

# ***The Image Sensor Market***

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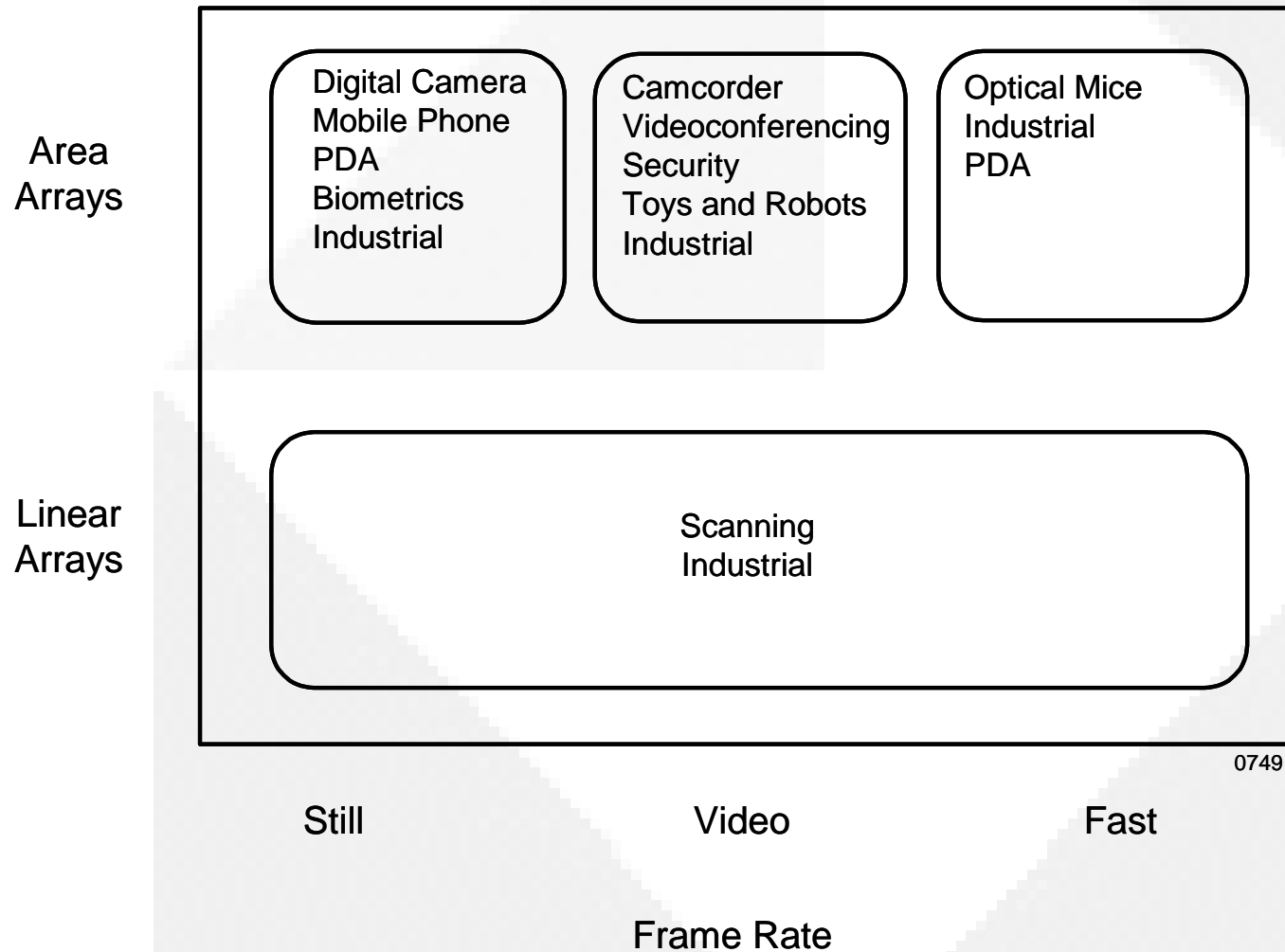
# Image Sensor History

<u>Years</u>	<u>Period</u>
Before ~1960	Film photography and vacuum tubes
1960-1975	Early CCD and CMOS R&D
1975-1990	CCD Commercialization
After 1990	CMOS re-emergence, amorphous Si

# Segmentation and Differentiation

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

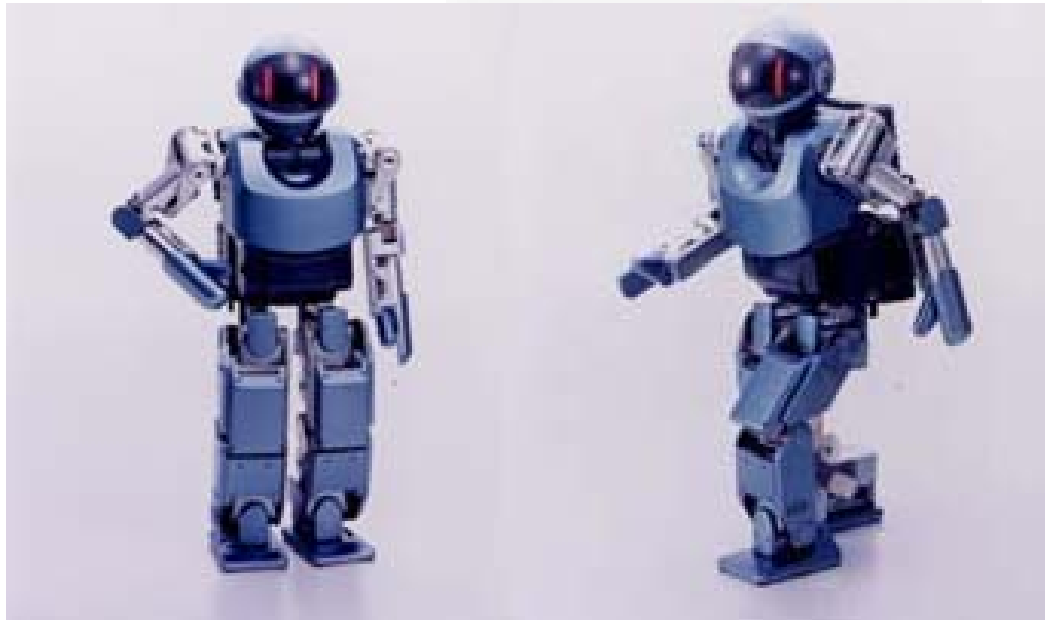
# Map of Applications



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# Imaging Applications

Mobile videophone (Orange)



Sony Dream Robot



# Imaging Applications



Virtual keyboard (Canesta)

Fingerprint scanner (Identix)



# Imaging Applications



IR night vision (Bendix)

Self-parking car  
(Toyota Prius)



Lane control  
(Honda Inspire and Accord)

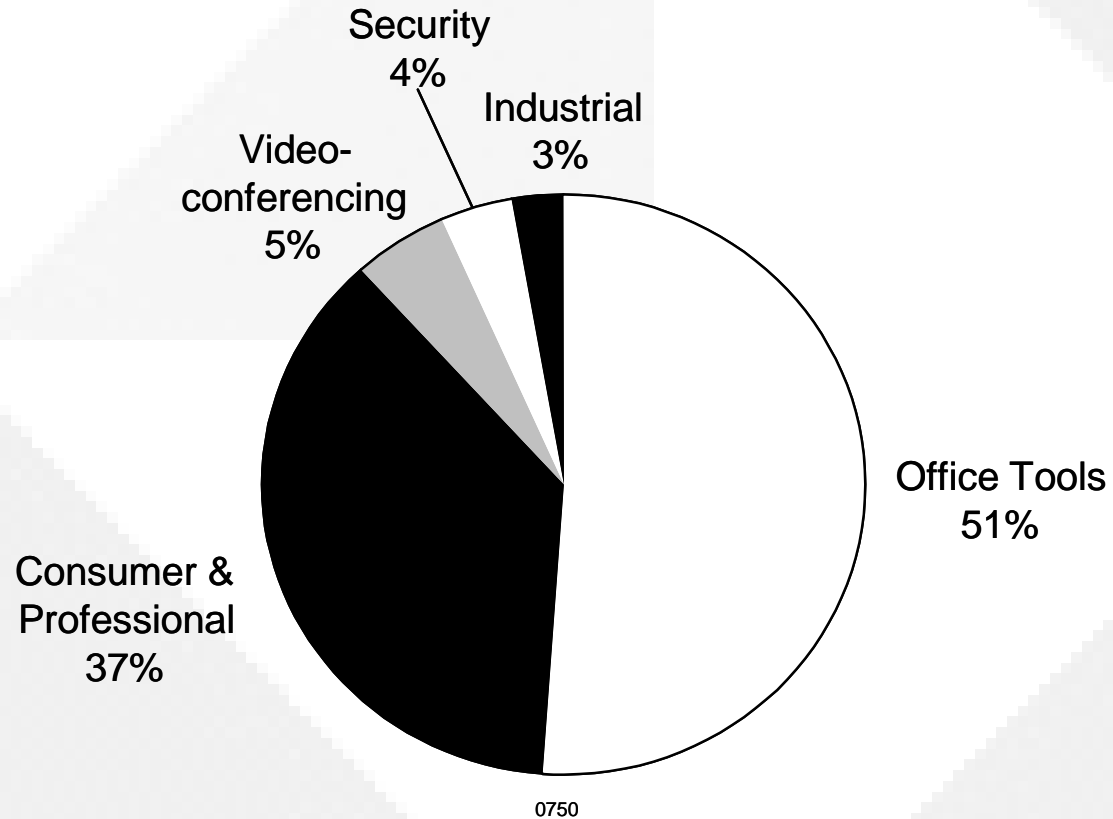
# Imaging Applications

Wireless endoscope capsules  
(Given Imaging)



Digital intraoral camera  
(Suni Medical Imaging)

# Image Sensor Applications



# 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

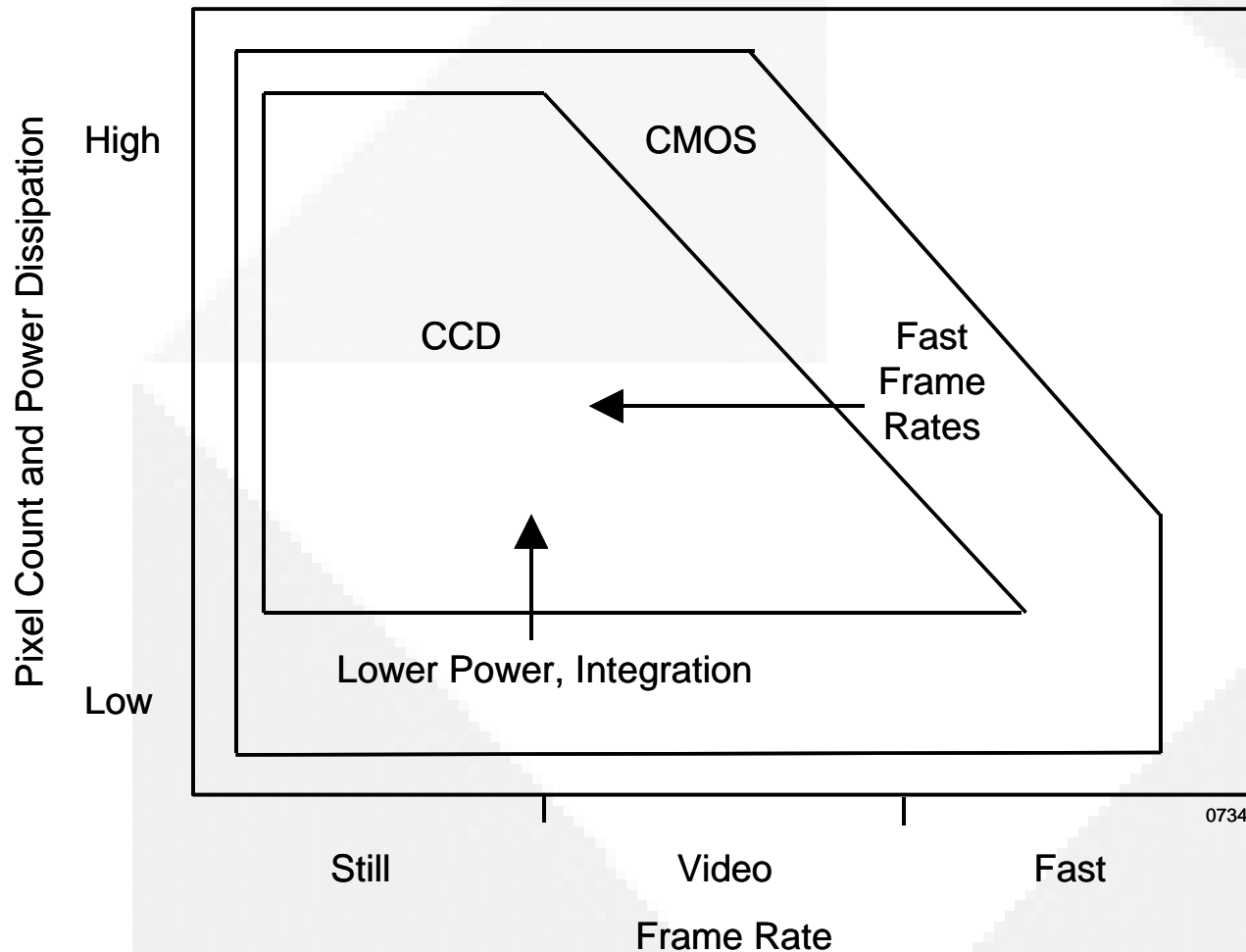
## CCD

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

## CMOS

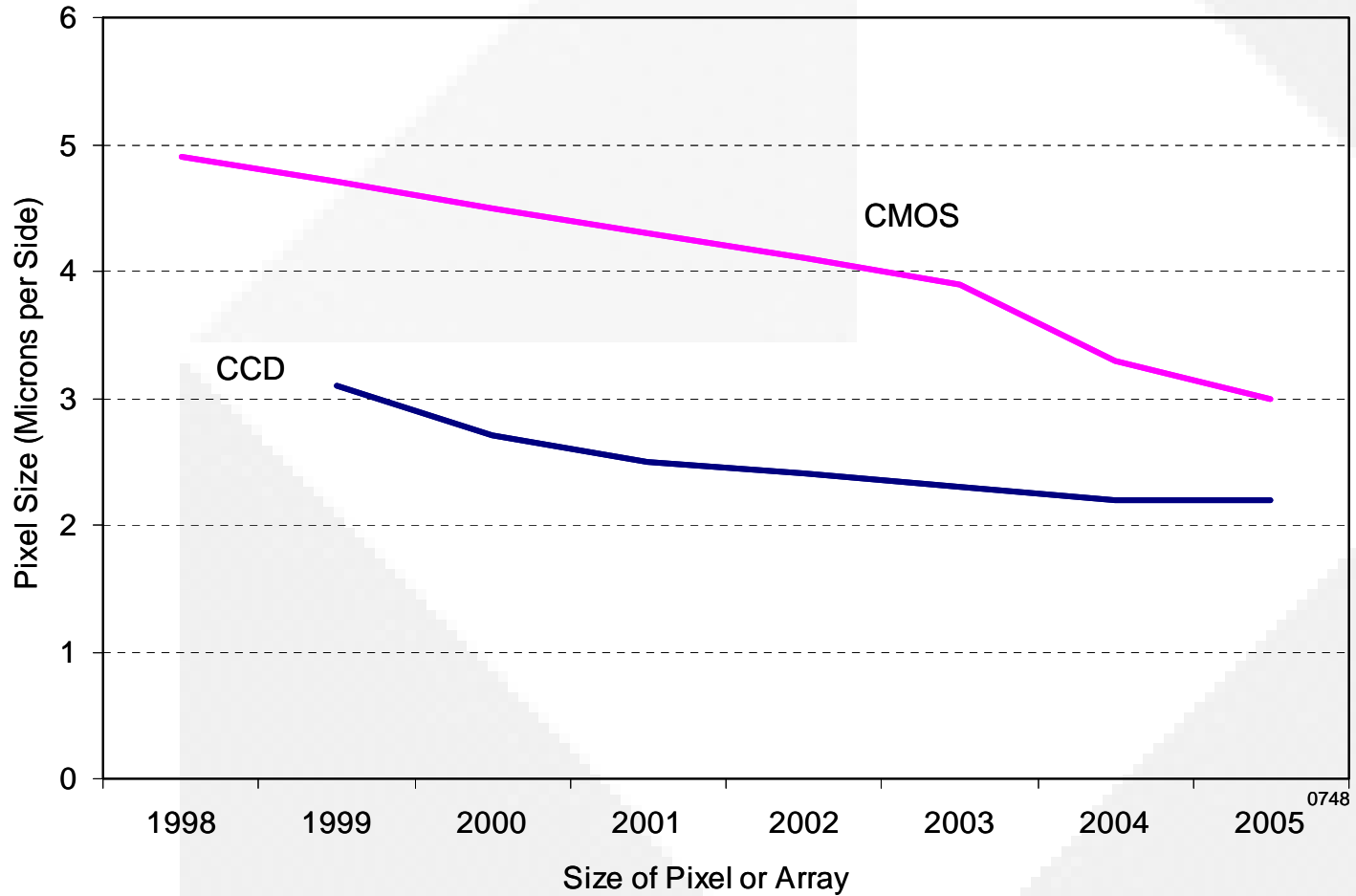
- More like SRAM or DRAM
- Converts charge to voltage on bus
- More complex pixel and chip
- More application specific
- Largest pixels
- Lower noise at high frame rates
- Lower power consumption
- Single voltage supply

# CMOS Encroaches on CCDs



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# Shrinking Pixels



# Photonics vs. Electronics

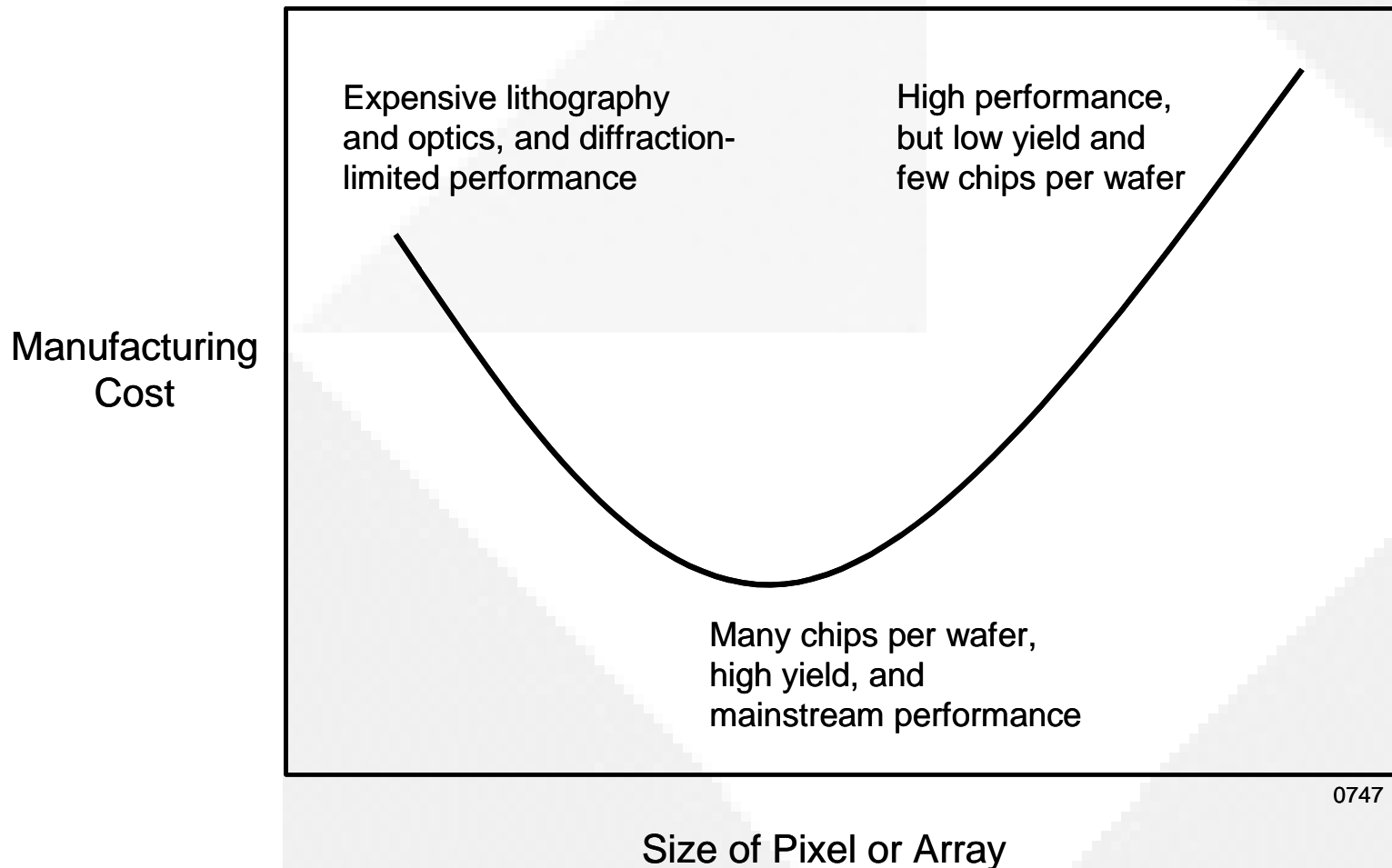
As pixel size decreases:

- Image area decreases
- Sensitivity decreases
- Fabrication cost increases

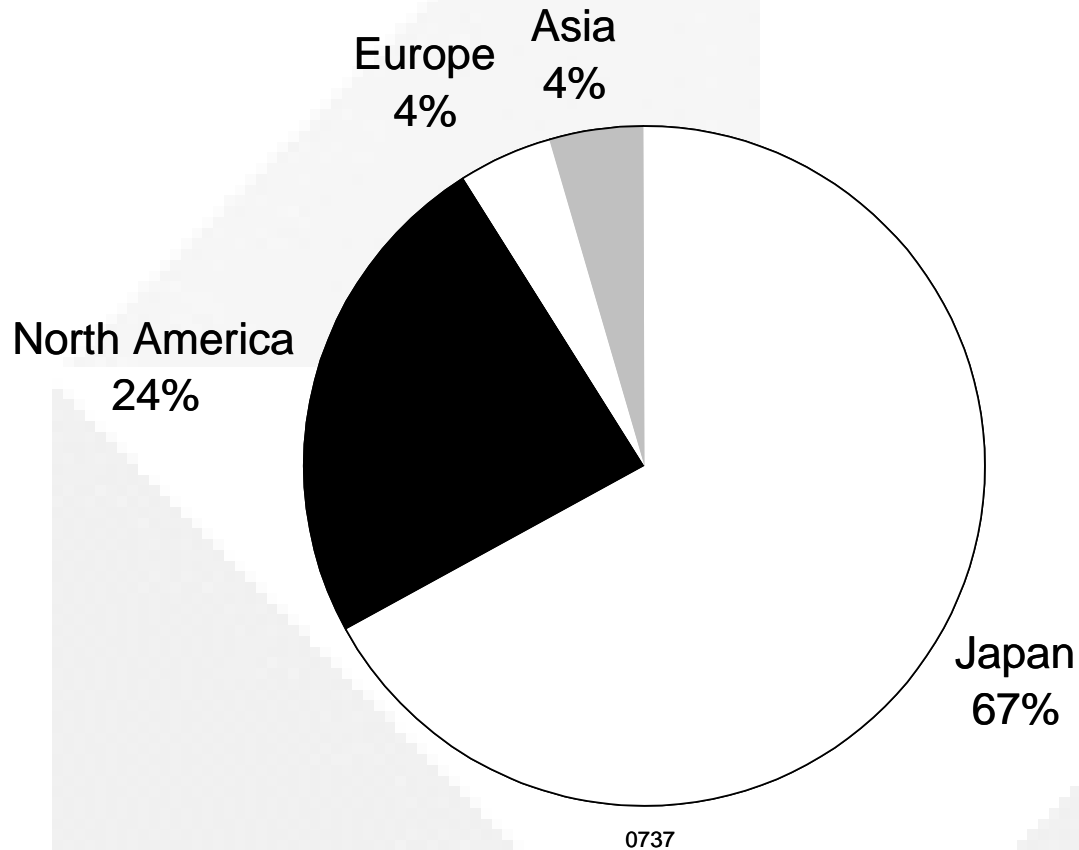
As format (number of pixels) increases:

- File size increases
- Frame rate decreases

# Moore's Law Does Not Apply



# Production by Region



# Four Types of Suppliers

<u>Type of Company</u>	<u>Share</u>	<u>Source</u>	<u>Location</u>	<u>State</u>	<u>Technology</u>
Electronics	62%	Internal	Japan	Established	CCD
Imaging	17%	Internal	Various	Established	CCD
Semiconductor	12%	Acquired	Various	Emerging	CMOS
Fabless	10%	Start-up, Acquired	NA, Europe	Emerging	CMOS

# Strong Long-Term Growth

