

# *Electronic Displays Market Overview*

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# *Outline of Presentation*

- MCG Overview
- Markets and Applications
  - Information and Communications, Entertainment, Vehicles
- Display Technologies
  - CRT, LCD, Projection, Plasma, OLED
- Display Materials and Components
  - Glass, Films, Chips, Consumables
- Display Players
  - Japanese, Korean, Chinese
- Dielectric Materials

# *MCG Products and Services*

- Market and technology databases, forecasts, and reports
  - Microdisplays, projection, and personal displays
  - 3G Cellphone Market Opportunities
- Custom consulting for displays and liquid crystal products
  - Reflective color, plastic substrate displays
  - Polymer semiconductors and OLEDs
  - New product or market opportunity analysis
  - Development of business plans
  - Company formation, financing, and launch of marketing and sale
- Annual Projection Industry Summit Conference
  - June 2002 conference for projection supply chain
  - Sponsored jointly with Insight Media and Infocomm (ICIA)

# Resources

- MCG Team
  - Chuck McLaughlin, Launching new products in new markets
  - Market analysts: Ron Cooke, Jim Pfeiffer
  - Technology Analysts: Dr. Kirk Moffit, Dr. David Armitage, Dr. Felix Schuda, Scott Holmberg
  - Research, databases and website: Adrienne Hefter, Fred Nobile
- Affiliates:
  - Japan: Interlingua
  - U.S.: Insight Media (Microdisplay Report)
  - Europe: Decision Tree Consulting

# Substrates, Films, and Coatings Projects

Area	Scope of Work	Methodology
Plastic Substrates	<ul style="list-style-type: none"> <li>• Market segmentation</li> <li>• Current products and sped database</li> <li>• Market trends, competition, forecast</li> <li>• Company profiles</li> </ul>	<ul style="list-style-type: none"> <li>• Extensive research</li> <li>• Face to face surveys of Japanese and Western players</li> </ul>
AR Coatings	<ul style="list-style-type: none"> <li>• Spin coating and Direct sputtering</li> <li>• AR coated PET and Sol Gel Coatings</li> <li>• Segmentation, trends, competition, forecast</li> </ul>	<ul style="list-style-type: none"> <li>• Survey of specifications, technical literature, and face to face survey of players</li> </ul>
Barrier Coatings	<ul style="list-style-type: none"> <li>• LCD wants and needs</li> <li>• OLED opportunities</li> <li>• Trends, requirements, process integration</li> </ul>	<ul style="list-style-type: none"> <li>• Survey of LCD manufacturers and OLED developers</li> </ul>
Polarizers	<ul style="list-style-type: none"> <li>• Trends, requirements, segmentation, forecast</li> <li>• Player profiles</li> </ul>	<ul style="list-style-type: none"> <li>• Secondary research</li> </ul>
Light Control Films and Screens	<ul style="list-style-type: none"> <li>• Polarization recycling, diffusers, and projection screens</li> <li>• Segmentation, trends, requirements</li> </ul>	<ul style="list-style-type: none"> <li>• Secondary research and surveys</li> </ul>
Other	<ul style="list-style-type: none"> <li>• Backlight and front lights, color filters, touch panels</li> </ul>	<ul style="list-style-type: none"> <li>• Secondary research, alternative technologies</li> </ul>

# *Display Forecast by Markets and Applications*

Televisions

Desktop Computer Monitors

Notebook Computers

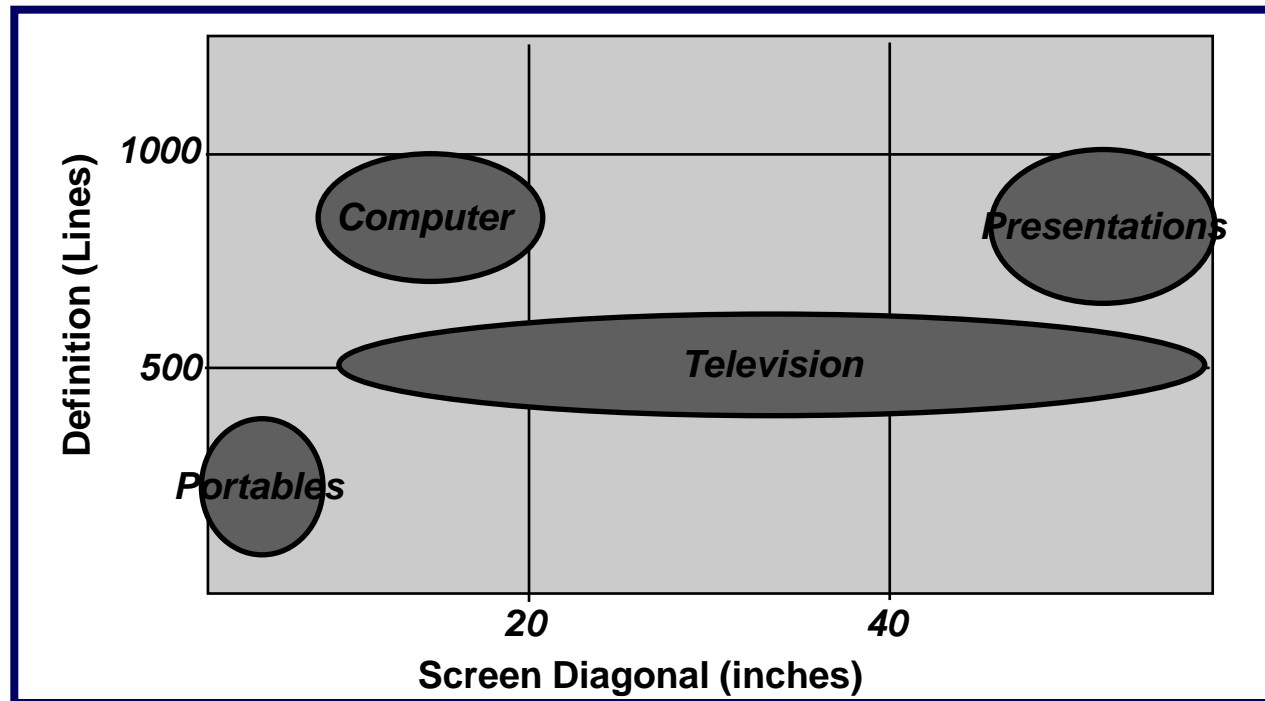
Cellphones

Auto Monitors

PDA's and Palmtops

# Yesterday's Display Platforms

- Simple world of 4 non-overlapping markets
  - Different products for different applications
- Four non overlapping markets, products, and channels
  - Computer, consumer electronics, A/V Dealer, and OEM channels



# Today's Spectrum of Display Requirements

	Handhelds	Computer	Television	Presentations
Screen Diagonal (in.)	2-8	15-21	5-70	>50
Imaging	Monochrome Graphic	Full Color Graphic	Full Color Video	Full Color Graphic
Brightness (nits)	Reflective	100-200	300-500	50-100
Typical Definition (lines)	QVGA (240)	XGA (768)	NTSC (480)	XGA(768)
Incumbent Technology	PMLCD	CRT AMLCD	CRT	Front Projection
Display Price Range	\$10-\$50	\$150-\$1,000	\$100-\$3,000	\$2,000-\$20,000

# Market Trend Highlights

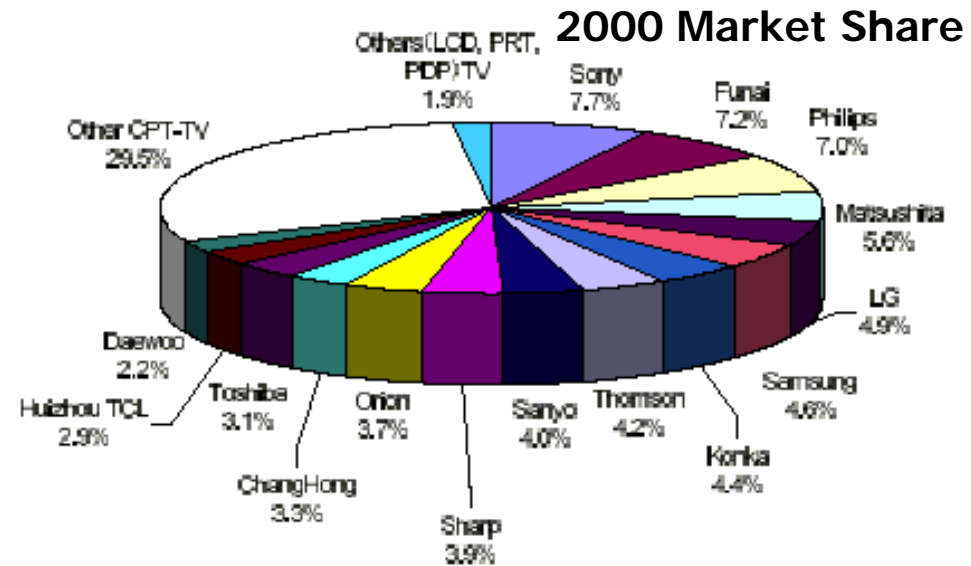
- Sustained growth of all market segments
  - Cellphones and pagers lead in portables; laptops still strong
  - Monitor growth tied to PC growth; flat panels take 20% share
  - Small TV sales stagnate; WW growth mainly in 28 to 36 inch CRTs
    - Big screens (plasma and projection) big dollars, modest units
  - Sustained high growth of presentation projectors
    - Stable price points; increased performance
- Few shifts in display technologies
  - CRT monitors and TVs continue to handle bulk of applications
  - As AMLCD prices fall, penetration extends into monitor and TVs
  - Small share for plasma flat panels in high end TV
  - Latest buzz is around OLED technology

# *Billion Dollar Market Applications*

<b>Application</b>	<b>2000 Display Revenue</b>	<b>2006 Display Revenue</b>	<b>CAGR</b>
<b>Television</b>	\$14,769	\$25,603	10%
<b>Desktop monitor</b>	\$12,186	\$22,206	11%
<b>Notebook PC</b>	\$8,336	\$12,405	7%
<b>Portable phone</b>	\$3,301	\$7,281	14%
<b>Other Monitors</b>	\$733	\$2,507	23%
<b>In-vehicle monitor</b>	\$675	\$2,042	20%
<b>Public displays</b>	\$827	\$1,923	15%
<b>Data projector</b>	\$547	\$1,224	14%
<b>PDA</b>	\$342	\$1,193	23%
<b>All Other</b>	\$4,519	\$7,139	8%
<b>Total</b>	\$46,235	\$83,523	10%

# Television (\$26 B\*)

- Growth of digital video
  - DVD, HDTV, DBS, Internet
  - Consumers pay for choice
- Home theater experiences
  - More big screens
  - Wider choice of programming
  - Higher definition images
- TV/Monitors in every room
  - Small flat panel PCTVs



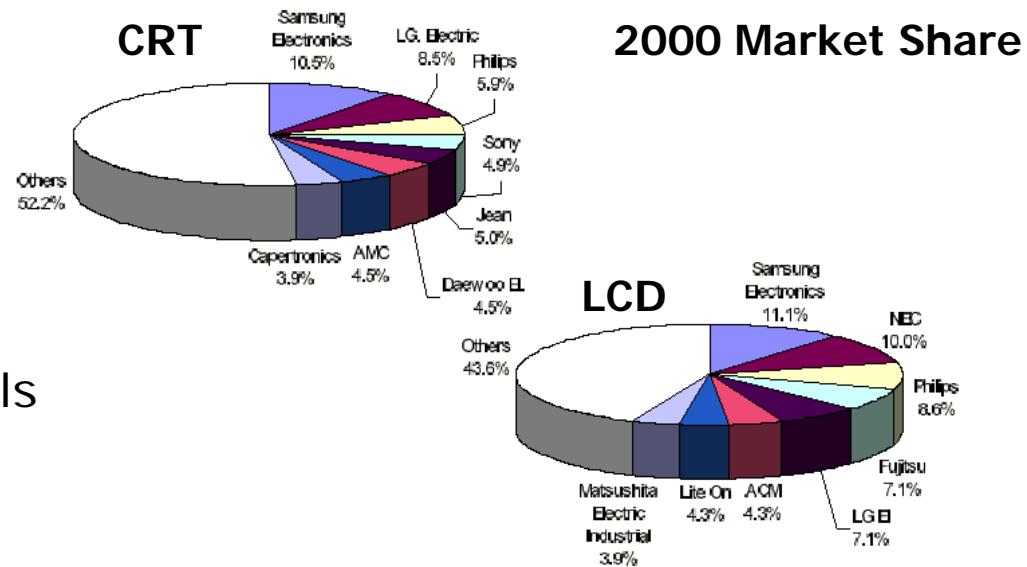
Product	2000 (M units)	2006 (M units)	CAGR
CRT	133.1	159.5	3%
LCD	0.3	8.0	73%
PDP	0.0	3.8	114%
Projection	2.3	5.5	16%
<b>Total</b>	<b>135.8</b>	<b>176.8</b>	<b>4%</b>

\* Forecasted 2006 Revenue

2006 ASP: \$145

# Desktop Monitors (\$22 B\*)

- PC market maturity
  - Lower growth rates
  - Slower replacement rates
  - Focus on developing world
- Competitiveness of flat panels
  - Smaller price premiums
  - Smaller foot print
  - Higher pixel counts
  - Sharper images
- Multi-monitor desktops
  - More power users



Product	2000 (M units)	2006 (M units)	CAGR
CRT	94.3	114.0	3%
LCD	7.0	44.0	36%
<b>Total</b>	<b>101.3</b>	<b>158.0</b>	<b>8%</b>

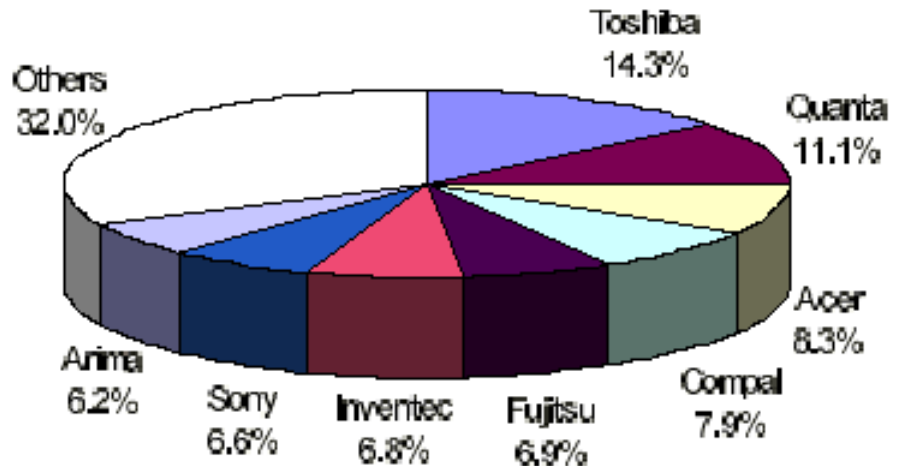
\* Forecasted 2006 Revenue

2006 ASP: \$140

# Notebook PCs (\$12 B\*)

- Gain share from desktop PC
  - Lower LCD prices
  - Improved speed and capacity
- Standardization/lower prices
  - Taiwanese dominance
  - Cost down pressures
- Total dominance of AMLCD

2000 Market Share



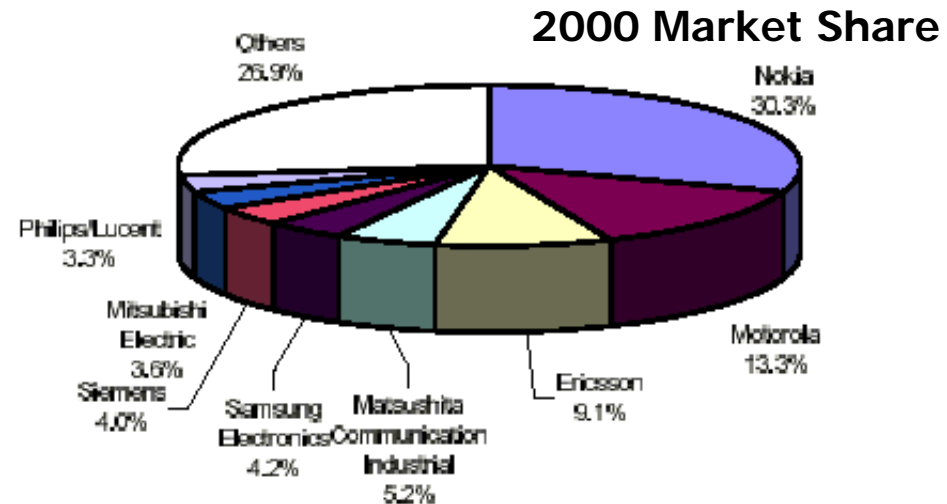
Product	2000 (M units)	2006 (M units)	CAGR
LCD	23.5	51.8	14%

\* Forecasted 2006 Revenue

2006 ASP: \$240

# Cellular Telephone (\$7 B\*)

- Sustained subscriber growth
  - Focus on developing countries
  - China potential is HUGE
- 3G drives handset upgrades
  - Always on updates
  - New applications and services
- DoCoMo drives full color video
  - Photo exchange
  - Games
  - Video



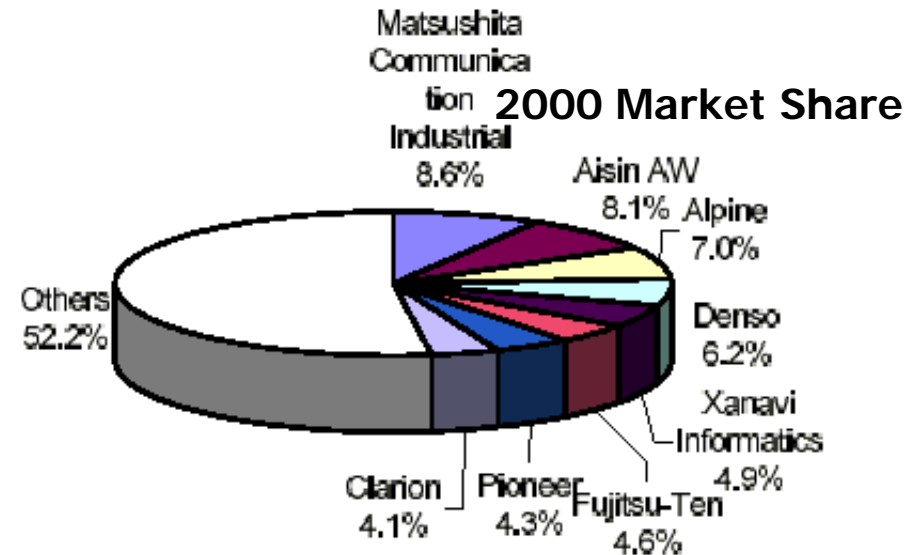
Product	2000 (M units)	2006 (M units)	CAGR
Mono PM LCD	384.0	370.0	-1%
Color PM LCD	24.0	175.0	39%
AMLCD	2.0	135.0	102%
OLED	0.9	21.0	71%
<b>Total</b>	<b>410.9</b>	<b>701.0</b>	<b>9%</b>

\* Forecasted 2006 Revenue

2006 ASP: \$10

# Automotive Monitors (\$2 B\*)

- Multifunction controller
  - HVAC, GPS, Cellphone
- In-Vehicle video
  - DVD and broadcast
  - Rear seat only in U.S.
- Two channel
  - OEM install
  - Aftermarket
- Highest pull in Japan
  - 70% of current market



Product	2000 (M units)	2006 (M units)	CAGR
AMLCD	3.7	11.0	20%

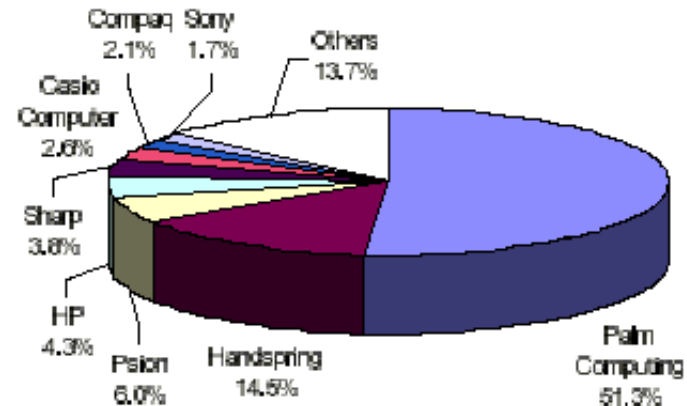
\* Forecasted 2006 Revenue

2006 ASP: \$185

# PDA's (\$1 B\*)

- Two market applications
  - Extension of enterprise
  - Consumer Convenience
- 3G wireless applications
  - Corporate Intranet portal
  - Always on updates
  - New applications and services
- Pocket PC challenges Palm
  - Enterprise embraces PPC
  - Palm embeds in smart phones

2000 Market Share



Product	2000 (M units)	2006 (M units)	CAGR
Mono PM LCD	8.2	8.0	0%
Color PM LCD	2.0	14.0	38%
AMLCD	1.5	17.0	50%
OLED	nil	1.5	na
<b>Total</b>	<b>11.7</b>	<b>40.5</b>	<b>23%</b>

2006 ASP: \$29

\* Forecasted 2006 Revenue

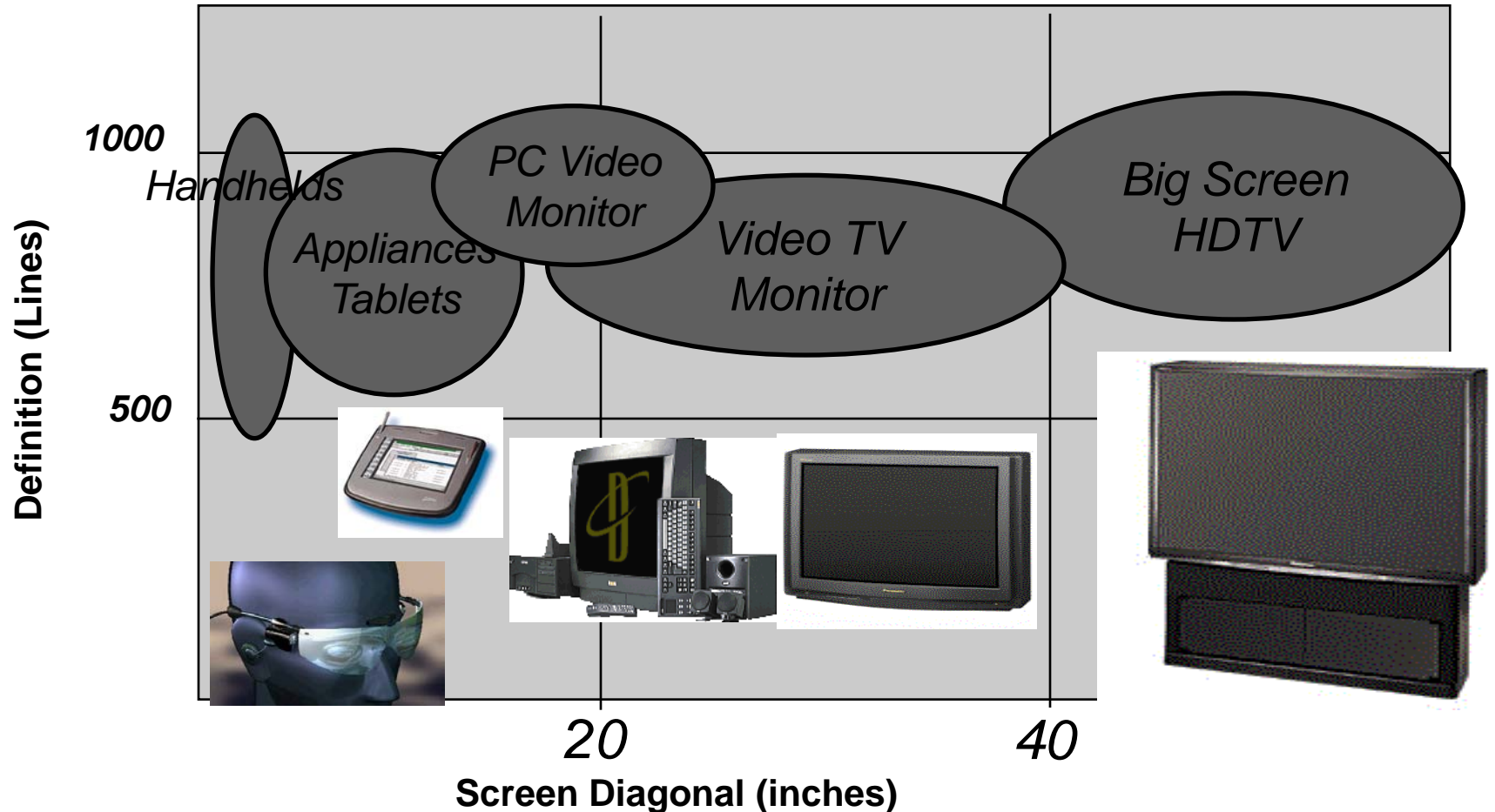
# *Other Market Applications*

- Presentation Projectors (\$1.2 B\*)
  - 20% CAGR to 2.9 M units in 2006 @ \$420 per system
  - U.S. based InFocus/Proxima holds 25% share
  - Three competing microdisplay technologies, including TI DLP™
  - ≈10 U.S. developers targeting LC on silicon
- Camcorders and Digital Still Cameras (\$1.5 B\*)
  - 16% CAGR to 68 M units in 2006 @ \$18 per unit
  - Drives competition in small (2-3") full color video monitors
  - Microdisplay companies capture viewfinder market share

# Forecast Notes

- Basis of Forecast
  - Fuji Chimera Research
- Value chain basis
  - Display revenue valued at “module” level
  - Includes interface IC, backlights, bezels, etc.
  - Does not include monitor and television tuners, cabinets, interfaces

# Future Promises Overlapping Markets

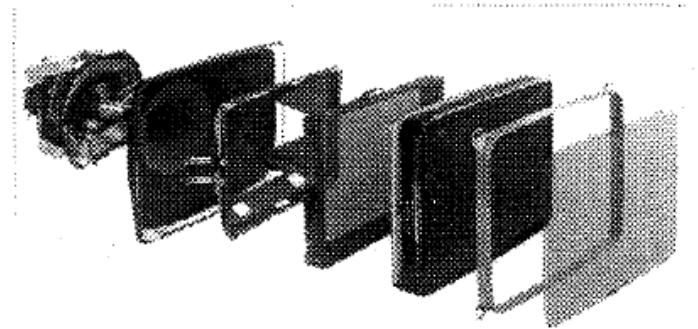


# *Display Technologies*

CRT	Cathode Ray Tube
PMLCD	Passive Matrix Liquid Crystal Display
AMLCD	Active Matrix Liquid Crystal Display
PDP	Plasma Display Panel
OLED	Organic Light Emitting Diode
Others	LED, EL, FED, eInk, PDLC, etc.

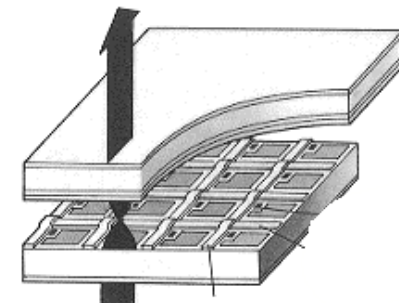
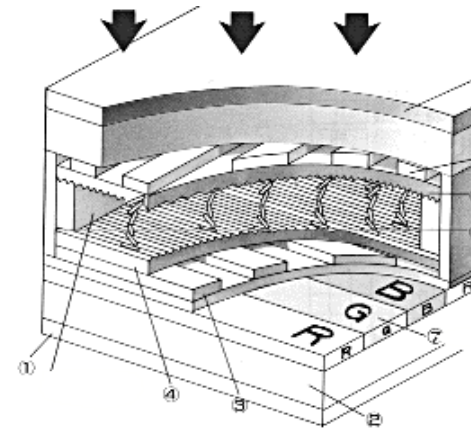
# CRT Technology

<b>Status</b>	Mature
<b>Capability</b>	Full color video
<b>Infrastructure</b>	Worldwide
<b>Mode</b>	Emissive
<b>Addressing</b>	Scanned
<b>Form Factor</b>	Bulky
<b>Power</b>	High
<b>Investment</b>	Low
<b>Processes</b>	Shadow Mask Phosphor Delta Phosphor Stripe Vacuum gettering Frit Sealing
<b>Strengths</b>	Best full color vide image Lowest prices
<b>Weaknesses</b>	Bulky, not portable High power



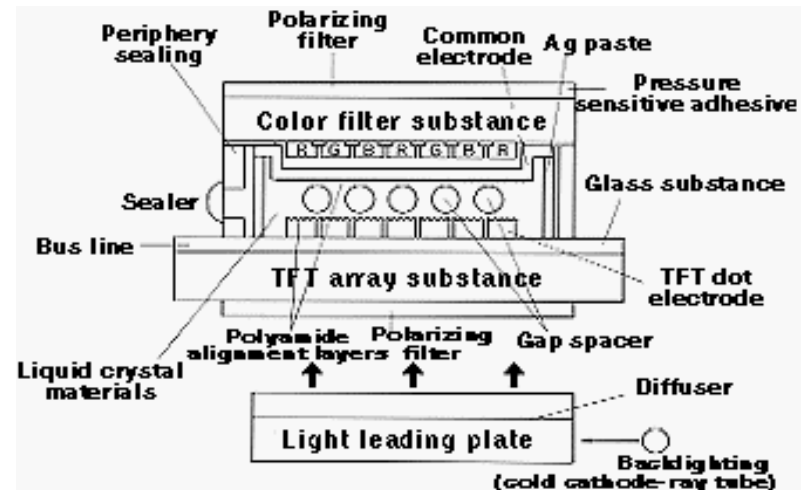
# PMLCD Technology

Status	Mature
Capability	Graphic
Infrastructure	Asia
Mode	Transflective
Addressing	Passive
Form Factor	Thick Flat Panel
Power	Low to Moderate
Investment	Moderate
Processes	Photolith of ITO Cell spacing Alignment Surfaces Liquid Fill Film Lamination
Strengths	Low power Thin, light weight Low to Moderate cost
Weaknesses	Poor color Not video rate



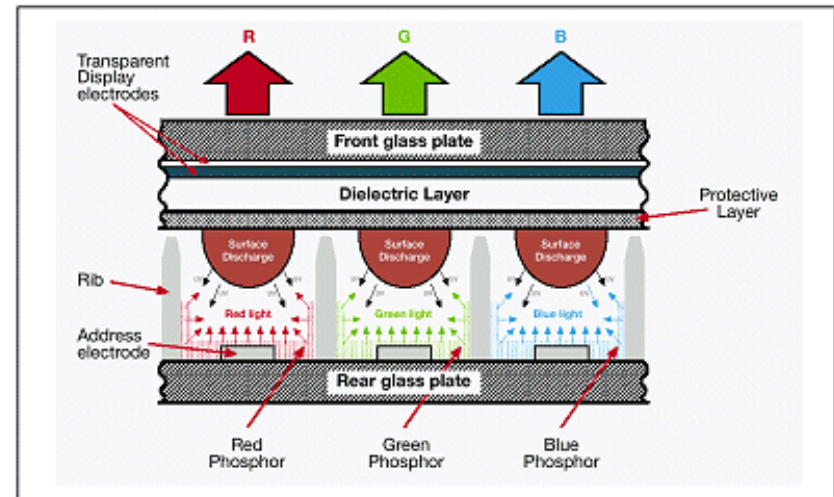
# AMLCD Technology

<b>Status</b>	High Growth Expansion
<b>Capability</b>	Full color video
<b>Infrastructure</b>	Japan, Korea, Taiwan
<b>Mode</b>	Transflective, Backlit
<b>Addressing</b>	Active Matrix
<b>Form Factor</b>	Thick Flat Panel
<b>Power</b>	Low to Moderate
<b>Investment</b>	High
<b>Processes</b>	Same as TN plus: a-Si CVD & AM photolith Color filter fab Large area process Backlight design & controllers
<b>Strengths</b>	Low power reflective Full color video backlit Sharp high pixel count images Moderate thickness & weight
<b>Weaknesses</b>	Constrained viewing angle Affordable pricing



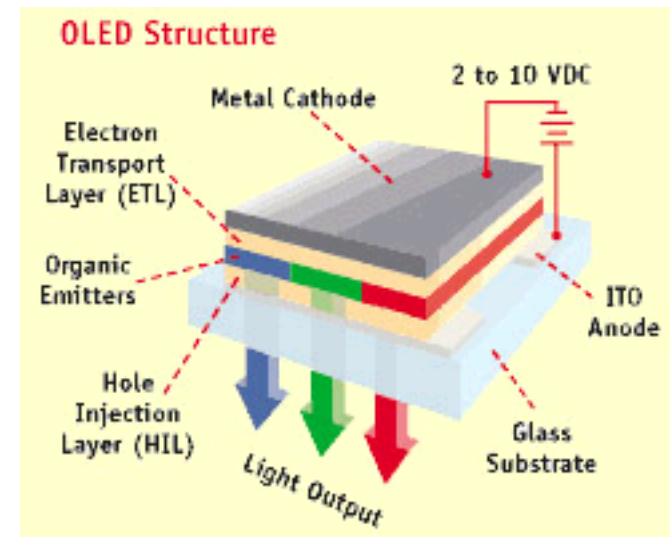
# PDP Technology

<b>Status</b>	Early Production
<b>Capability</b>	Full color video
<b>Infrastructure</b>	Japan, Korea
<b>Mode</b>	Emissive
<b>Addressing</b>	Passive
<b>Form Factor</b>	Thick Flat Panel
<b>Power</b>	High
<b>Investment</b>	High
<b>Processes</b>	Barrier rib formation UV Phosphor printing Gas filling Large area cell fab
<b>Strengths</b>	Bit screen full color video Moderate thickness
<b>Weaknesses</b>	Premium pricing High power High emissions



# OLED Technology

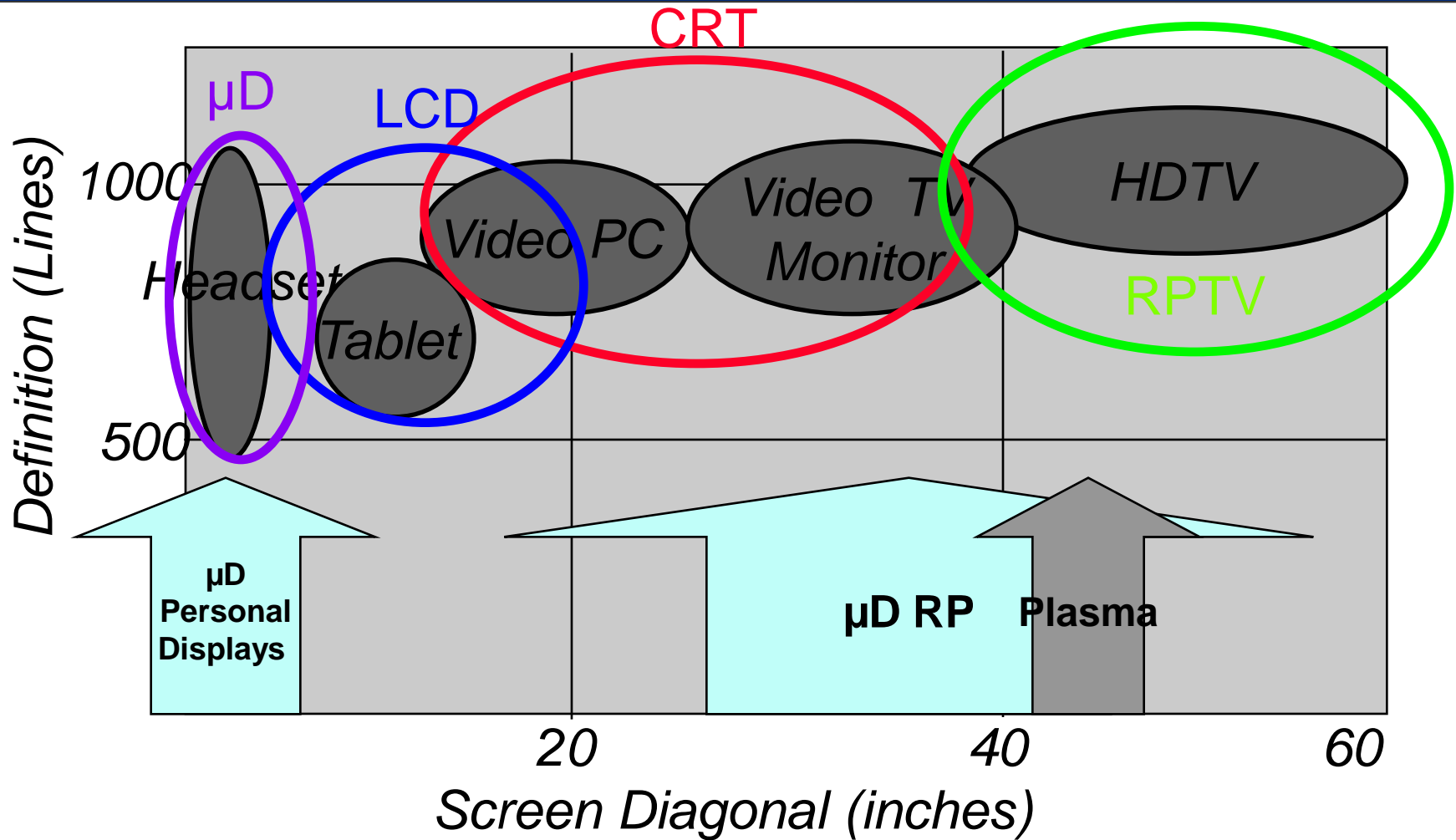
<b>Status</b>	Development
<b>Capability</b>	Full color video
<b>Infrastructure</b>	Japan, Korea, Taiwan, U.S. Europe
<b>Mode</b>	Emissive
<b>Addressing</b>	Active Matrix
<b>Form Factor</b>	Thin Flat Panel
<b>Power</b>	Moderate
<b>Investment</b>	High
<b>Processes</b>	Vacuum deposition Barrier depositions ITO photolith Low temp p-silicon AM Ink jet PLED
<b>Strengths</b>	Thinnest and lightest Moderate power
<b>Weaknesses</b>	PM limited performance AM required for video High power at high brightness Limited product lifetime



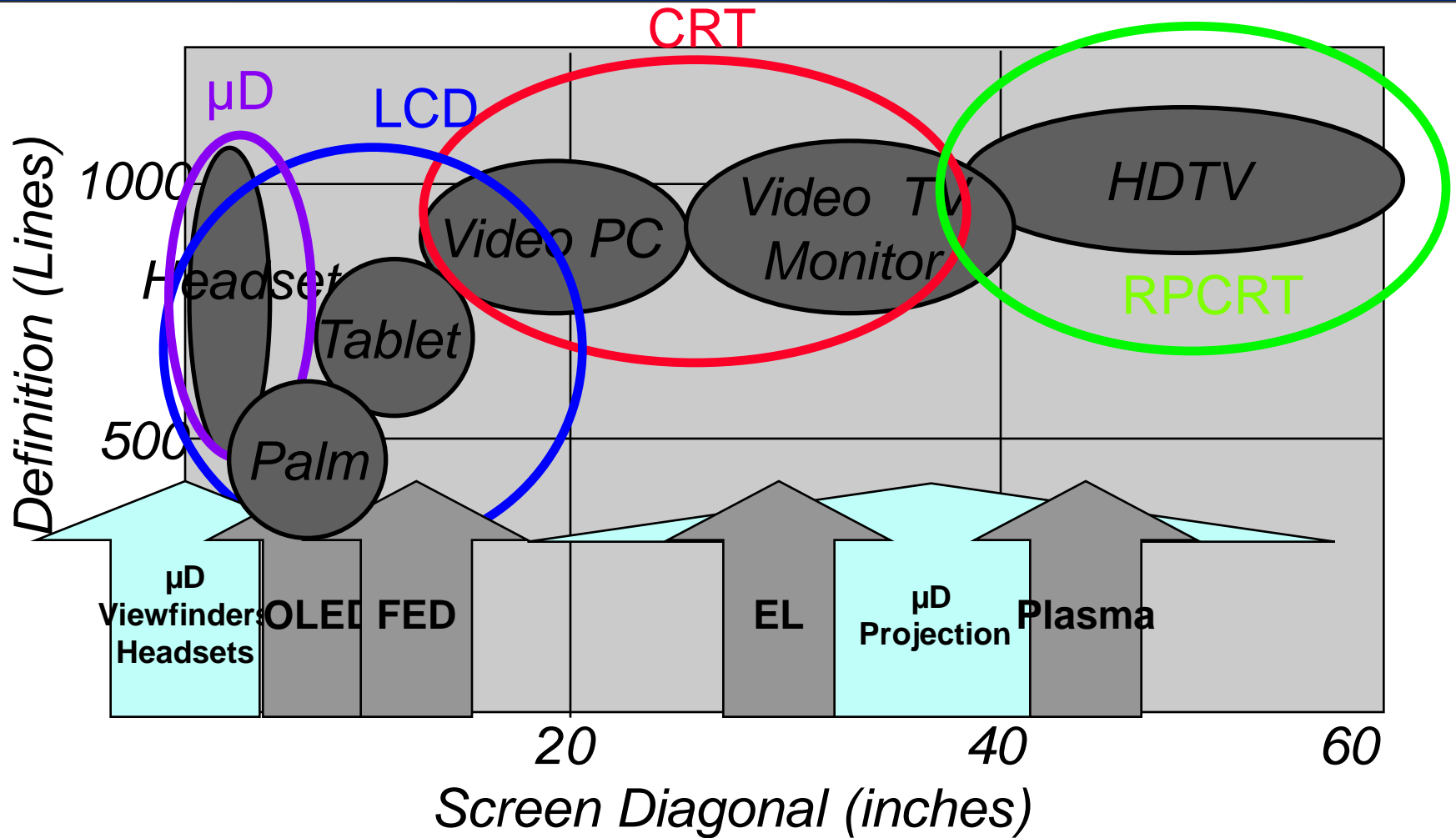
# *Other Display Technologies*

- ePaper Technologies
  - eInk electrophoretic
  - Tyco PDLC, KSU/Philips PSCT, Kent Digital
  - Xerox Gyricon
- Westaim iFire EL PM full color video
- Microdisplays
  - Chip scale AM LC and MEMs devices
  - Projection and near eye applications
  - Sony, Epson, Ti in production; numerous LCOS developers

# Microdisplays and PDP Challenge



# Emerging Emissive Display Wannabes



# *Display Forecast by Technology*

CRT	Cathode Ray Tube
PMLCD	Passive Matrix Liquid Crystal Display
AMLCD	Active Matrix Liquid Crystal Display
PDP	Plasma Display Panel
OLED	Organic Light Emitting Diode
Others	LED, EL, FED, eInk, PDLC, etc.

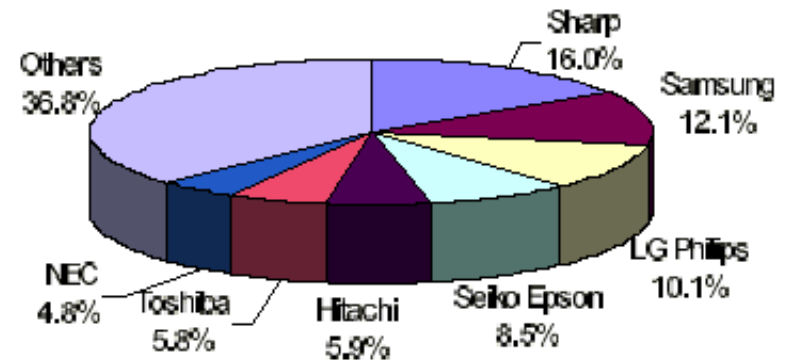
# Major Display Technologies

Display Technology	2000 Display Revenue	2006 Display Revenue	CAGR
LCD	\$21,602	\$46,999	14%
CRT	\$22,242	\$26,078	3%
PDP	\$470	\$5,657	51%
Microdisplays	\$778	\$2,081	18%
OLED	\$99	\$1,175	51%
Other	\$1,044	\$1,534	7%
<b>Total</b>	<b>\$46,235</b>	<b>\$83,523</b>	<b>10%</b>

# LCDs (\$48 B\*)

- Continuous Improvement
  - Improved full color video
  - Highest pixel counts
  - Lowest power
  - Price reductions
- Dominance in portables
  - Laptops, PDA, Notebooks
  - 3G Cellphones and wireless
- Gaining share from CRT
  - Parity in desktop monitors
  - Televisions in every room

2000 Market Share

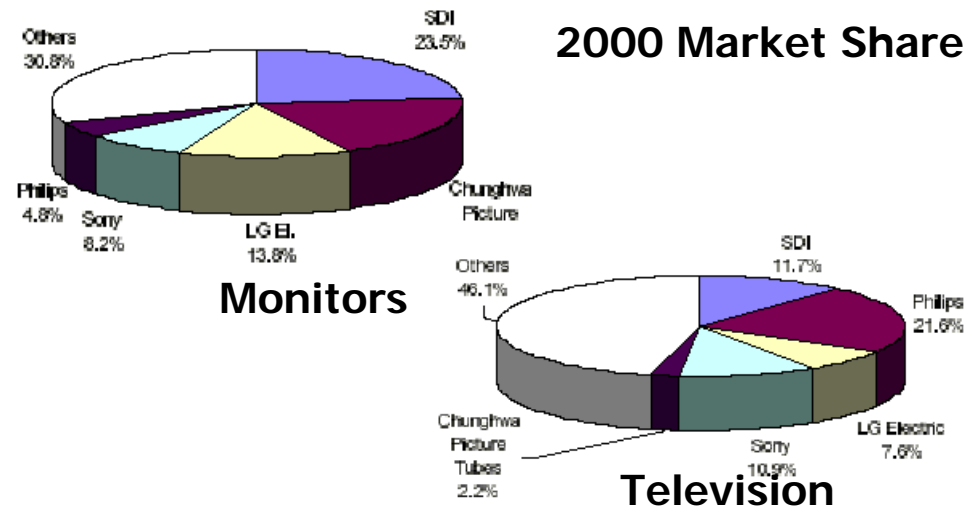


Application	2000 Revenue	2006 Revenue	CAGR
Desktop	4,450	13,530	20%
Notebook PC	8,336	12,405	7%
Cellphones	3,286	6,722	13%
Television	274	3,592	54%
Auto	636	1,660	17%
Other	\$4,619	\$9,091	12%
<b>Total</b>	<b>\$21,602</b>	<b>\$46,999</b>	<b>14%</b>

\* Forecasted 2006 Revenue

# CRT (\$26 B\*)

- Value Leadership
  - Standard for video excellence
  - Lowest prices
  - Very competitive market
  - Flat face enhancement
- Weaknesses
  - Large footprint and form factor
  - High power



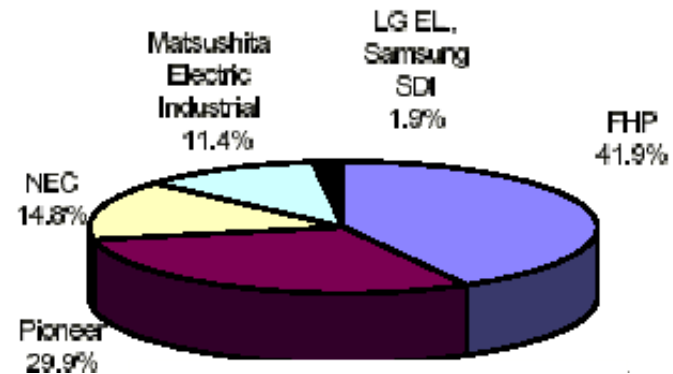
Application	2000 Revenue	2006 Revenue	CAGR
Television	\$14,505	\$17,402	3%
Monitor	\$7,736	\$8,676	2%
Total	\$22,242	\$26,078	3%

\* Forecasted 2006 Revenue

# PDP (\$6 B\*)

- Only big screen flat panel
  - Presentation success
  - Attack home television
  - Focus on Japan and Europe
  - Focus on price down
- Technical Challenges
  - High power, low efficacy
  - Complex architecture
- Cost Down Challenges
  - Glass procurement/processing
  - Depositions
  - High voltage drivers

2000 Market Share

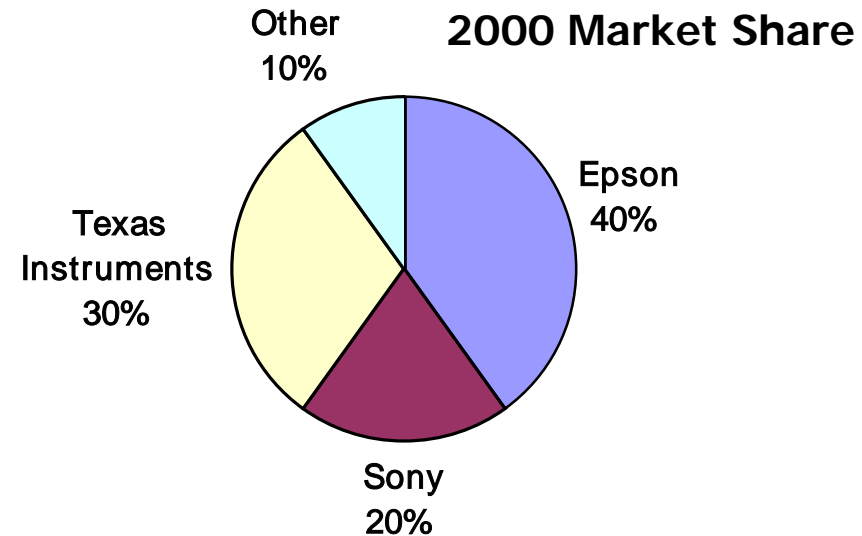


Application	2000 Revenue	2006 Revenue	CAGR
Television	0	\$4,621	n.a.
Presentations	\$470	\$1,036	14%
<b>Total</b>	<b>\$470</b>	<b>\$5,657</b>	<b>51%</b>

\* Forecasted 2006 Revenue

# Microdisplays (\$2 B\*)

- Front Projection Flourishing
  - Unit growth of 3-4X by 2006
  - 2 Kg ultraportables < \$2,000
- Big screen RPTV next target
  - High definition imaging
  - Bright big viewing angles
- Near eye application growth
  - Camcorder viewfinders
  - DSC previewers
  - Wireless headsets



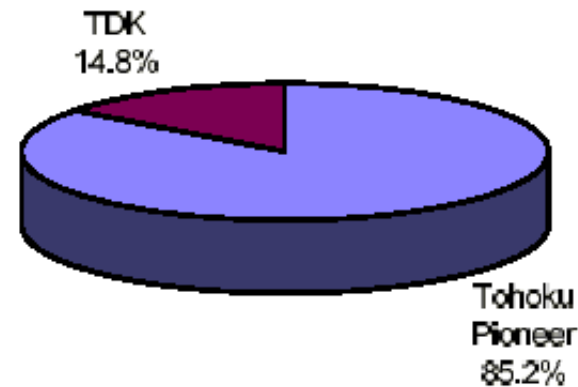
Applications	2000 (M units)	2006 (M units)	CAGR
Presentations	\$547	\$1,224	14%
Television	\$36	\$587	60%
Near Eye	\$195	\$270	6%
<b>Total</b>	<b>\$778</b>	<b>\$2,081</b>	<b>18%</b>

\* Forecasted 2006 Revenue

# OLED (\$1 B\*)

- Great Bright Hope
  - Emissive CRT full color video
  - Simple thin flat panel form
  - Moderate voltage and power
  - First organic semiconductor
- Technical Challenges
  - High brightness/low power
  - Product lifetime
- Cost Down Challenges
  - Requires LTPS AM drive
  - Special fab requirements
  - Hermetic sealing

2000 Market Share



Application	2000 Revenue	2006 Revenue	CAGR
Cellphones	\$14	\$559	84%
Auto Monitor	\$0	\$340	n.a.
Auto Other	\$85	\$275	22%
<b>Total</b>	<b>\$99</b>	<b>\$1,175</b>	<b>51%</b>

\* Forecasted 2006 Revenue

# Other Technologies

- Technologies of fading interest
    - Vacuum Fluorescent (VF) green character displays
      - High brightness, long life, used in auto and consumer electronics
    - Field Emission Displays (FED): great bright hope of the 90s
      - High voltage, vacuum in a flat panel prove an overwhelming challenge
    - Inorganic Electro-Luminescent (EL)
      - Planar (U.S.) and Westaim iFire (Canada) hold onto the vision
  - Electronic Paper Wannabes
    - Polymer Dispersed Liquid Crystal (PDLC)
      - Continues in low volume production (Tyco, NSG, St. Gobain)
    - Encapsulated Electro-phoretic (eInk)
      - Modest prototypes with a long way to go
    - Bistable cholesteric LC systems (PSCT)
      - Marginal reflectivity, difficult drive schemes (Kent, Advanced Display, others)
- Others: Gyricon, Suspended Particle, etc.

# *Materials Suppliers*

# Summary LCD Materials

	2005 TAM	CAGR	Description
Optical Films	\$5,512	9%	Color filters, polarizers, and Films
Lamps and Lighting	\$5,010	18%	Backlights, nightlights, and modules
ICs and Interconnect	\$4,805	14%	Driver ICs, interconnect
Substrates	\$2,933	19%	Glass and thin film coatings
Cell Materials	\$1,839	13%	Gasses photoresist, masks, targets

Source: Fuji Chimera

- Three Categories of materials and films
  - Optical filters and films
  - Glass substrates and coatings
  - LC cell materials and consumables
- Light sources and integrated circuits account for 50% of purchases
  - Driver IC and fluorescent lamp modules are big business

# Cell Materials

	<b>Gasses</b>	<b>Photoresists</b>	<b>Pigments</b>	<b>Liquid Crystals</b>
Application	AMLCDs TFT CVD and cleaning	AMLCD positive spin Color filter resist film	AMLCD Color Filters Dispersed in acrylic and polyimide with solvents	TN 20% STN 35% AMLCD 45%
2005 TAM (\$M)	\$843	\$287	\$253	\$218
2005 Volume		2 M gallons	2.6 Million liters	45 K Kg
1999 Price Range (\$/M2)	\$300/Kg	\$150-\$250/Gal	\$100-\$200/liter	\$1-\$10/gm
CAGR	25%	12%	7%	3%
Typical Materials	Monosilane Nitrogen Trifluoride	Napthoquinone Cresol novolac resin	Antraquinone (R) Thalocyanine halides (G) Phtlalocyanine (B)	Fluorinated LCs
Leading Players	Air Products Central Glass Mitsui Chemicals Denal Silane	Clariant Japan Tokyo Ohka Kogyo Shipley Far East	Fuji Film Olin Toyo Ink (Toppan) Inctec (DNP)	Chisso Merck Dai Nippon Ink

# Optical Film Market Overview

	Color Filters	Polarizers and Retarders	Viewing Angle	Brightness Prism Films
Application	All Color LCDs	All LCDs	Monitors Large Sizes	Monitors Large Sizes
2005 TAM (\$M)	\$1,611	\$1,125	\$306	\$315
2005 Volume	78.5 M units	43 M m2	14 M m2	112 M units
CAGR	10%	6%	15%	5%
1999 Price Range (\$/M2)	\$10	\$15 to \$90 \$40 ASP	\$30	\$80
Typical Sheet Size (mm x mm)	Mother Glass Size	Display Size	Display Size	Display Size
Coatings	Black matrix ITO	AG, AR, HC PSA	PSA	none
Other Features		Compensation Retarder Reflector		
Leading Players	Toppan Printing Dai Nippon Printing Toray	Nitto Denko Sumitomo Sanritz Techno Arizawa Chinese	Fuji Photo Film Sumitomo Chemical Nitto Denko	3M Sumitomo Mitsubishi Rayon Sekisui Chemical

# Other Optical Films

	Touch Panels	Anti-Reflection	Projection Screens
Application	Pen input Handhelds	Camcorders, DSC, televisions, OLEDs	Rear Projection Front Projectin
2005 TAM (\$M)	\$861	\$408	\$544
2005 Volume	n.a.	8.8 M m2	2.5 M units
CAGR	8%	22%	10%
Price Range (\$/device)	\$2.00 to \$50.00/pc	\$3.00 to \$5.00/ft2	\$10.00/ft2
Substrate thickness (mm)	0.1 to 0.2	0.1 to 0.2	Microns
Coatings	Hardcoat, AR, Hydroscopic	Hardcoat, Hydroscopic	Lenticular elements Fresnel lenses
Other Features	Controller and interface	PSA for attaching to CRTs	
Leading Players	Nissha Printing Matsushita Denshi Fujimori Kogyo Microtouch Elo Touch	Toyo Metalizing Southwall Sony	Dai Nippon Printing Kuraray Draper Daylight

# Substrate Market Segments

	Non-Alkaline	Film Deposition	Soda Lime	Plastic
Application	TFT	ITO on STN, TN glass ITO on Color Filters	STN, TN	STN
2005 TAM (\$M)	\$2,130	\$375	\$360	\$4
2005 Volume	24 M m <sup>2</sup>	18.6 M m <sup>2</sup>	17 M m <sup>2</sup>	20 K m <sup>2</sup>
CAGR	24%	6%	10%	nil
Price Range (\$/M <sup>2</sup> )	\$70 to \$120	SiO <sub>2</sub> : \$15 ITO: \$10 to \$60 Cr: \$50	TN: \$15 to \$30 STN: \$30 to \$80	Today: \$150 2005: \$100
Typical Sheet Size (mm x mm)	700 x 900		350 x 350 420 x 530	
Substrate thickness (mm)	0.5 to 1.1		0.4 to 1.1	0.1 to 0.2
Coatings	none	SiO <sub>x</sub> , ITO, Cr	SiO <sub>x</sub> ITO	Barrier ITO
ITO Resistivity (Ω/Sq.)	na		TN: 100 STN: 5 to 50	40
Leading Players	Corning Asahi Nippon Electric	Geomatec Sanyo Vacuum Asahi NSG	Asahi Nippon Sheet Glass Central Glass Nippon Electric Glass Samsung-Corning	Fujimori Kogyo Teijin (PC) Sumitomo (PES) Kanegafuchi (PAR)
Other Players		Applied Films Chinese	Pilkington	3M Southwall Toyo Metalizing Courtalds

# Summary PDP Materials

	2005 TAM	CAGR	Description
<b>Optical Filter</b>	\$921	72%	AR, IR, EMI, coatings on glass or acrylic
<b>ITO target materials</b>	\$338	62%	Sputter coat on ribs and front glass
<b>Glass substrates</b>	\$330	63%	High strain point soda lime
<b>Photomask</b>	\$269	59%	Glass and thin film coatings
<b>Barrier Rib Materials</b>	\$265	60%	Screen printed glass vs. sandblasting
<b>Driver IC</b>	\$179	44%	Special high voltage
<b>Phosphor Paste</b>	\$153	72%	Screen print vs. paste vs. dry film resist

Source: Fuji Chimera

- All materials, specs, and pricing are in flux
  - Higher performance vs. lower prices
  - Alternative high volume manufacturing processes impact materials
  - Makers vie for advantage thru materials and process innovation
  - No standardization of sizes, materials, or processes
- Price down pressures are extreme
  - 5 M sets in 2005 may be a prayer, not a forecast unless prices <\$2,000

# Summary OLED Materials

Hurdles	Description
Small Molecule OLEDs	Extensive Kodak patents
Vacuum depositions	First gen small molecule requires patterned shadow mask depositions
Polymer OLEDs	CDT, Dupont, Philips, Dow pooling patents
Ink jet printing	Major process and cost break thur for PLED
Barrier Layers	Water, oxygen seals for back electrode
Active matrix drive	Low temperature polysilicon is a requirement

- 2006 Forecast vary from \$1 to \$5 Billion
  - PM small molecule technology is in production at Pioneer
  - AM low temp poly silicon is needed for big success in cellphones
  - Epson, Sony, Samsung and Sanyo are the key developers
- Key hurdles remain high brightness at low power and lifetime
  - Overcoming materials and process hurdles are critical
  - Then huge investments required to assure capacity

# *Display Industry Players*

Japanese Pioneers	Losing share to Koreans and Chinese
Korean	Samsung and LG lead large AMLCD
Chinese	Starting up 3rd wave of capacity
Western Innovators	LCOS microdisplays, OLED materials IP
Materials and Equipment Majors	Concentrated in Japan, plus 3M, Corning

# Regional Patterns

- Japan
  - Have pioneered mass production of all commercially successful display technologies and has the deepest display infrastructure
  - Investment in AMLCD has lagged and Japan is falling behind
- Korea
  - Huge financial and business investment in high volume dominance
  - Samsung and LG dominate the desktop and laptop markets
- Chinese
  - Taiwanese dominate the latest round of AMLCD investment
  - Current focus on backward integration for the laptop business
- West
  - Recent success of Texas Instruments in microdisplays
  - Kodak, Philips, CDT, and Dupont make major commitment to OLEDs

# Major Japanese Display Makers

Company		2001 Revenue (\$ Million)	Trend	Partners
Sharp	Extensive LCD product portfolio	\$3,729	Level	Quanta
Seiko Epson	Leader in small LCDs	\$2,034	Up	
Toshiba	AMLCD, leader in LTPS	\$1,864	Up	Hann Star
Hitachi	AMLCD, PDP with Fujitsu	\$1,441	Level	
Matsushita	All LCD products plus PDP	\$1,159	Level	
NEC	Large AMLCD, PDP, OLED with Samsung	\$1,037	Level	
Sanyo	AMLCD plus LTPS leader	\$911	Up	Top Poly
Optrex	Passive LCD only; cellphone player	\$678	Up	Asahi
Casio	Small LCD focus	\$610	Up	
Sony	Very weak flat panel position	\$508	Up	
Fujitsu	AMLCD plus PDP leadership	\$424	Level	
Mitsubishi	AMLCD only, fading	\$410	Down	CPT
Pioneer	PDP player plus OLED leadership	\$236	Up	
FHP	Fujitsu- Hitachi JV leads in PDP	\$159	Up	

# Major Korean Display Makers

Company		2001 Revenue (\$ Million)	Trend	Partners
Samsung Electronics	Leading high volume AMLCD producer	\$3,803	Up	
Samsung Display	Leader in small PMLCD plus PDP	\$627	Up	
Samsung NEC	OLED developer	nil	Start Up	NEC
LG Philips	Large AMLCD volume leader	\$2,603	Up	Philips
LG Electric	PDP plus OLED	nil	Up	
Hyundai	Struggling to survive	\$175	Down	

# Major Chinese Display Makers

Company		2001 Revenue (\$ Million)	Trend	Partners
CPT	Laptop and monitor AMLCD	\$707	Start Up	Mitsubishi, Sharp
AU Acer/Unipac	Laptop and monitor AMLCD	\$1,068	Start Up	
Chi Mei	Laptop and monitor AMLCD	\$576	Start Up	IBM
Hann Star	Laptop and monitor AMLCD	\$254	Start Up	Toshiba
Prime View	Laptop and monitor AMLCD	\$81	Start Up	
Quanta	Laptop and monitor AMLCD	nil	Start Up	Sharp
Top Poly	LTPS	nil	Start Up	Sanyo
Ritek	OLED	nil	Start Up	Dupont

# Major Western Display Makers

Company		2001 Revenue (\$ Million)	Trend	Partners
Three five	Supplier PMLCD to Moto for cellphones	\$120	Level	
Planar	Last EL Player;	\$80	Down	
Kopin	Microdisplay LCOS viewfinder	\$30	UP	UMC
Displaytech	Microdisplay LCOS viewfinder	\$20	Up	Citizen
Zight	Microdisplay LCOS headsets	nil	Start Up	
Kodak	Leader in OLED IP' Licensing	nil	License	Sanyo
Dupont	Building OLED Partnerships	nil	Up	Ritek, CDT
Philips	PMLCD cellphone modules for Nokia	\$72	Level	LG
CDT	Polymer OLED IP leader; Licensing	nil	License	Dupont, Epson

# The Major Players

	CRT	Small LCD	AMLCD	Plasma	Micro-Display
Sony	●			○	●
Panasonic	●		●	●	
Philips/LG	●	●	●	○	○
Sharp	●	●	●	○	○
NEC	●		●	●	
Hitachi	●	●	●	●	
Samsung	●	●	●	○	○
Toshiba			●		
Mitsubishi	●	●	●		
Sanyo	●		●		
Casio		●			
Epson		●	●		●
Chungwa	●		○		
Fujitsu			●	●	
TI					●

Leading Manufacturer	●
Second Tier	●
Developer	○