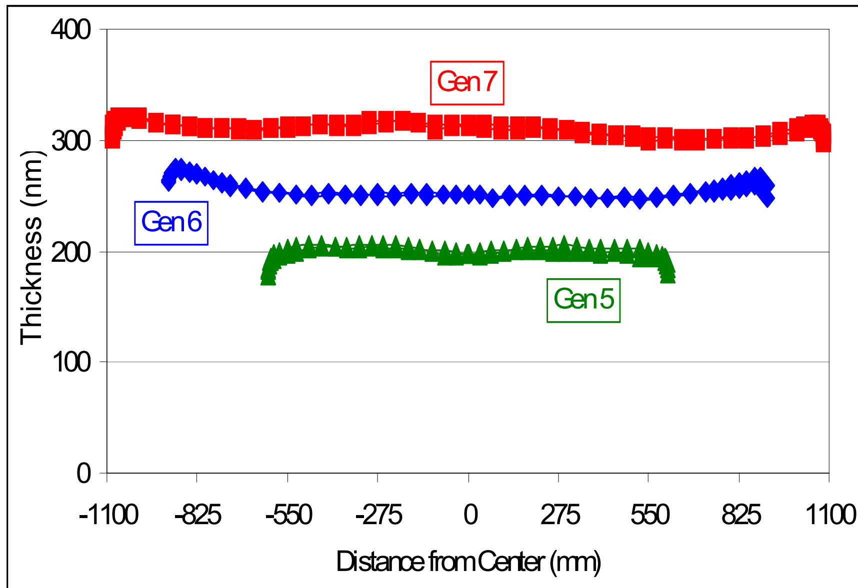
- Creating differentiated cone profiles and utilizing the Hollow Cathode Effect to counter the Standing Wave Effect



AKT Innovative Solution – APX_L® PE-CVD Chamber

AKT

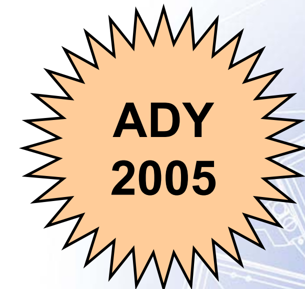
AKT-APX_L PE-CVD chamber achieved excellent film uniformity on Gen. 7 substrate and can be further scaled up beyond Gen. 7



2005 ADY (Advanced Display of the Year)

Display Equipment Award

at FineTech, Japan



Envisioning the Future

AKT

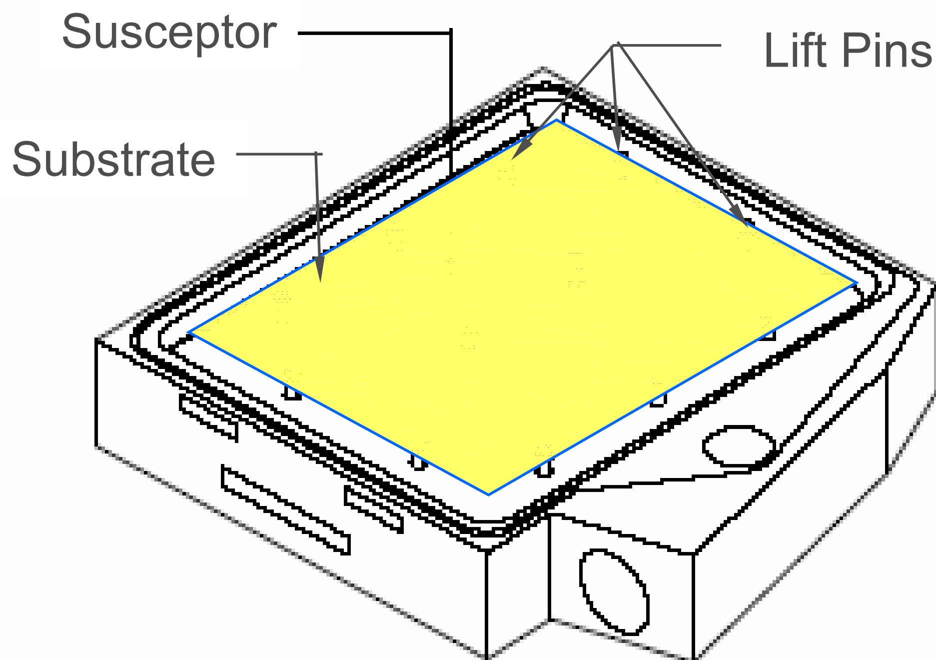
Example: Roller Bushing Lift Pin

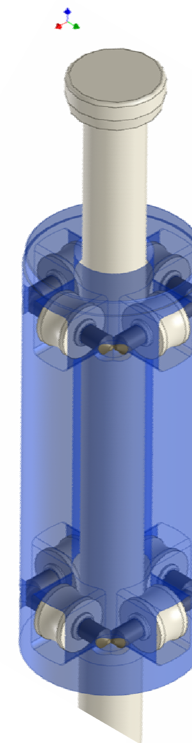
Challenge

- Sticking of lift pins causes glass breakage

Solution: Roller Bushing Lift Pin

- Guiding rollers totally eliminated lift pin sticking issue.





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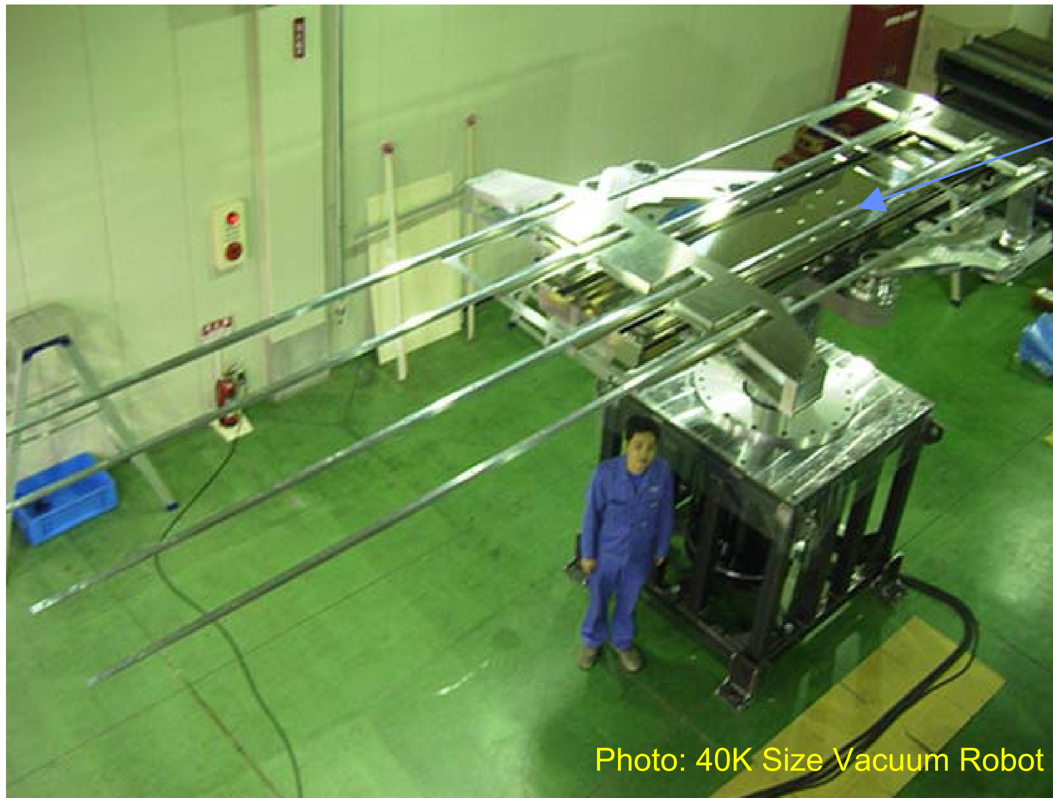


Liner Motion

- AKT-40K and 50K PECVD vacuum robot
  - Dual arm
  - Linear motion with link arm construction

Vacuum Robot

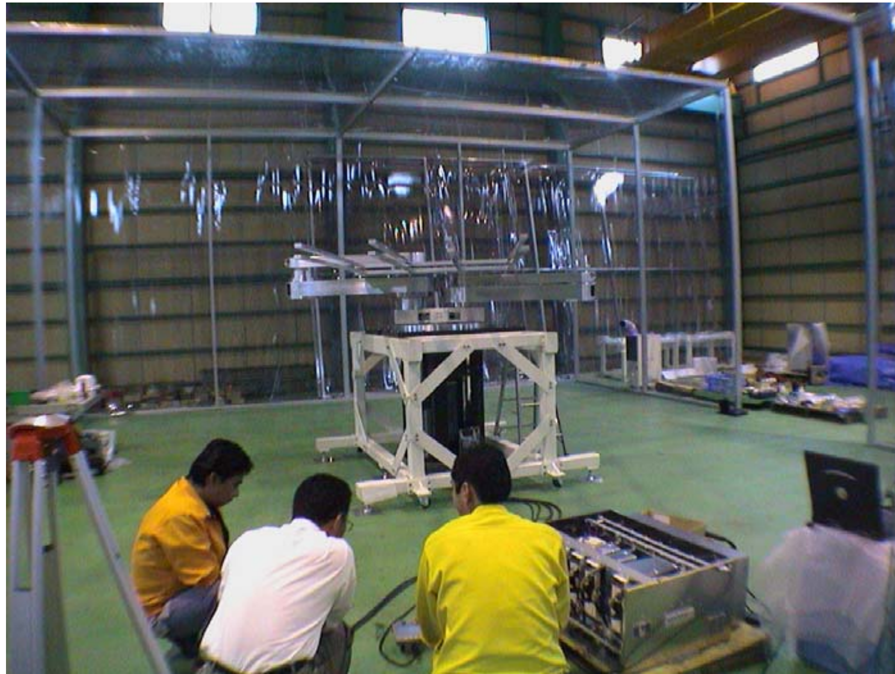


Fig 1 Production Robot #1 Cycle Test Condition (5/31/04)

Fig 2 Proto Type Cycling Condition
(170K cycling test from 5/21 with 120% load, 80% speed)

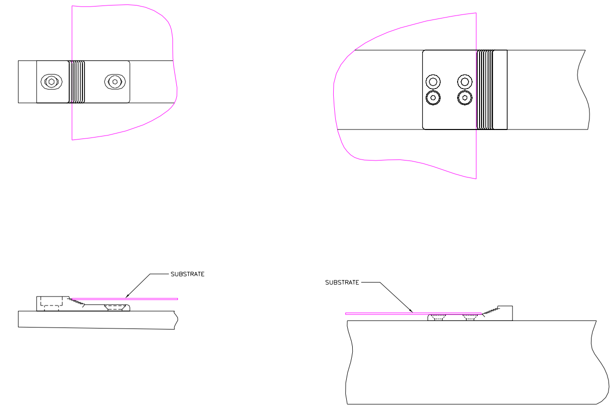
Envisioning the Future

Vacuum Robot

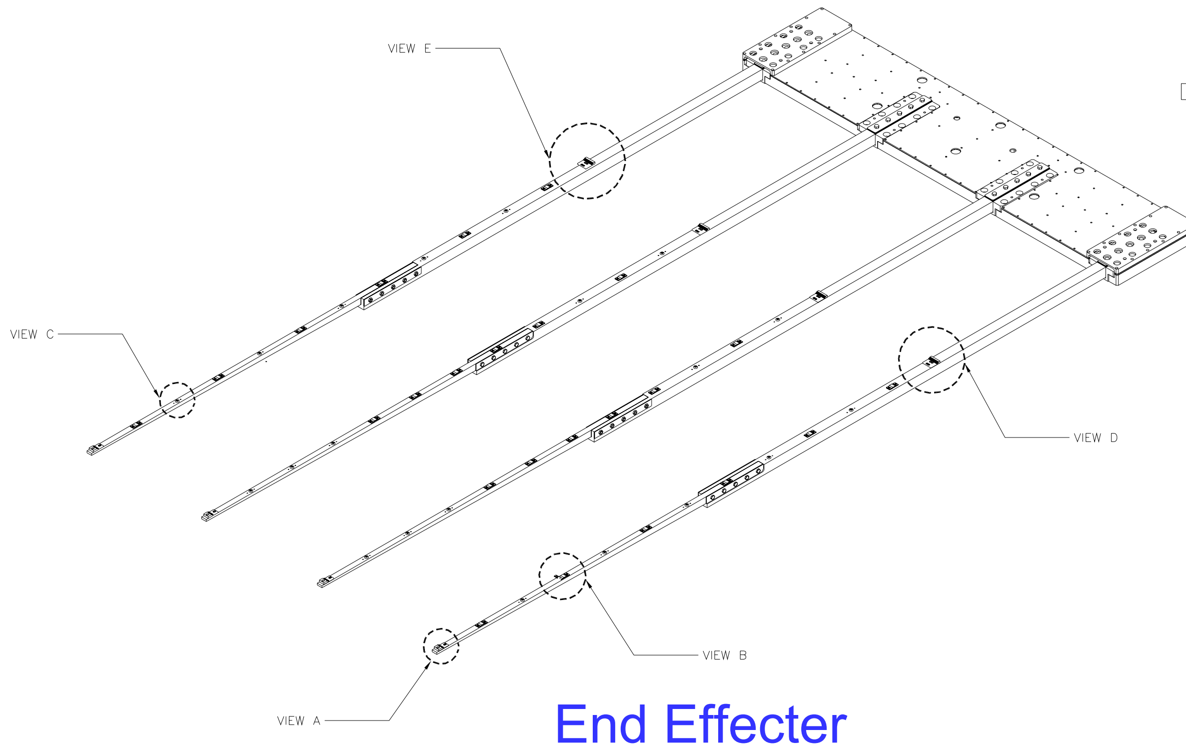
Vacuum Robot End Effecter and Pad

AKT

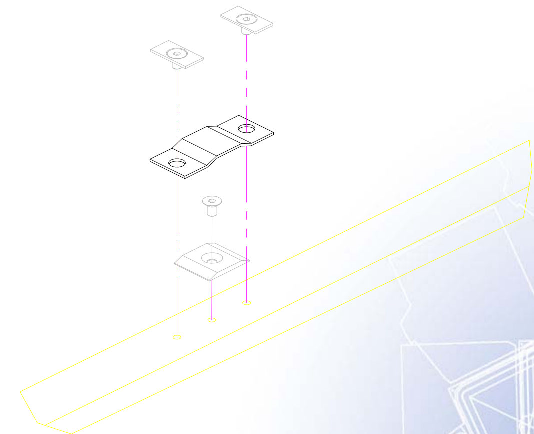
- Center
  - High friction pad and rest pad
- Front and Rear
  - Step pad



Step Pad



End Effecter



High Friction Pad

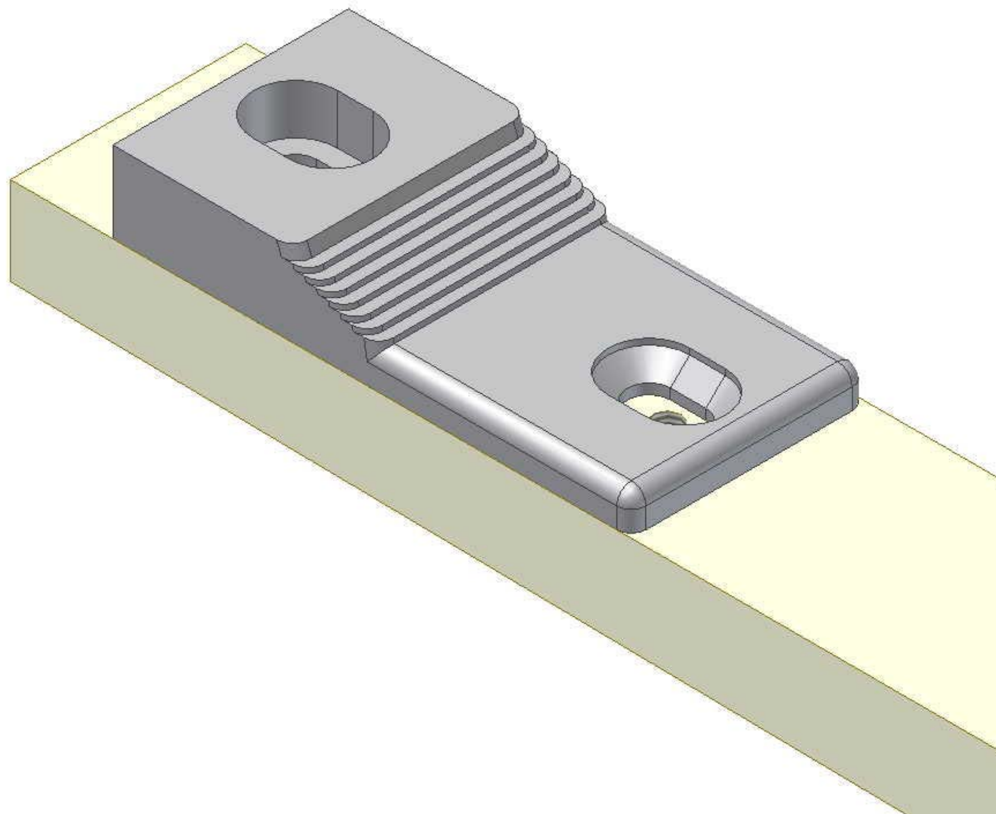


Fig. 3-1 Tip step pad (material: metal)

Envisioning the Future

AKT Confidential

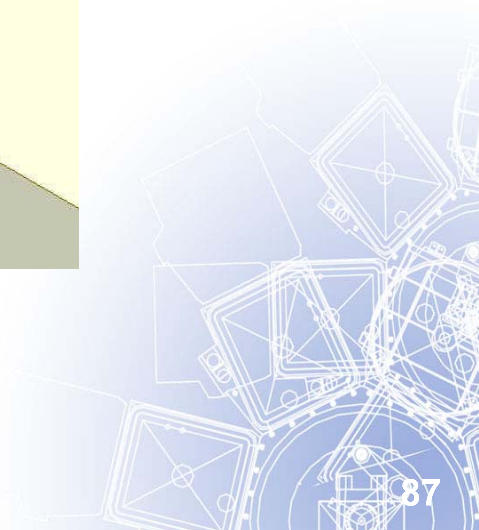
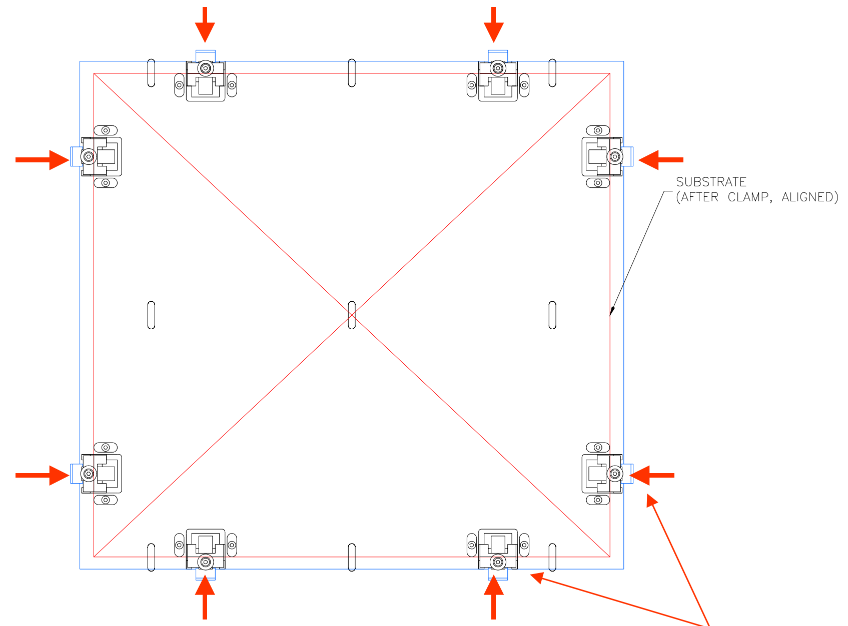


Fig. 3-2 Rear step pad (material: metal)

- **FEATURE**
  - **SIMPLE & CLEAN**
    - **No Additional Actuator**
    - **No Vacuum Seal**
    - **No Lubrication/ No Bearing**
  - **NO THROUGHPUT IMPACT**

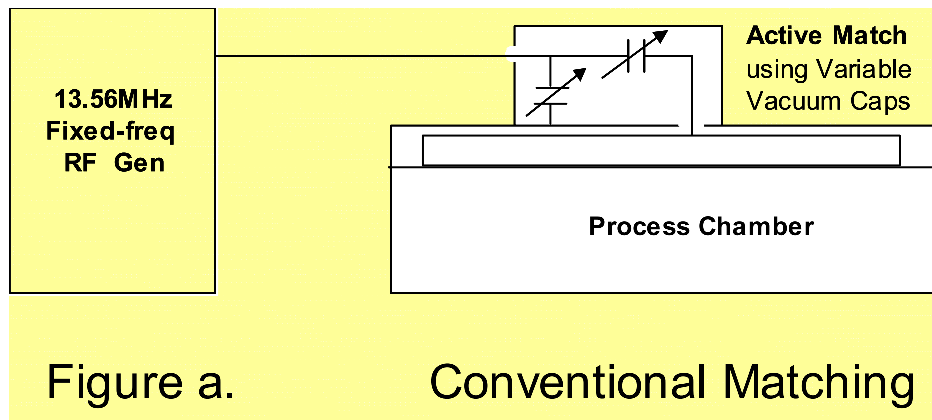


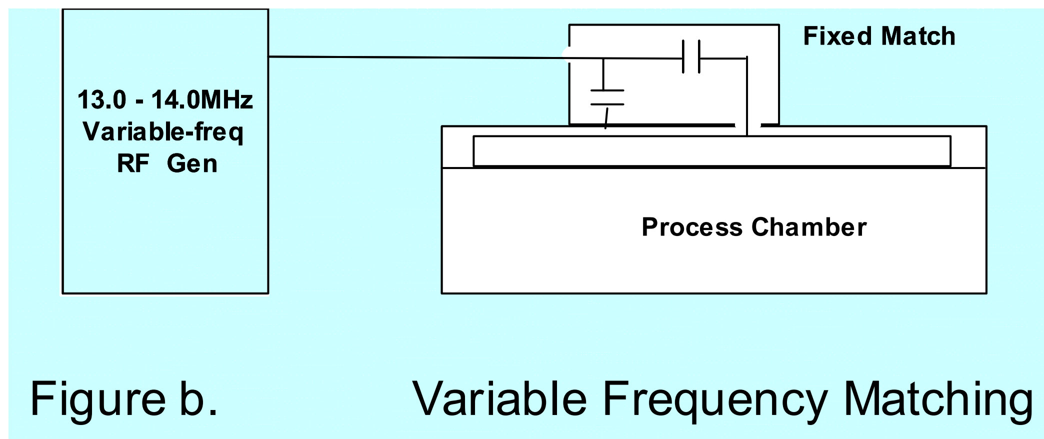
- **PERFORMANCE**
  - **REQUIRED POSITIONING ACCURACY OF ATMOSPHERIC ROBOT**
    - **Approx. +/- 3 mm from the calibrated DDSL load /unload position**
  - **ALIGNMENT ACUURACY OF DDSL SUBSTRATE ALIGNMENT EQUIPMENT**
    - **< +/- 0.5 mm**

Go to DDSL movie

Variable Frequency RF Match

– faster matching with higher reliability





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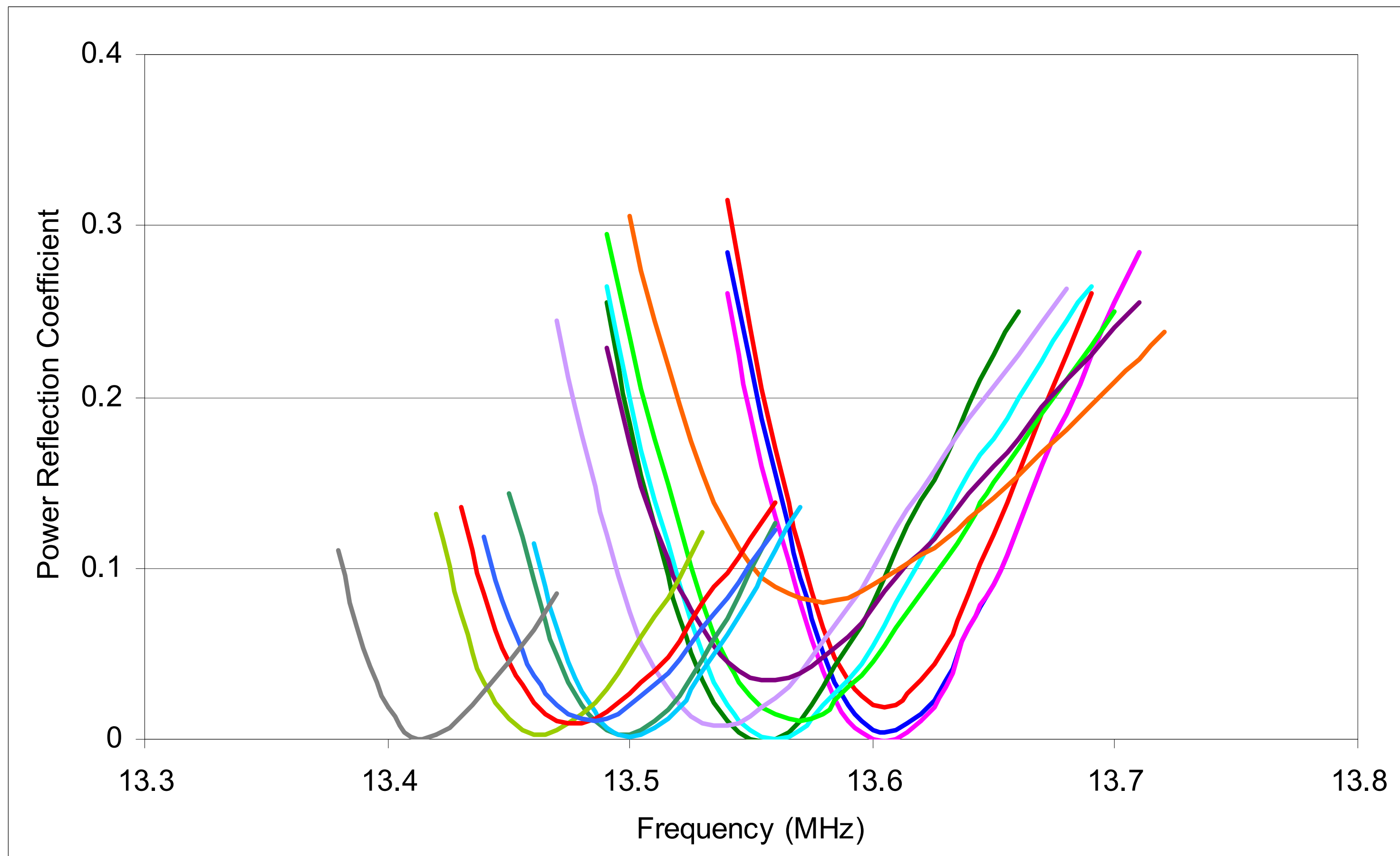
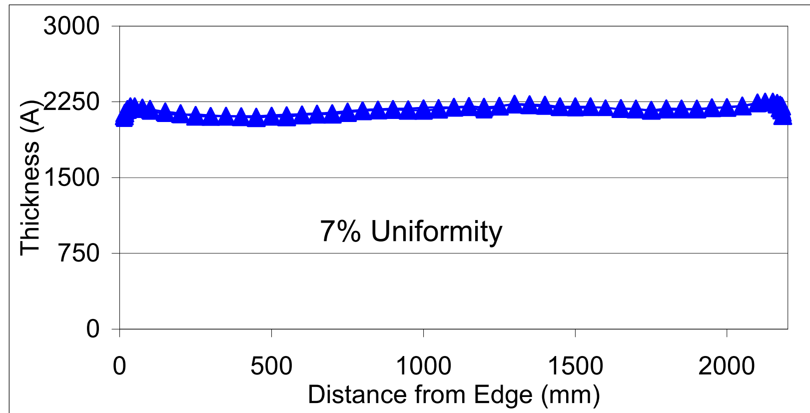


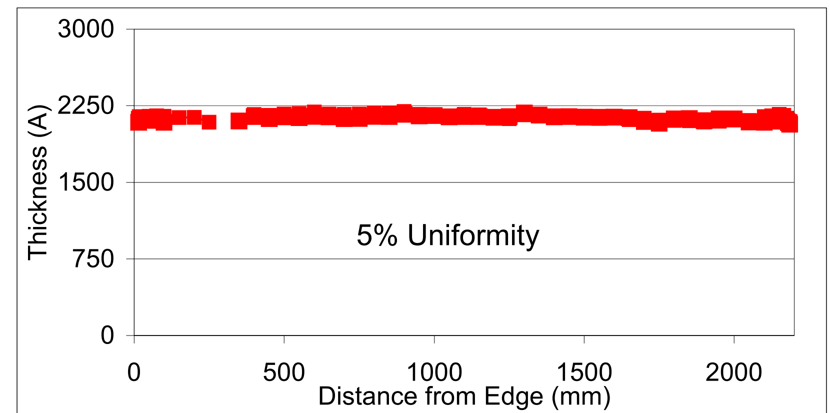
Calculated Reflection Coefficient vs. RF Frequency for all Process Impedance

AKT

a-Si Conventional Matching



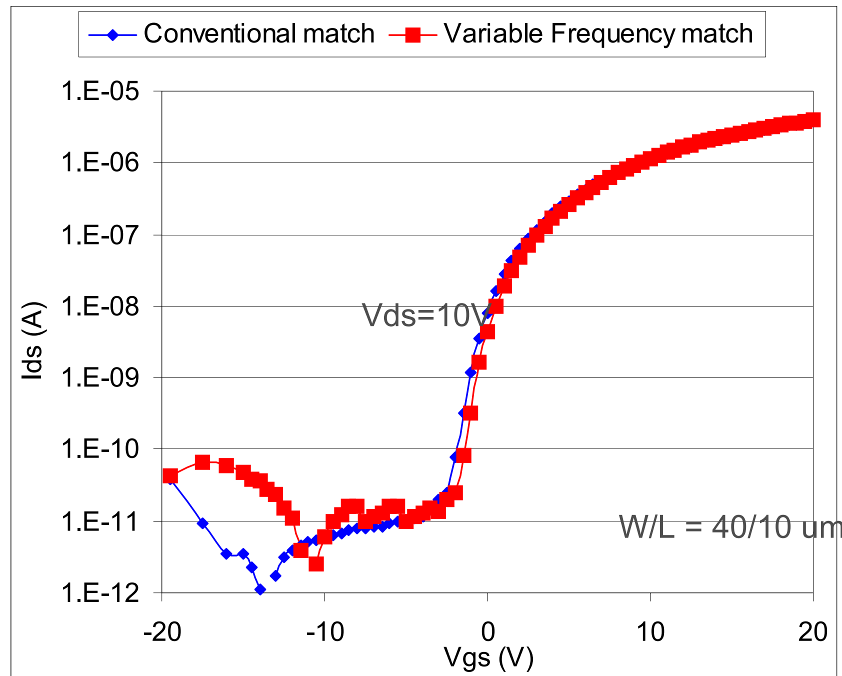
a-Si Variable Frequency Matching 13.55MHz



	DR A/min	Stress E9D/cm^2	Peak Pos cm^{-1}	WH/T arb unit
a-Si 1	1800	C 8.0	1994	0.56
a-Si 2	300	C 5.8	1994	0.50

	DR A/min	Stress E9D/cm^2	Peak Pos cm^{-1}	WH/T arb unit
a-Si 1	1800	C 7.6	1994	0.56
a-Si 2	300	C 4.8	1995	0.46

AKT

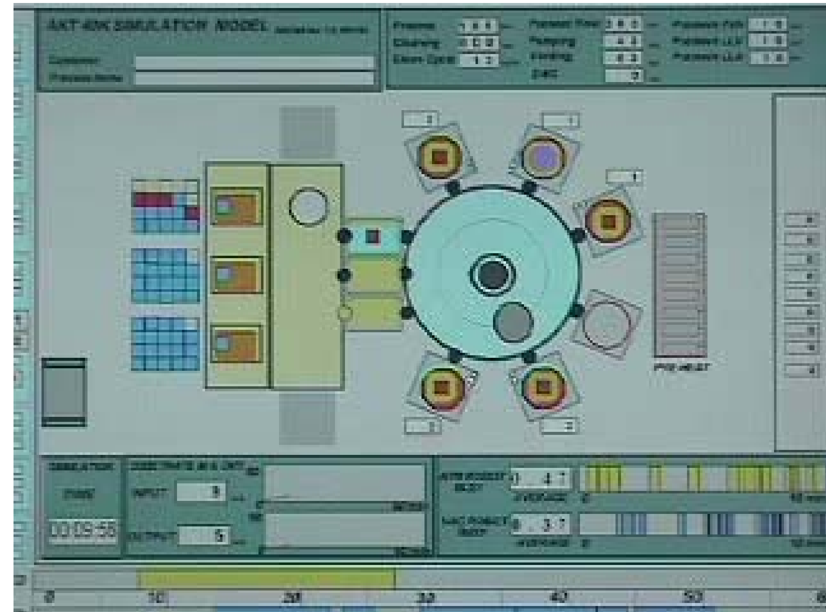


	Mobility V/cm^2 sec	Vth V	Ion (A) @ Vg= 20V	Ioff (A) @ Vg= -7V	S V/dec
Conventional Matching	0.66	-1.0	3.1E-06	1.2E-11	0.80
Variable Freqency Matching	0.68	0.2	3.1E-06	2.0E-11	0.83

Software (Substrate Routing) Development

AKT

- Pre-move vacuum robot
- Dynamic substrate quantity control
- Synchronization of cleaning cycle
- Balance usage of process chamber



Process	System	Preheat (sec)		Cln (sec)	Cycle (sub)	Depo (sec)	Vent (sec)	Pump (sec)	Slit V (sec)	PreMv (sec)	P/C # (Qty)	TPT (sub/hr)
Passivation Layer	DDSL	360	Hch	800	12	150	35	35	3	0	4	48.5
(SiN)		35	Pch	800	12	150+35	35	35	3	0	5	49.8
	TSSL	360	Hch	800	12	150	60	40	3	40	4	53.5
		35	Pch	800	12	150+35	60	40	3	40	5	61.0
Active Layer	DDSL	360	Hch	800	6	380	35	35	3	0	4	23.3
(g-SiN/a-Si/SiN)		35	Pch	800	6	380+35	35	35	3	0	5	30.5
	TSSL	360	Hch	800	6	380	60	40	3	40	4	24.0
		35	Pch	800	6	380+35	60	40	3	40	5	31.3

5 Pch (Preheat at Pch) and TSSL configuration improved >125~134% TPT

AKT-40K PE-CVD system: gross weight ~ 2x Boeing-747-400

(approx. gross weight: 130 Ton)

(B747-400 Uses 66.68 Tons of high strength Aluminum)

Large system manufacturing requires improved skills and capabilities.

In 2004, AKT uses more aluminum than Boeing Co.

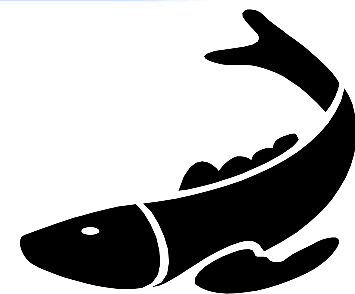
– materials procurement also becomes challenging.

SUMMARY

- FPD era is already here. As the main growth engine of the TFT-LCD, LCD-TV shall thrive against the competitions from CRT & other FPD TVs.
- Accelerated system scale-up pace requires innovative solutions with fundamental understanding of the system & process to ensure the same or better film quality and system performance with **no** compromise at each new generation.
- Designing, engineering and manufacturing for the productivity – an overall approach to support the concept of **Production Worthiness**.

Our Culture…..AKT'S TALE OF THE HUNGRY FISH

AKT



There are different kinds of fish…

Fish found in rivers wait for the current to bring food to them. They are passive and content with the flow of resources available to them. However, the fish found in lakes are constantly swimming around, looking for food. They consistently seek out opportunities and exhibit efficient behavior while doing so.

There are also different kinds of people…

The success of AKT is based upon a strong company culture personified by the "Hungry Fish". We encourage team work amongst our employees who are focused on our business, our products and the value our company offers to it's customers.

謝謝！
Thank you !