

Touch Screen Market Update

FlexTech Alliance Workshop:

How Do We Get From Today's Flexible Electronics Technology
to Tomorrow's High Performance Sensors?

San Jose, November 10, 2010

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Senior Vice President
DisplaySearch

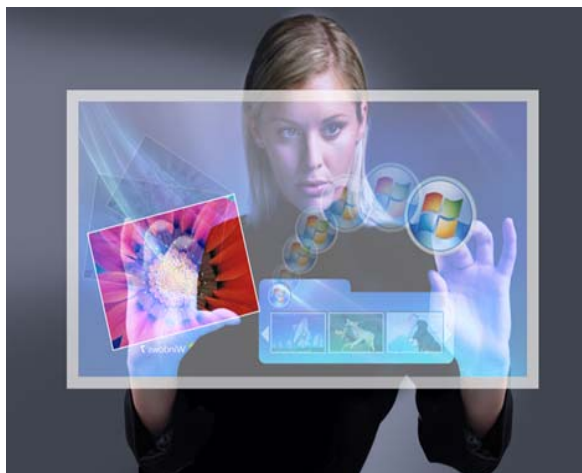


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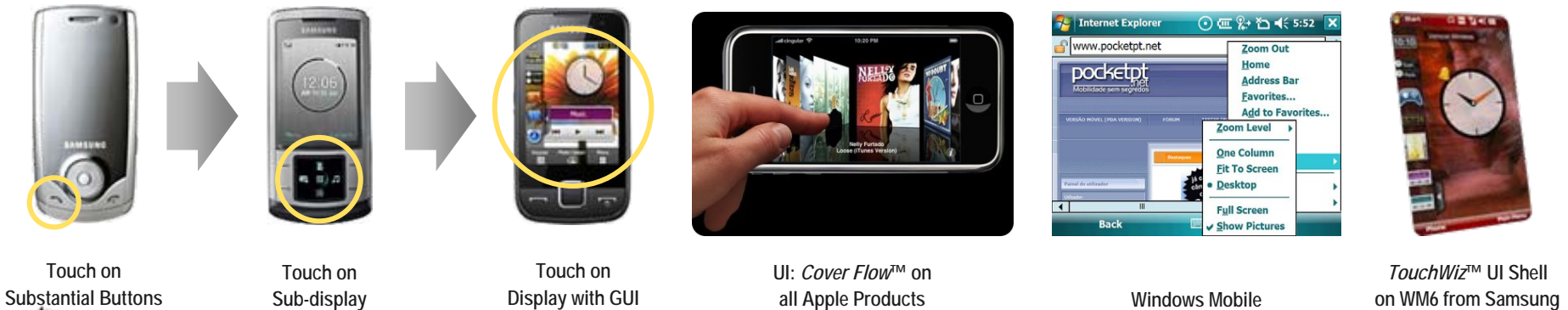
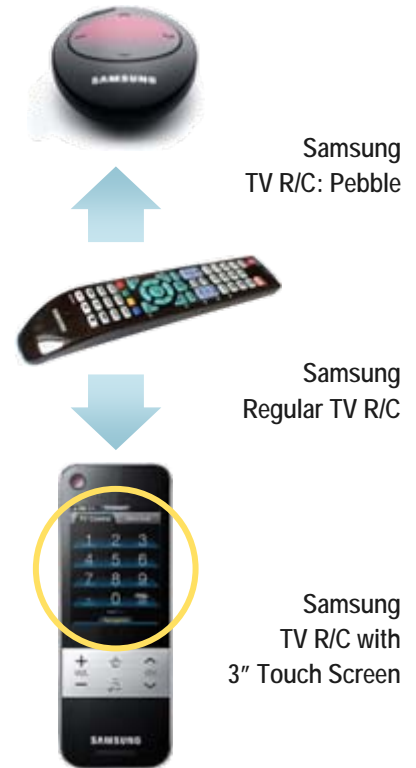
Touch Panel Market Drivers

- Easy and intuitive to use
- Availability of new user interfaces with touch technology, particularly multi-touch
- Reduction of labor cost through customer self-service
- Attempts to create a competitive advantage
- Lower costs for related components and materials
- Easier cleaning and maintenance
- Improved flexibility for customization and upgrades
- Innovative touch panel technology, materials, and adjunct technologies
- Software and hardware improvements promote touch, such as Windows 7 with multi-touch included



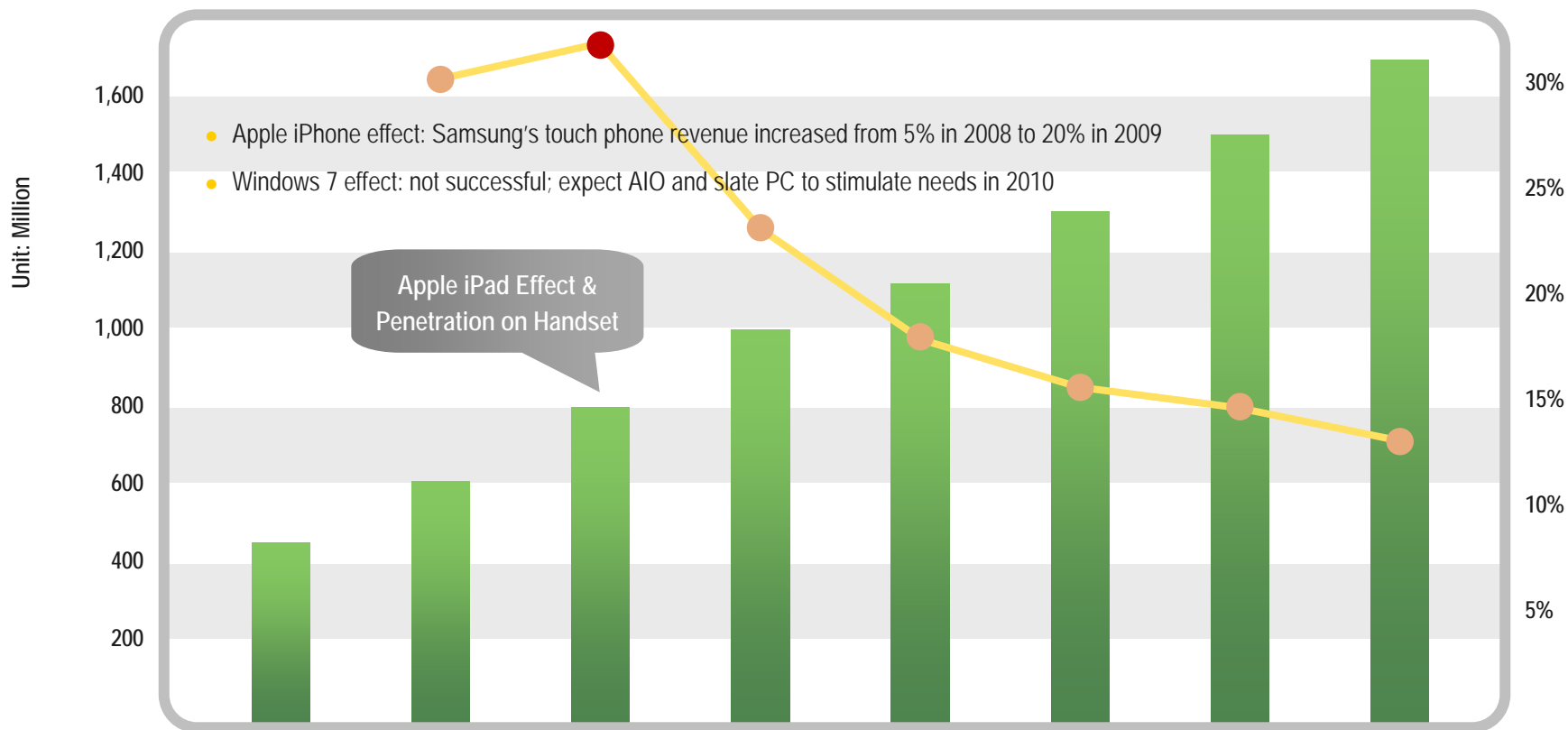
Why is Touch Everywhere?

- Touch advantages for user interfaces
 - Display can be an input device and combine with graphical user interface delivered
 - Real-time interaction for users
 - Offers users the ability to use finger or stylus to interact with devices instead of pointing devices or keyboards
 - Reduces buttons and menus, making user interface simpler
- Not just for the main display
 - To solve the complexity of remote controls, Samsung developed the *Pebble*. It now has a touch-enabled remote control for its C9 series.



Touch Module Shipment Forecast

- Suppliers' high expectations for growth in IT applications have not been realized.
 - Many suppliers entered the market in 2010, expecting strong growth in PCs. However, most of the growth has been in mobile phone and CE. The iPad is a crossover product between IT and CE

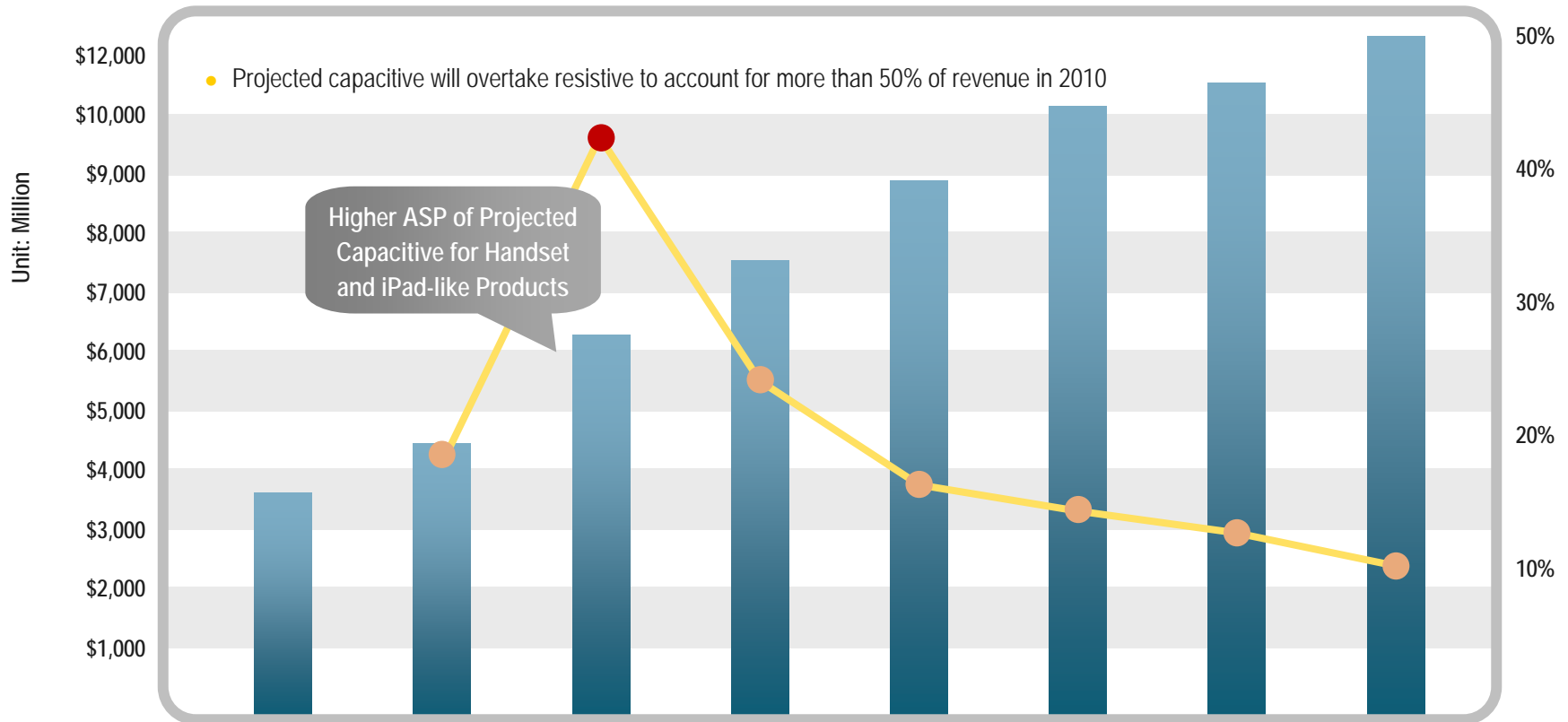


| Unit: Mn | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|-----------|------|-------|-------|-------|-------|-------|-------|-------|
| Shipment | 468 | 607 | 800 | 987 | 1,161 | 1,341 | 1,538 | 1,735 |
| YY Growth | | 29.6% | 31.8% | 23.3% | 17.6% | 15.6% | 14.7% | 12.8% |

SOURCE: DisplaySearch 2010 Touch Panel Market Analysis Report

Touch Module Revenue Forecast

- New technologies for mid- to large-size applications
 - Projected capacitive for mobile phones and iPad-like products is driving revenues in 2010. Optical imaging with higher ASPs can contribute to revenue; however, volume is not high yet.

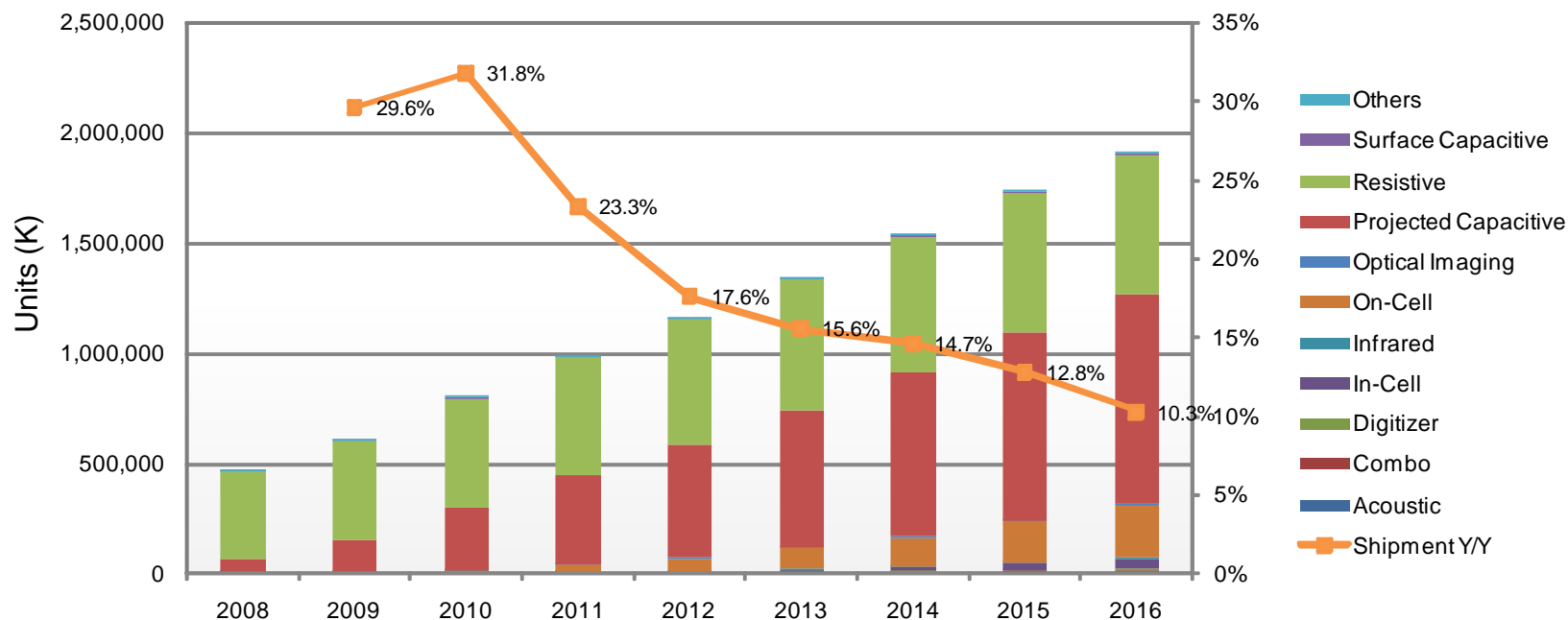


| Unit: Million | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---------------|---------|---------|---------|---------|---------|----------|----------|----------|
| Revenue | \$3,642 | \$4,332 | \$6,177 | \$7,646 | \$8,900 | \$10,146 | \$11,331 | \$12,432 |
| YY Growth | | 19% | 42.6% | 23.8% | 16.4% | 14.0% | 11.7% | 9.7% |

SOURCE: DisplaySearch 2010 Touch Panel Market Analysis Report

Touch Panel Shipment Forecast by Technology

- Projected capacitive is growing rapidly, as it is designed into new mobile phones/slate PCs.
- Resistive is losing momentum in mobile phones.
- On-cell reached good yield rates (70-80%) at the end of 2009. Its growth will be much stronger in 2H'10.
- In-cell will take off in 2011.
- Optical imaging has been generally used for all-in-one PCs (61%) and education/training (25%); but Apple has not adopted touch in iMacs yet.
- Combo had good growth in 2009, since it was adopted in notebook PCs. However, it will face competition from projected capacitive in 2010 and beyond.



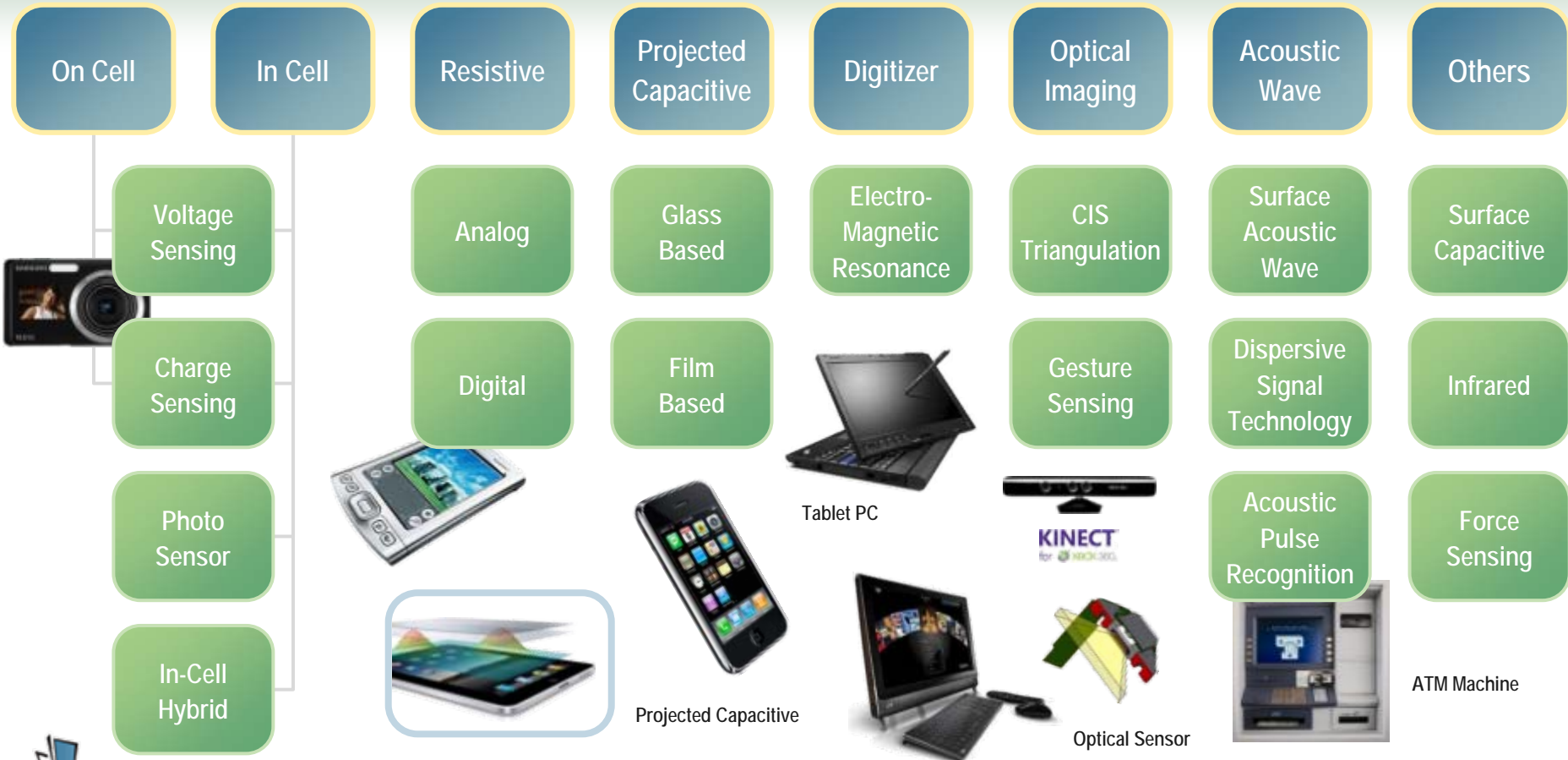
SOURCE: DisplaySearch 2010 Touch Panel Market Analysis Report

Touch Technologies

- Many technologies have been developed, but few of them are in high-volume applications.
- Vertical applications have high margins, but CE and IT have volume, driving cost, and capacity
- Resistive and projected capacitive are ready for growing IT and CE markets

For CE & IT Applications: Hand-held, Portable & Desktop

For Vertical Applications



SOURCE: DisplaySearch 2010 Touch Panel Market Analysis Report, Next Window, Apple

Technology: 2009 Touch Market Review

- Resistive and projected capacitive are mature technologies.
 - Benefiting from mobile phone and iPad, projected capacitive grew from 12.5% to 23.9% share.
 - Optical imaging has advantages for 20" +, such as AIO, where projected capacitive has a low yield.

| Technology | Shipment % |
|----------------------|------------|
| Acoustic | 0.3% |
| Combo | 0.2% |
| Digitizer | 0.1% |
| In-Cell | 0.0% |
| Infrared | 0.1% |
| On-Cell | 0.5% |
| Optical Imaging | 0.2% |
| Projected Capacitive | 23.9% |
| Resistive | 74.4% |
| Surface Capacitive | 0.4% |
| Others | 0.0% |

CE Contributing More Shipments

Vertical Apps Contributing More Revenues

| Technology | Revenue % |
|----------------------|-----------|
| Acoustic | 3.4% |
| Combo | 1.7% |
| Digitizer | 1.1% |
| In-Cell | 0.0% |
| Infrared | 1.5% |
| On-Cell | 0.6% |
| Optical Imaging | 3.1% |
| Projected Capacitive | 35.4% |
| Resistive | 48.1% |
| Surface Capacitive | 5.0% |

| Resistive | Shipment % |
|----------------------|------------|
| Mobile Phone | 56.9% |
| PND | 11.9% |
| Game-Portable | 6.4% |
| Factory / Industry | 3.4% |
| PMP / MP3 Player | 2.8% |
| Digital Still Camera | 2.4% |
| Automobile Monitor | 2.0% |
| Printer / Office | 1.3% |

| Projected Capacitive | Shipment % |
|----------------------|------------|
| Mobile Phone | 81.8% |
| PMP / MP3 Player | 16.4% |
| PND | 0.7% |
| NB / Slate PC | 0.5% |
| Digital Still Camera | 0.3% |

| Optical Imaging | Shipment % |
|----------------------|------------|
| All-in-one PC | 60.7% |
| Education / Training | 24.6% |
| Desktop Monitor | 8.4% |

Technology: Touch Market Forecast

- Resistive technology is still strong, but projected capacitive is gaining.
 - Projected capacitive is growing fast, moving to medium sizes. Revenue is growing faster than shipments, and projected capacitive will overtake resistive, accounting for half of the marketing revenues.
 - Resistive is being replaced by projected capacitive for 3" + mobile phone applications.
 - Panel makers (AUO and SMD) are shipping on-cell touch for mobile phone and DSC displays.

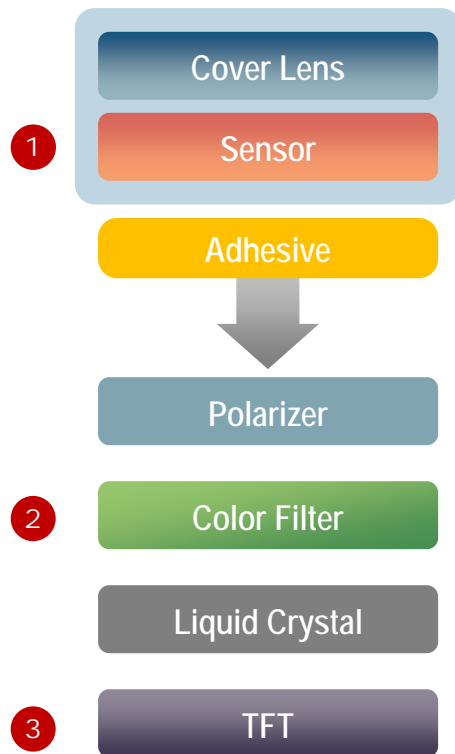
| Technology | Shipment | | | | Revenue | | | |
|----------------------|----------|-------|----------|----------|---------|-------|----------|----------|
| | 2010 | 2011 | 2010 Y/Y | 2011 Y/Y | 2010 | 2011 | 2010 Y/Y | 2011 Y/Y |
| Acoustic | 0.3% | 0.3% | 13.9% | 13.2% | 2.7% | 2.3% | 10.2% | 5.2% |
| Combo | 0.2% | 0.2% | 51.2% | 49.1% | 1.7% | 2.0% | 42.9% | 43.4% |
| Digitizer | 0.1% | 0.1% | 49.9% | 66.3% | 1.0% | 1.2% | 31.4% | 41.5% |
| In-Cell | 0% | 0.1% | 175% | 1,989% | 0% | 0.4% | 465% | 1,323% |
| Infrared | 0.1% | 0.1% | 15.9% | 15.5% | 1.1% | 0.9% | 5.0% | 1.1% |
| On-Cell | 1.0% | 3.5% | 166% | 336% | 1.3% | 5.0% | 216% | 383% |
| Optical Imaging | 0.2% | 0.2% | 30.7% | 49.4% | 2.5% | 2.7% | 15.9% | 32.3% |
| Projected Capacitive | 36.3% | 41.0% | 100% | 39.3% | 51.2% | 53.7% | 106% | 29.9% |
| Resistive | 61.5% | 54.1% | 9.0% | 8.6% | 34.4% | 28.1% | 1.8% | 1.4% |
| Surface Capacitive | 0.4% | 0.3% | 25.4% | 9.3% | 4.1% | 3.5% | 15.8% | 6.6% |
| Others | 0% | 0.1% | 193% | 815% | 0% | 0.1% | 54.2% | 512% |

SOURCE: DisplaySearch 2010 Touch Panel Market Analysis Report

In-Cell & On-Cell Touch by Panel Makers

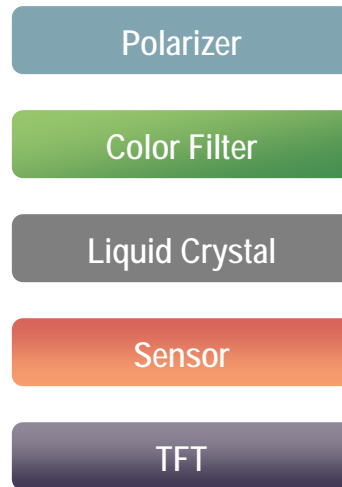
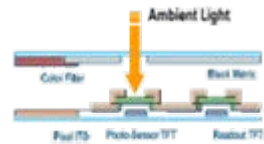
- In-cell solution is becoming more mature and further available in 2010.
- The major in-cell technologies are photo, charge, and voltage, in order of priority.
- Panel makers' in-cell solutions have advantages: transmissivity and lower material cost.
 - Will this change the value chain and influence module makers in the future?
- SMD and AUO are both aggressively providing in-cell and on-cell solutions.

Conventional 3 Glass Solution

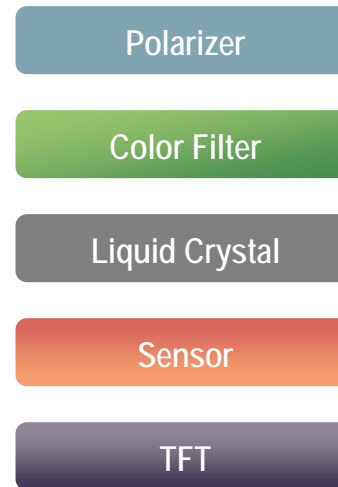
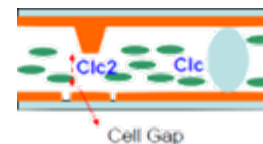


AUO LCD Panel-built-in Solutions

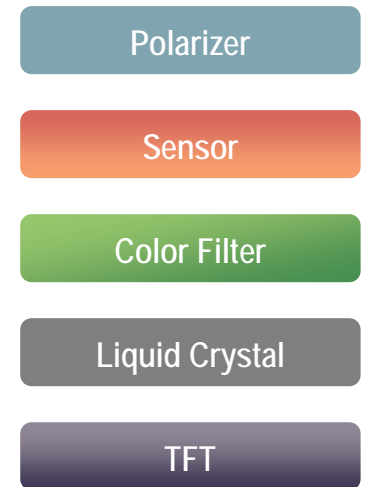
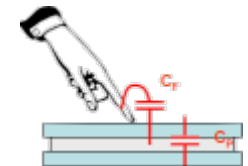
In-Cell: Photo Sensing



In-Cell: Voltage Sensing



On-Cell: Charge Sensing



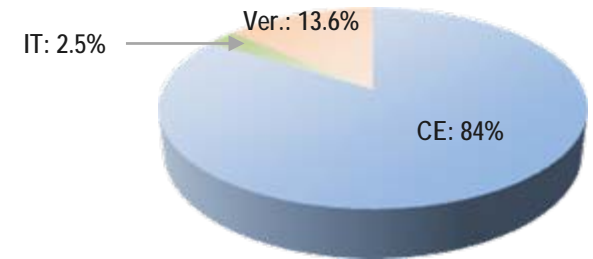
SOURCE: AUO

Application: 2009 Touch Market Review

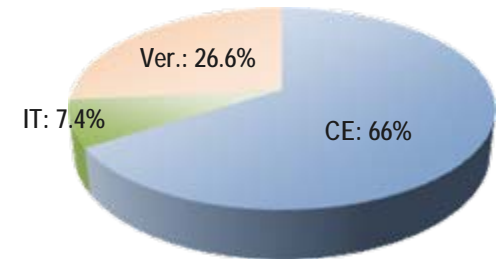
- CE is driving shipment volume, but vertical markets contribute revenue.
 - IT/CE and vertical have different results for shipment and revenue. Business models differ too.
 - Slate PCs (categorized in "IT") are newer developments, and OS and eco-system are uncertain.

| | Application | Shipment % | Revenue % |
|----------|--|------------|-----------|
| CE | Digital Still Camera / Camcorder | 2.0% | 0.9% |
| | Game-portable | 4.7% | 2.5% |
| | Mobile Phone | 62.0% | 48.2% |
| | PMP / MP3 Player | 6.1% | 7.1% |
| | Portable Navigation Device | 9.2% | 7.3% |
| IT | All-in-one PC | 0.1% | 1.4% |
| | Desktop Monitor | 0.1% | 0.4% |
| | Mini-Note / Slate PC / MID: ARM, Atom™ | 0.2% | 0.5% |
| | Notebook / Slate PC: Windows 7 | 0.7% | 4.1% |
| | PDA | 0.4% | 0.2% |
| Vertical | Printer / Office | 1.0% | 0.7% |
| | ATM / Financial | 0.1% | 1.3% |
| | Automobile Monitor | 1.5% | 1.6% |
| | Education / Training | 0.1% | 2.4% |
| | Factory / Industry Automation | 2.5% | 3.8% |
| | Game-casino | 0.1% | 2.1% |
| | Medical | 0.7% | 1.6% |
| | Point of Information (POI) & self-check in | 0.7% | 4.6% |
| | Retail and POS / ECR | 1.2% | 4.1% |
| | Ticketing | 0.0% | 0.5% |
| Other | 6.5% | 4.7% | |

Shipment %



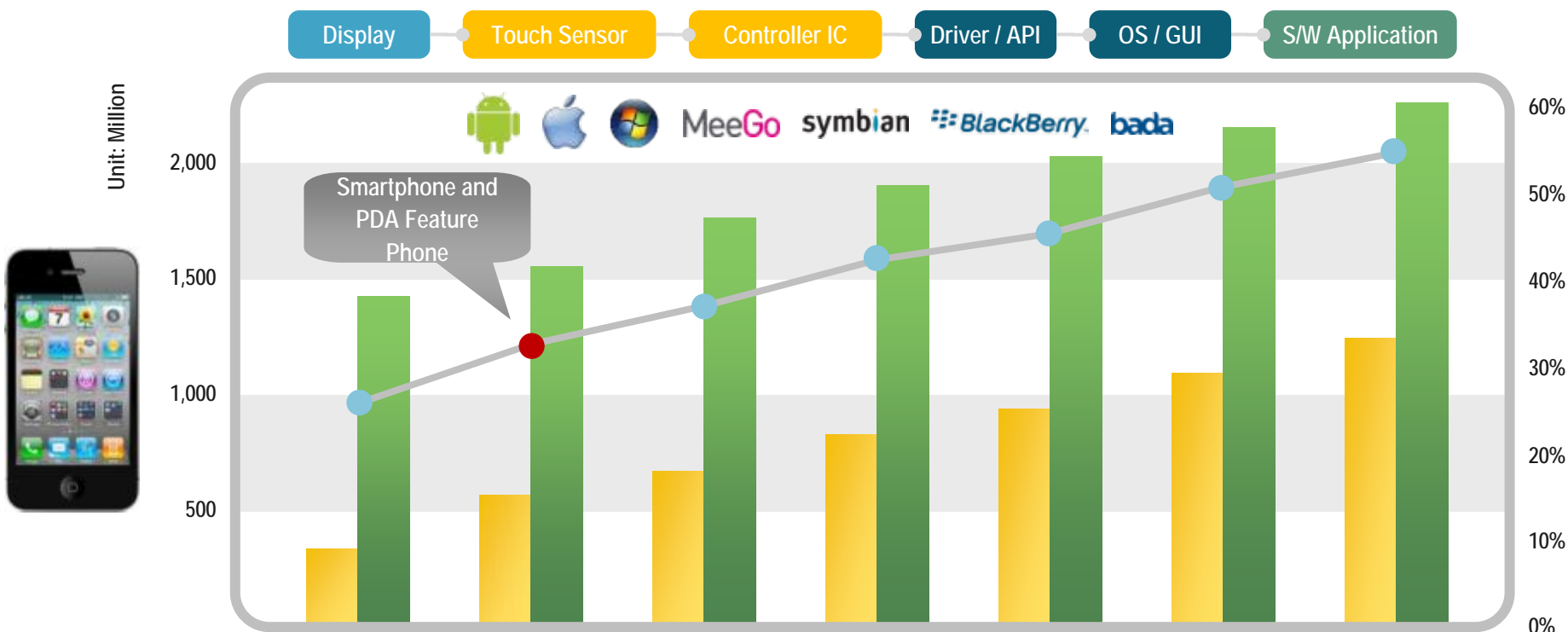
Revenue %



| Application | Shipment % | Revenue % |
|-------------|------------|-----------|
| CE | 84% | 66% |
| IT | 2.5% | 7.4% |
| Vertical | 13.6% | 26.6% |

Touch Market Forecast: Mobile Phone

- Mobile phones are the key volume driver for touch growth.
 - Mainstream OS will optimize their graphical user interface and support higher display resolutions for touch input. Smart phone trend proves usage is far beyond original purpose of making calls.



| Unit: Million | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|----------------------|-------|-------|-------|-------|-------|-------|-------|
| Touch Module | 377 | 531 | 679 | 816 | 965 | 1,128 | 1,283 |
| Mobile Phone Display | 1,464 | 1,588 | 1,777 | 1,936 | 2,081 | 2,240 | 2,392 |
| Touch Penetration | 25.7% | 33.4% | 38.2% | 42.1% | 46.4% | 50.4% | 53.6% |
| Touch Growth YY | 69.7% | 41% | 27.8% | 20.2% | 18.3% | 16.9% | 13.8% |

Tactile Feedback

- Accuracy is improving user experience.
- Suppliers include Immersion, Nissha, NXT, Senseg, and more.
 - Immersion has over 700 issued and pending patents on tactile technologies.
 - Technology called 'force-feedback' uses a mechanical motor to make vibration/movement.
 - Senseg has developed tactile technology without mechanical motors.
 - A biophysical electro-sensory field effect, called E-Sense™, was developed in 2007.
 - Toshiba had demo with Senseg. First products are expected to be introduced to the market soon.

- Several products are using haptic feedback technology:



LG Dare (VX-9700)



LG Incite



LG Viewty (KU-900)



Samsung
OMNIA



Samsung
Haptic



Samsung
Soul



Samsung
SCH-n330



Samsung
P3



Ishii Hyoki (SMK)
GOP-4000

Touch Market Forecast: Other CE Applications

- Usage modes determine the need for touch.
 - Apple iPod touch and iPhone are cannibalizing the market of other competitors and portable games.
 - PND products need touch for usage (in the car), but are threatened by smart phone navigation.
 - Nintendo DS adopts touch in portable gaming, but Sony PSP does not.
 - Touch is a “nice to have” feature for digital cameras. Penetration is lower.



Game Portable



Portable Media Player



Digital Still Camera



Personal Navigator Device

| Unit: Million | 2009 | 2010 | 2011 |
|------------------|------|------|------|
| PMP & MP3 Player | 51 | 48 | 47 |
| Touch Module | 37 | 39 | 45 |
| Penetration | 71 % | 82% | 94% |
| PND | 68 | 67 | 69 |
| Touch Module | 55 | 56 | 53 |
| Penetration | 80% | 84% | 77% |

| Unit: Million | 2009 | 2010 | 2011 |
|-----------------|------|------|------|
| Game Portable | 73 | 74 | 87 |
| Touch Module | 29 | 32 | 367 |
| Penetration | 40% | 44% | 42% |
| DSC & Camcorder | 167 | 193 | 200 |
| Touch Module | 12 | 17 | 31 |
| Penetration | 7% | 9% | 16% |

Touch Market Forecast: IT Applications

- Windows 7 disappointed industry expectations for touch.
 - Is touch better than using a keyboard and mouse for productivity on Windows GUI?
 - Most Notebooks and Netbooks adopted multi-touch track pad instead of a touch screen.
 - Slate PCs definitely need touch, but who can succeed in the future except Apple?
 - What is needed to improve IT applications (GUI, applications, ergonomic issues)?



Regular NB

Tablet PC

Slate PC

LCD Monitor

All-in-one PC

SOURCE: patentlyapple.com

| Unit: Million | 2009 | 2010 | 2011 |
|--------------------|------|------|------|
| Netbook / Slate PC | 45 | 57 | 67 |
| Touch Module | 1.4 | 13 | 19 |
| Penetration | 3% | 23% | 28% |
| Regular Notebook | 129 | 160 | 69 |
| Touch Module | 4 | 6 | 8 |
| Penetration | 3% | 4% | 4% |

| Unit: Million | 2009 | 2010 | 2011 |
|---------------|------|------|------|
| All-in-one PC | 6 | 7 | 8 |
| Touch Module | 0.9 | 1.6 | 2.1 |
| Penetration | 15% | 23% | 25% |
| LCD Monitor | 163 | 171 | 181 |
| Touch Module | 0.6 | 1.0 | 1.2 |
| Penetration | 0.3% | 0.6% | 0.7% |

Future Influential Factors: Scenarios for Devices

- Different devices require different input methods and performance tradeoffs.

| Technology | Mobile | PND | MID / Slate PC | eBook | Notebook | AIO / DT PC | TV Display | Public Display |
|---------------------------|--|--|--|---|---|---|---|--|
| Distance with Device | Very Near | Near | Very Near | Very Near | Near | Near | Far | Near or Far |
| Purpose of Use | Social, Multimedia | Navigation | Web Surfing, Messaging | Reading, Notebook | Computing, Web Surfing | Computing, Web Surfing | Entertainment, Information | Advertising, Interaction |
| Frequency of Input | Very Often | Not Often | Intensive | Not Often | Intensive | Intensive | Not Often | None or Intensive |
| Major Input Method | Finger Stylus Pen | Finger | Finger Stylus Pen | Finger Stylus Pen | Mouse, Keyboard | Mouse, Keyboard | Remote Controller | Finger, Motion |
| Supportive Actions | Touch, Gesture | Touch, Gesture | Touch, Gesture | Touch, Gesture | Touch, Gesture | Touch, Gesture | Button Clicking | Touch, Motion |
| Sensor Location | Touch Panel, MEMS | Touch Panel | Touch Panel | Touch Panel | Touch Pad, Touch Panel | Touch Panel Tablet Pad | IR on R/C | Touch Panel CIS Cam |
| Single Touch or Multiple? | Can Be Both | Single | Can Be Both | Can Be Both | Can Be Both | Can Be Both | Single | Can Be Both |
| Single User or Multiple? | Single | Single | Single | Single | Single | Single | Single | Can Be Both |
| Remark | Touch and MEMS will be critical input methods. | Touch is very suitable for use in the context. | Touch is the best input for the design w/o keyboard. | Touch is a good option for writing feature. | touch pad is much more ergonomic for computing. | For education or media center, touch is useful. | Touch panel or pad can be designed onto the controller. | Touch and CIS cam will bring versatile applications. |



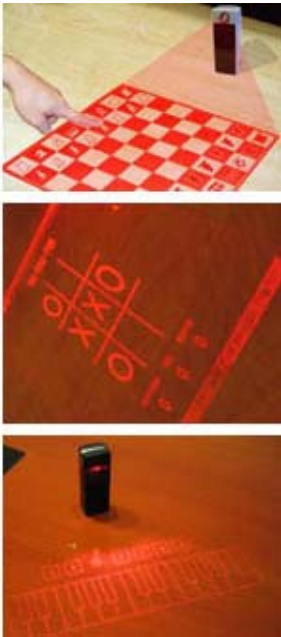
- Apple carefully solves multi-touch issues using a touch pad that even integrates mouse buttons.

- Does it make sense to provide touch on a monitor? As the hand moves along the Z-axis, it can become fatigued from intensive use.

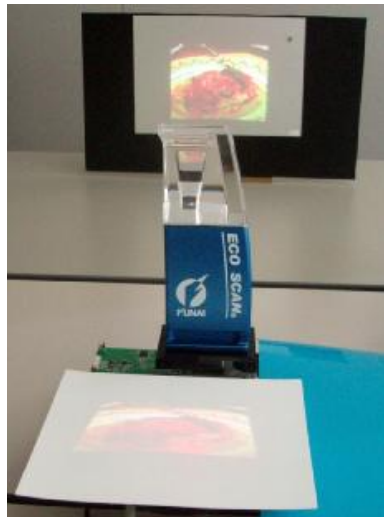


Emerging Applications: Pocket Projectors, E-Books with Touch

- At CES 2010, Light Blue Optics (LBO) announced Light Touch, an interactive projector that turns any flat surface into a 10" touch screen.
- Lumio has been selling projected touch keyboards since 2005.
- Funai Electric Co Ltd and Nippon Signal Co Ltd demonstrated pocket projectors with touch in 2009.
- Opportunities: optical imaging, low power, high transmissivity, software, controller IC.



Source: Lumio



Source: Funai and Nippon Signal



Source: Light Blue Optics



Source: Sony

Microsoft Kinect – Expanding Interactivity



Motion Sensor



Skeletal Tracking



Facial Recognition



Voice Recognition

Summary

- Technology
 - Resistive is still a cost-effective solution for 2.x" mobile phones.
 - Projected capacitive is mainstream and has been adopted in small to medium sizes.
 - Glass-based projected capacitive also driving changes in the value chain.
 - Optical imaging is limited for all-in-one PCs, which have no limited volume.
- Applications
 - Touch penetration in mobile phones will be more than 30% and growing.
 - Slate PCs depend on OS and applications to grow. This could be another big segment.
- Value Chain
 - Many suppliers from different industries are moving into projected capacitive.
 - Vertical integration and module production capacity expansion are key strategies.
 - Opportunities from handset name brands are still concentrated on tier-one touch module makers.
 - Others can still pursue second-tier customers.
 - What will happen to the future value chain for 2-in-1 glass and in/on cells?
- Complexity
 - Application demands will sustain several technologies.
 - New technologies can create new applications.

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