The Image Sensor Market

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# Image Sensor History

<table>
<thead>
<tr>
<th>Years</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before ~1960</td>
<td>Film photography and vacuum tubes</td>
</tr>
<tr>
<td>1960-1975</td>
<td>Early CCD and CMOS R&amp;D</td>
</tr>
<tr>
<td>1975-1990</td>
<td>CCD Commercialization</td>
</tr>
<tr>
<td>After 1990</td>
<td>CMOS re-emergence, amorphous Si</td>
</tr>
</tbody>
</table>
## Segmentation and Differentiation

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>CCD, CMOS, Hybrid, CID</td>
</tr>
<tr>
<td>Wavelength</td>
<td>Visible, IR, X-ray</td>
</tr>
<tr>
<td>Substrate</td>
<td>Si, InP</td>
</tr>
<tr>
<td>Array type</td>
<td>Linear, 2-D</td>
</tr>
<tr>
<td>Format</td>
<td>VGA (digital), PAL (analog)</td>
</tr>
<tr>
<td>Scanning method</td>
<td>Progressive, interlace</td>
</tr>
<tr>
<td>Image transfer</td>
<td>Full frame, frame transfer</td>
</tr>
</tbody>
</table>
Map of Applications

Area Arrays

- Digital Camera
- Mobile Phone
- PDA
- Biometrics
- Industrial

Linear Arrays

- Camcorder
- Videoconferencing
- Security
- Toys and Robots
- Industrial

- Optical Mice
- Industrial
- PDA

Scanning
Industrial

Still Video Fast

Frame Rate
Imaging Applications

Mobile videophone (Orange)

Sony Dream Robot
Imaging Applications

Fingerprint scanner (Identix)

Virtual keyboard (Canesta)
Imaging Applications

Self-parking car
(Toyota Prius)

IR night vision (Bendix)

Lane control
(Honda Inspire and Accord)
Imaging Applications

- Wireless endoscope capsules (Given Imaging)
- Digital intraoral camera (Suni Medical Imaging)
Image Sensor Applications

- Office Tools: 51%
- Consumer & Professional: 37%
- Video-conferencing: 5%
- Security: 4%
- Industrial: 3%
MOS Image Sensors: CCDS and CMOS

Both CCDS and CMOS sensors:

- Generate “spatial sampling functions” of image
- Count photons at each pixel
- Convert photons to electrons in reverse P-N junction
- Use MOS structures
- Extract data in “pseudo random access” manner
- Require specialized fabs
CCDs vs. CMOS

**CCD**
- More like bubble memory
- Moves charge along register
- Simpler pixel and chip
- More general purpose
- Smallest pixels

**CMOS**
- More like SRAM or DRAM
- Converts charge to voltage on bus
- More complex pixel and chip
- More application specific
- Largest pixels
- Lower noise at high frame rates
- Lower power consumption
- Single voltage supply
CMOS Encroaches on CCDs

Pixel Count and Power Dissipation

High

Low

CMOS

CCD

Fast Frame Rates

Lower Power, Integration

Still

Video

Fast

Frame Rate
Shrinking Pixels

The graph shows the trend of shrinking pixel size from 1998 to 2005. The y-axis represents pixel size (microns per side), and the x-axis represents the year. CMOS pixels have a consistently smaller size compared to CCD pixels throughout the years. The CMOS line starts at approximately 5 microns in 1998 and decreases to about 3 microns by 2005, while the CCD line starts at about 4 microns and decreases to around 2 microns by 2005.
Photonics vs. Electronics

As pixel size decreases:

- Image area decreases
- Sensitivity decreases
- Fabrication cost increases

As format (number of pixels) increases:

- File size increases
- Frame rate decreases
Moore’s Law Does Not Apply

- Expensive lithography and optics, and diffraction-limited performance
- High performance, but low yield and few chips per wafer
- Many chips per wafer, high yield, and mainstream performance

Manufacturing Cost

Size of Pixel or Array

0747
Production by Region

- Japan: 67%
- North America: 24%
- Europe: 4%
- Asia: 4%
## Four Types of Suppliers

<table>
<thead>
<tr>
<th>Type of Company</th>
<th>Share</th>
<th>Source</th>
<th>Location</th>
<th>State</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronics</td>
<td>62%</td>
<td>Internal</td>
<td>Japan</td>
<td>Established</td>
<td>CCD</td>
</tr>
<tr>
<td>Imaging</td>
<td>17%</td>
<td>Internal</td>
<td>Various</td>
<td>Established</td>
<td>CCD</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>12%</td>
<td>Acquired</td>
<td>Various</td>
<td>Emerging</td>
<td>CMOS</td>
</tr>
<tr>
<td>Fabless</td>
<td>10%</td>
<td>Start-up, Acquired</td>
<td>NA, Europe</td>
<td>Emerging</td>
<td>CMOS</td>
</tr>
</tbody>
</table>
Strong Long-Term Growth

![Revenue Chart](image)

- Year: 1996 to 2008
- Revenues in millions of dollars