



Photobit

CUSTOM AND CATALOG PRODUCT IMAGE SENSOR EXAMPLES



CATALOG PRODUCTS

Photobit

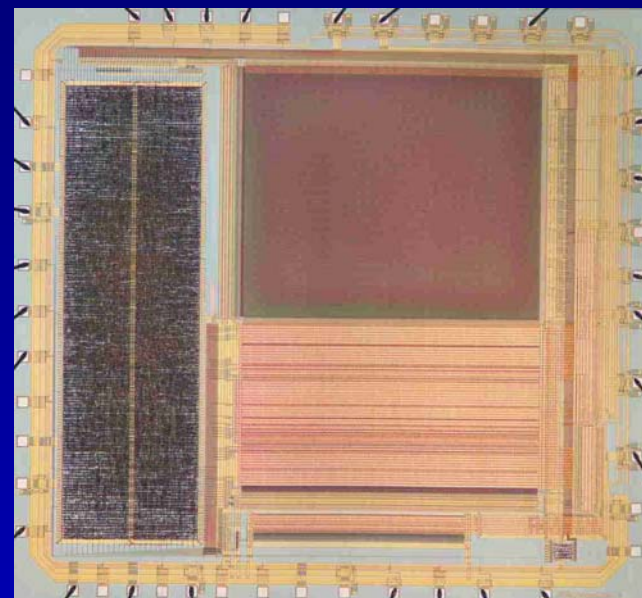
- PB0100 - CIF format (352x288) color camera on a chip
- PB0300 - VGA format (640x480) color camera on a chip
- PB0720 - HDTV format (1280x720) machine vision sensor
- PB1024 - Machine Vision (1024 x 1024) high speed sensor



PB100 FOR VIDEOCONFERENCING

Photobit

- 360x304 (352x288 effective) pixels
- 8b flash ADCs
- 7.9 μm x 7.9 μm (1/5" optical format)
- Progressive scan, window readout
- 15,000 gate on-chip logic
- >30 frames per sec (adj.)
- 3.3 V operation
- <100 mW total power
- Built-in autoexposure control
- On-chip biasing
- On-chip CFA
- >20 dB SNR @ 1 lux, 30 fps



Van Blerkom, Huang, Chan 1999

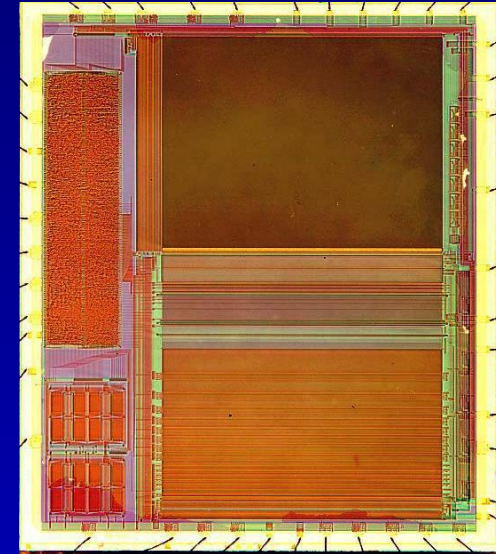


PB300 FOR MULTIMEDIA

Photobit

- 640x487 (640x480 effective) pixels
- 320 column-parallel 8b ADCs
- 7.9 μm x 7.9 μm (1/3" optical format)
- Progressive scan, window readout
- 15,000+ gate on-chip logic
- >30 frames per sec (adj.)
- 5 V operation
- <300 mW total power
- Built-in autoexposure control
- On-chip biasing
- On-chip CFA
- >20 dB SNR @ 1 lux, 30 fps

Panicacci, Cho 1999

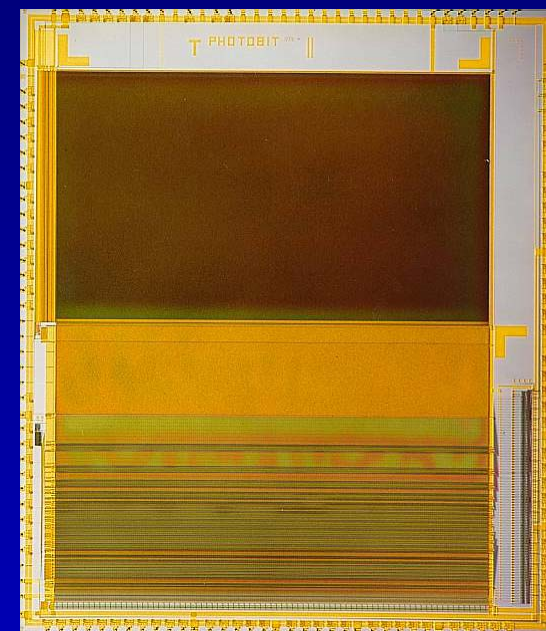
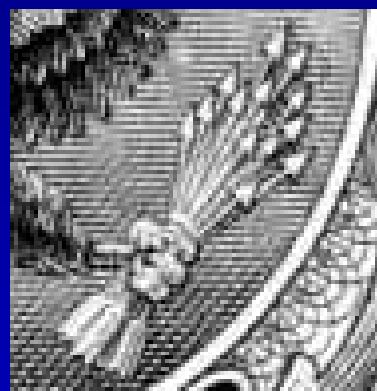




HIGH RESOLUTION HDTV SENSOR

Photobit

- Developed originally for DARPA
- 1280 x 720 pixels (SMPTE 296M)
- 640 10b ADCs
- 7.9 μm x 7.9 μm (2/3" optical format)
- Progressive scan
- 4 port output
- >60 frames per sec (adj.)
- Burst mode readout (74 Mb/s/port)
- <250 mW total power
- DNL/INL/FPN < 3 LSBs



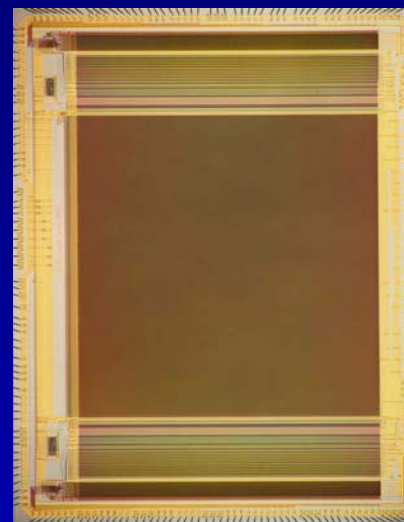
Mansoorian, Huang, Calderwood 1997



PB1024 HIGH SPEED SENSOR

Photobit

- 1024x1024 elements
- 10 μm x 10 μm pixel pitch
- 0.5 μm CMOS
- 1024 on-chip 8b ADCs
- 8 digital output ports (64 pins)
- Open architecture
- Power: 95 mW @ 60 fps
- Power: 270 mW @ 574 fps
- By far, world's pixel rate record of ALL image sensors (CCDs and CMOS)



Krymski, Van Blerkom, Bock, Anderson 1998



CUSTOM/CAPTIVE PRODUCTS

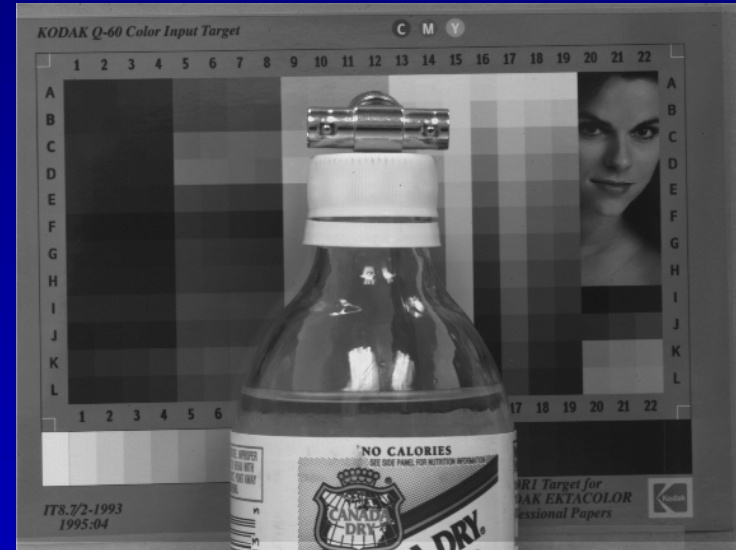
Photobit

- Develop long-term partnership or strategic alliance
- Examples:
 - Schick Technologies: medical radiography sensors for dentistry and osteoporosis detection
 - Gentex Corporation: sensors for automotive applications
 - Kodak: camera on a chip for teleconferencing cameras
- Photobit designs and produces custom prototype sensor
- Photobit manufactures captive product sensor and sells only to that customer.
- Photobit has designed and delivered over 20 custom sensors since 1995



PROMETHEUS

Photobit



- 576 (H) x 432 (V)
- 20.9 μm PD pixel pitch
- 1.4 μm process
- 576 single slope ADCs
- digital & analog output ports

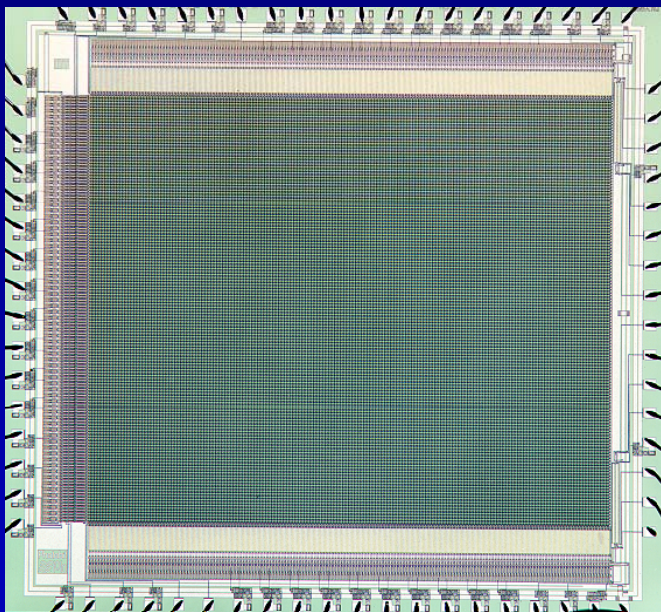
Panicacci 1996

Behind Every Great Digital Image



ITT LOW LIGHT SENSOR (NiVAPS)

Photobit



low light image (~0.004 lux)



- 176 (H) x 144 (V) elements
- 30 μm E-PG pixel pitch
- 1.2 μm process
- 20 fps analog output

Xue 1996



L080 LOW LIGHT SENSOR

Photobit

- 342 x 258 pixels
- 336 x 242 optical pixels
- 20 x 20 μm pixel pitch
- 64x on-chip gain
- On-chip gamma correction
- 8b digital output
- 10,000 gates on-chip logic
- EIA/NTSC timing
- 60 Hz progressive scan
- Autoexposure control
- --low light to sunlight @ F/1.4
- 150 mW



200 lux room light, 60 Hz, F/1.4



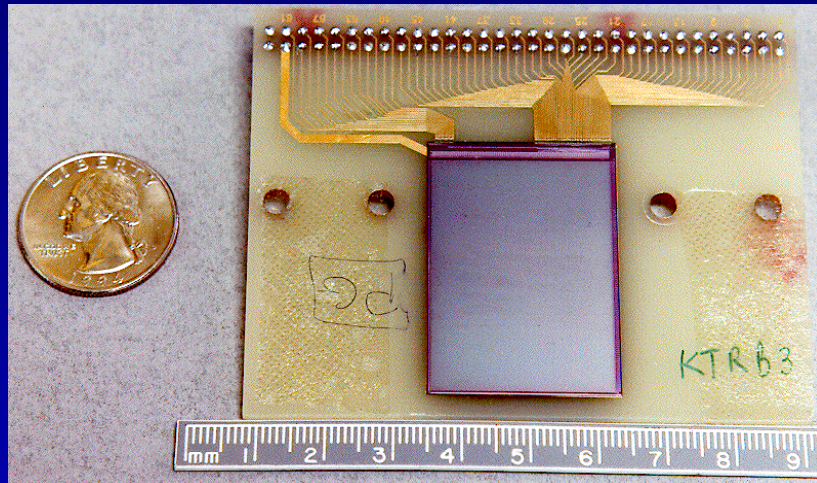
1000x less light: 200 millilux, 60 Hz, F/1.4

Barna, Ang, O'Conner, Wang 1999

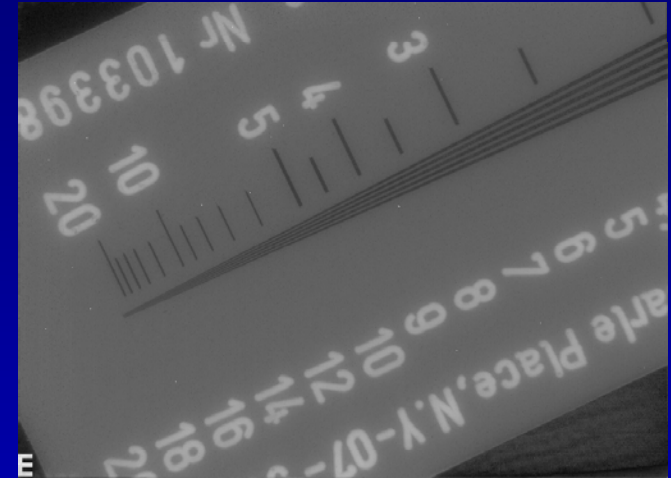


DENTAL X- SENSOR

Photobit



x-ray



- Total chip size: 37 x 27 mm
- 900 (V) x 675 (H) elements
- 40 μm pixel pitch
- 2 μm CMOS process
- Differential analog output
- On-chip timing and control
- Event detector self-triggered readout
- World's largest CMOS chip in production

*visible
flash*



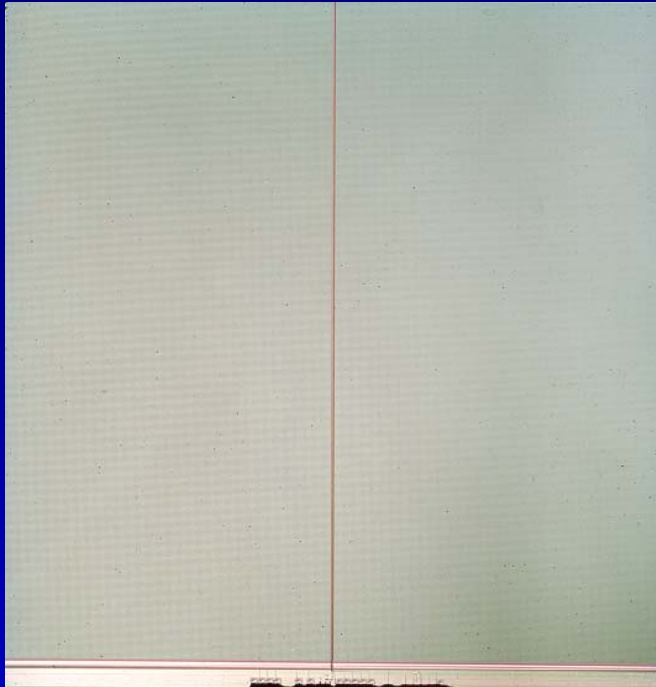
Nixon 1996

Behind Every Great Digital Image



BUTTABLE SENSOR

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- 466 x 466 elements
- 30 μm pixel pitch
- 0.8 μm process
- 2 column loss



- 3-sides buttable
- P-channel PD-type pixel
- Differential analog output
- Some on-chip circuits

Xue 1997

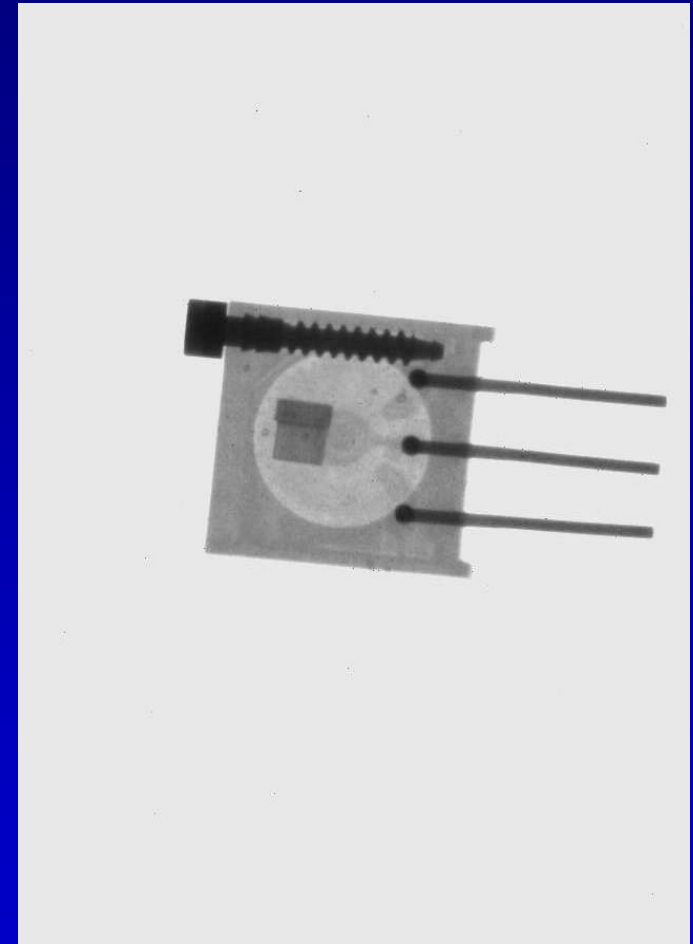
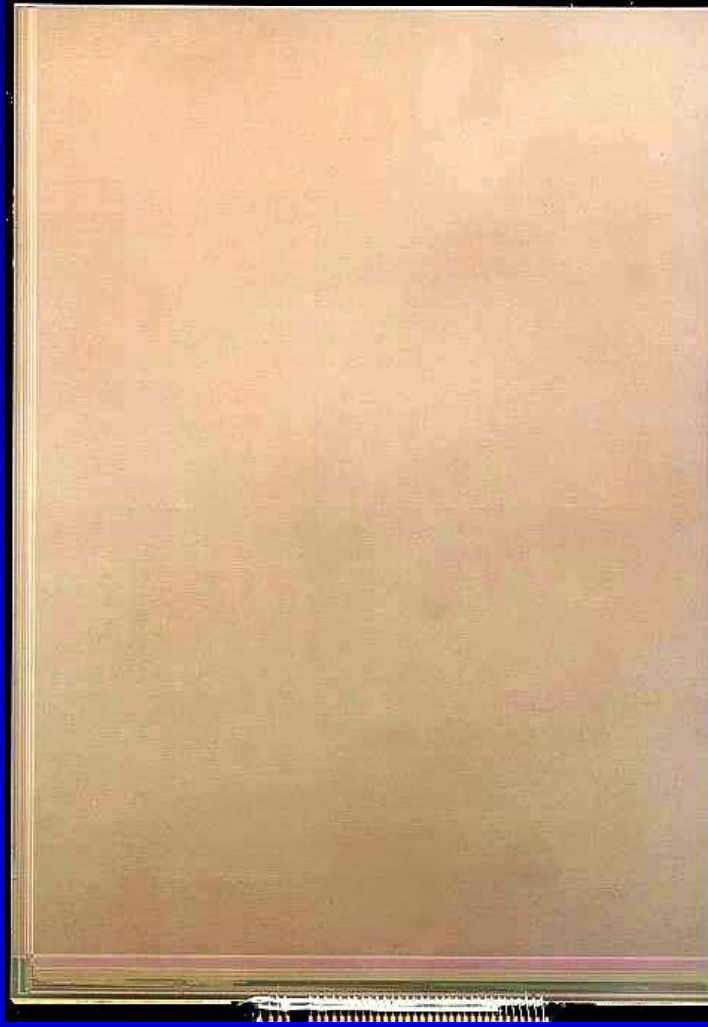
Behind Every Great Digital Image



BONE DENSITY SENSOR

Photobit

- Total chip size:
37 x 27 mm
- 900 (V) x 675 (H)
elements
- 40 μm pixel pitch
- 2 μm CMOS
process
- Differential analog
output
- On-chip timing
and control



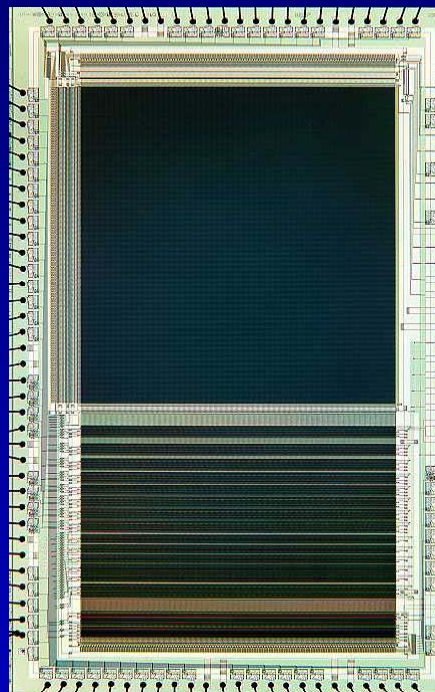
Xue 1998



256 x 256 DIGITAL CMOS APS AUTOMOTIVE SENSOR

Photobit

- 256x256 elements PD-type
- 20.4 um pixel (1.2 um CMOS)
- 256 column-parallel ADCs
- 8b resolution
- On-chip FPN suppression
- 30 frames per second
- Off-chip timing & control
- Under 50 mW total power
- Note lack of blooming or other artifacts

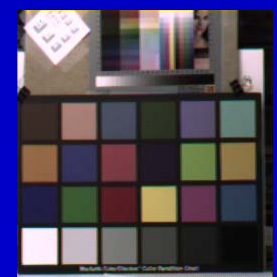


raw digital image

Analog output



3-chip color

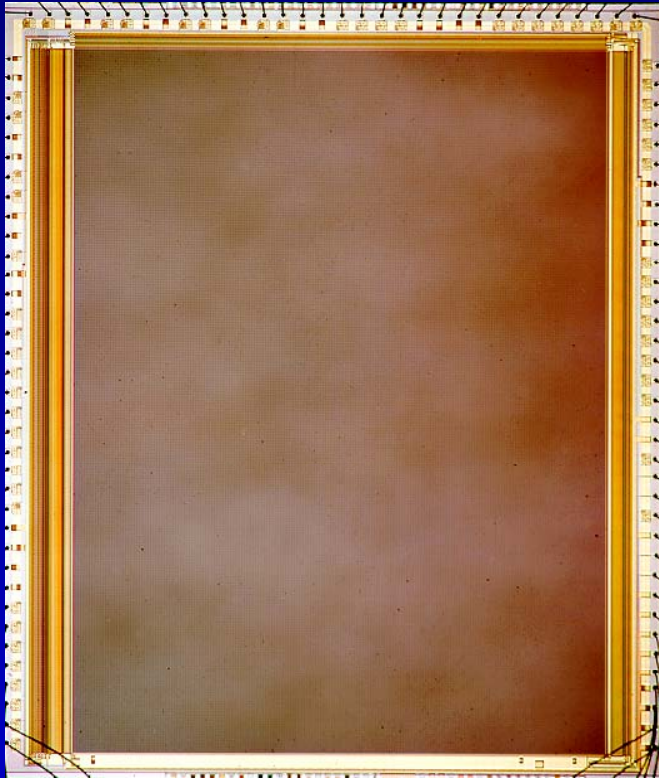


Panicacci 1996



LUCENT OPTICAL MEMORY

Photobit



- 816 (V) x 616 (H) elements
- 17 μm PD pixel pitch
- 0.8 μm process
- special column-parallel comparator circuit

Panicacci 1997

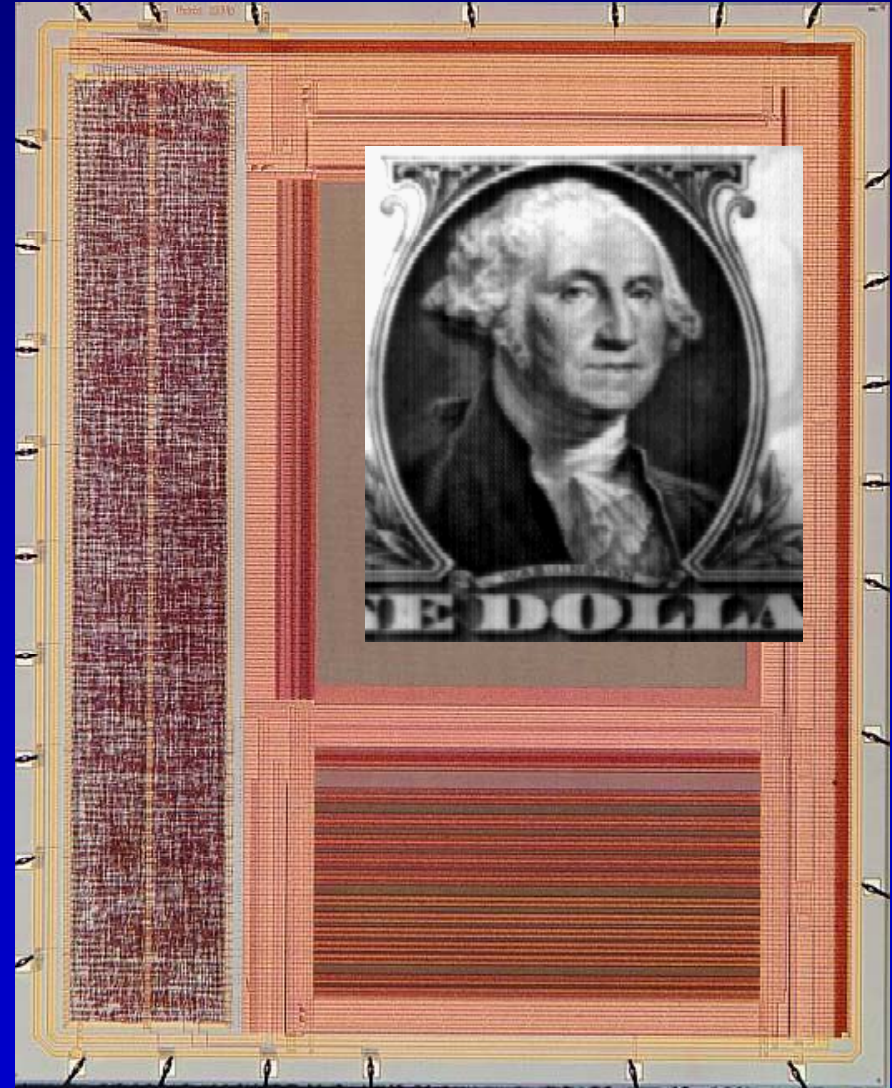
Behind Every Great Digital Image



HANDHELD MACHINE VISION SENSOR

Photobit

- 364 x 250 pixels
- 9.8 μm x 12.25 μm
- 0.5 μm CMOS
- 10,000 logic gates
- Analog and digital output ports
- 60 frames per second
- 5 bit on-chip ADC
- On-chip DACs
- On-chip exposure control
- I²C serial command interface
- Sleep mode



Alphonso-Gibbs, Panicacci 1998



KODAK TELECONFERENCING

Photobit

- 640x487 (640x480 effective) pixels
- 320 column-parallel 8b ADCs
- 7.8 μm x 7.8 μm (1/3" optical format)
- Pinned photodiode pixel
- Progressive scan, window readout
- 15,000+ gate on-chip logic
- >30 frames per sec (adj.)
- 5 V operation
- <300 mW total power
- On-chip CFA
- Fabricated at Motorola for Kodak



Panicacci, Ay 1998



LINEAR SENSOR

Photobit

- 5100x3 elements
- 8 μm x 8 μm pixel pitch
- 0.5 μm CMOS
- 10 MHz max. pixel rate
- 600 lines per second
- 68 dB dynamic range
- 5 volt operation
- 30 mW
- 4 analog output ports
 - 1 for each color (RGB)
 - 1 serial analog port
- Selectable resolution mode (150 dpi, 300 dpi, 600 dpi)
- Selectable parallel, line-packed or pixel-packed data output
- Timing and control on-chip



Ang, Krymski, Mansoorian 1998

Behind Every Great Digital Image



CONTRACT R&D

Photobit

- Photobit performs contract R&D for government Small Business Innovative Research Program
 - Strong success record for winning Phase I & Phase II
 - Government customers include:
 - NASA, US Navy, US Army, DARPA, BMDO
- Photobit performs direct and subcontract government R&D
 - Perfect track record for delivery on-time, on-cost
 - Customers include:
 - Kollmorgen (DARPA)
 - Lutronix (DARPA)
 - Draper Labs (Navy)
 - Holoplex (DARPA)



DRAPER STAR TRACKER

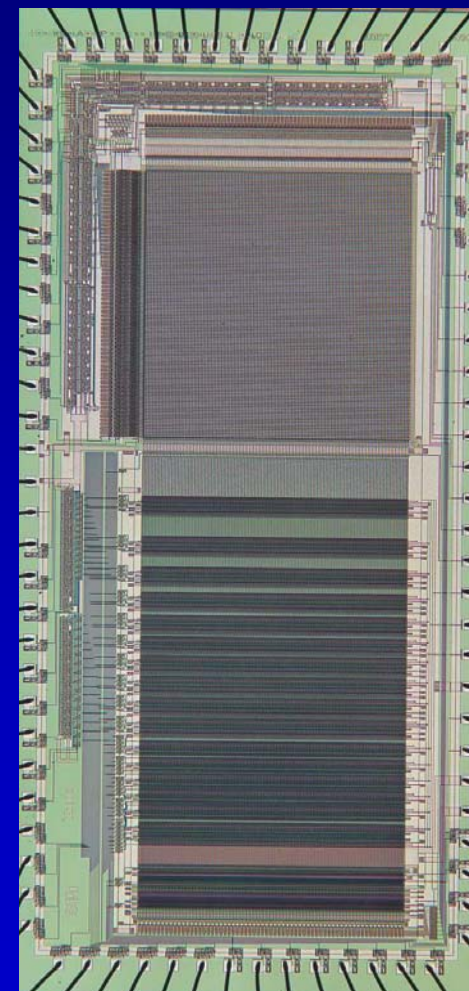
Photobit

- 128 x 128 elements
- 20.4 mm PD pixel pitch
- 1.2 mm process
- Analog and digital ports
- On-chip timing and control (analog/RO)
- Off-chip timing and control (ADC)
- 128 10b S/A ADCs

*digital
port*



*analog
port*



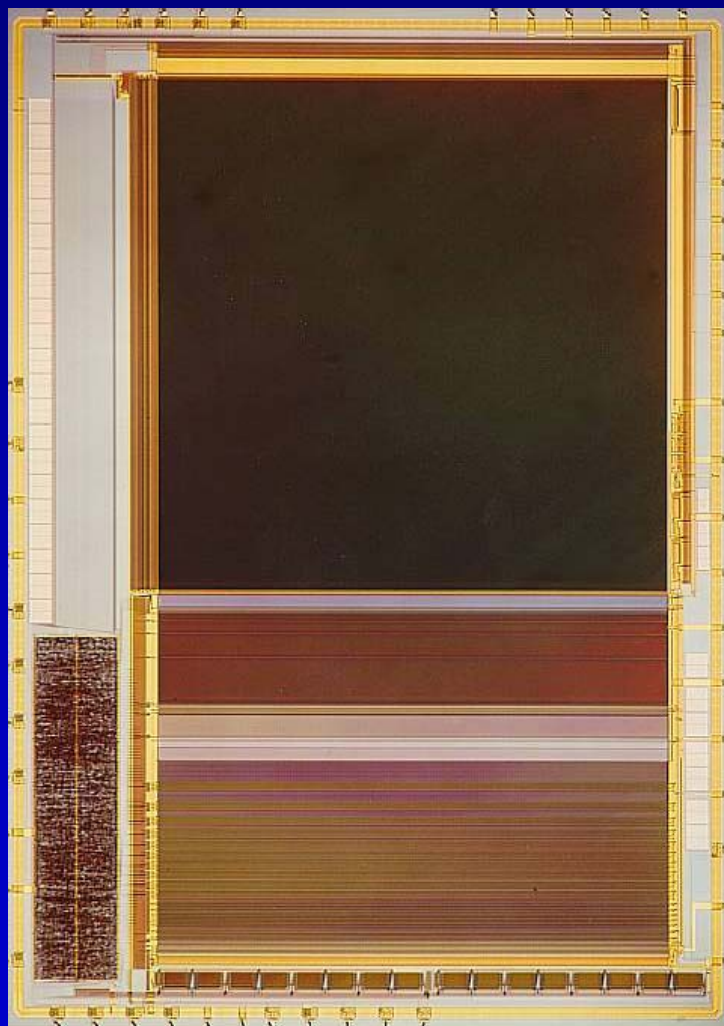
Chan & Cho 1997



1024 x 1024 DIGITAL CMOS APS CAMERA ON A CHIP FOR SPACE

Photobit

- Developed for NASA/JSC
- 1024 x 1024 pixels
- 512 10b ADCs
- Low noise analog output port
- 7.9 μm x 7.9 μm
- Window readout
- 15,000 logic gates
- >15 frames per sec (adj., digital port)



Chan, Ay, Panicacci 1998



MICROPOWER (48 μ W) IMAGE SENSOR

Photobit

- 0.35 μ m 2P 3M 3.3V CMOS
- Size: 1.2mm x 1.2mm
- 176x144 pixels (QCIF)
- 5.0 μ m pixel pitch
- 30% fill factor
- 8b successive approx. ADC
- DNL/INL: 1 LSB / 2LSBs
- 2.8 mV/LSB
- 20 frames/sec (0.5 Mpix/sec)
- 20 μ V/e- conv. Gain
- dark current: 4.64 LSB/sec
or 13 mV/sec or 650 e-/sec
- noise: 0.43 LSB or 1.2 mV or 60 e-
- saturation: 214.3 LSB or 600 mV or 30,000 e-
- operating voltage: 1.0-3.6V
- power: 48 μ W at 1.2V 20 fps (except pads)
- pad power: ~950 μ W at 3.3V (lots of pads)



1.0V

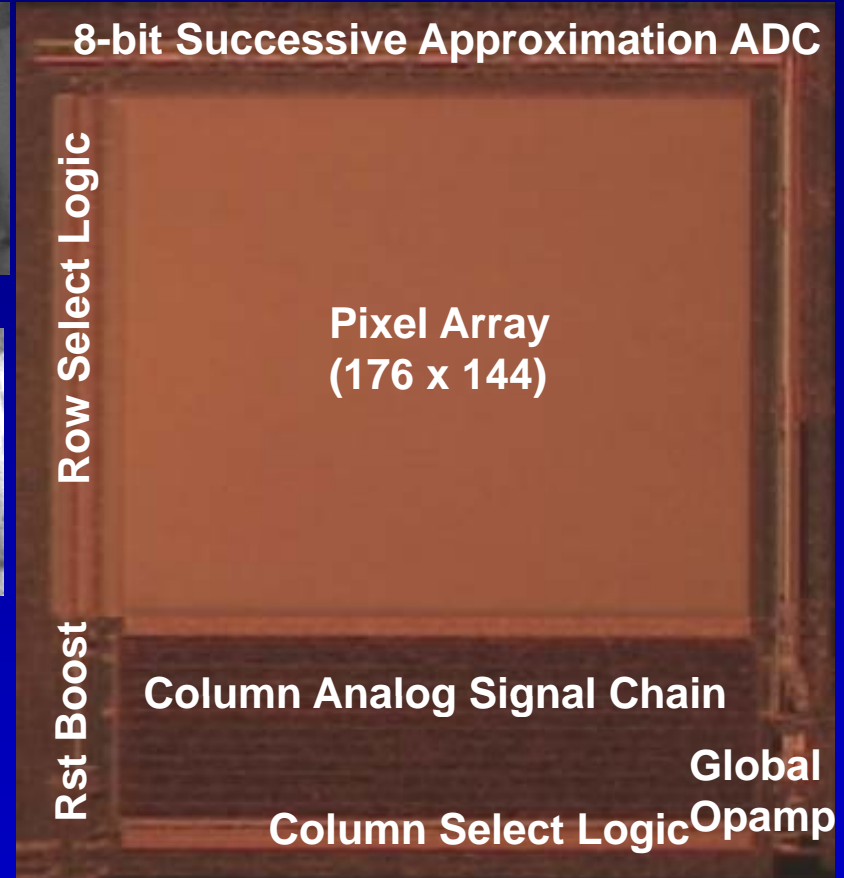


1.2V

1.5V



3.3V



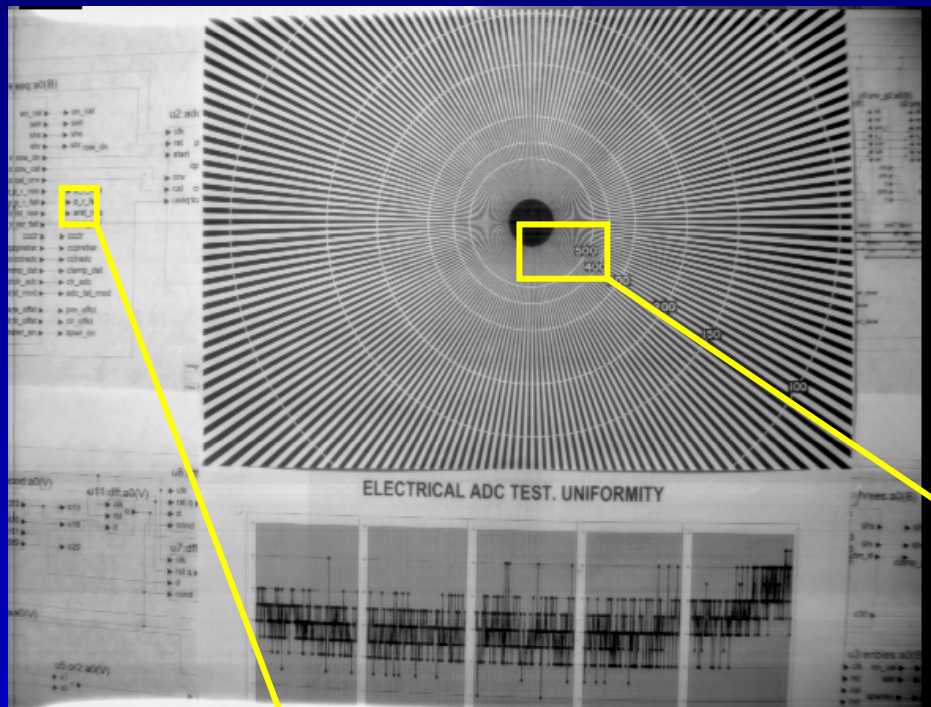
Cho, Krymski, Fossum 2000

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4Mpixel, 200 fps SENSOR

Photobit



- ▶ p_r_rise
- ▶ p_r_fall
- ▶ arst_rise
- ▶ arst_fall



Parameters

Photobit

Technology	0.35um 2P3M CMOS
Format	2368x1728 (4.1Meg)
Frame rate	200 <i>F/s @50 MHz mscclk</i>
Number of outputs	16x10bit
Data throughput	8.2 Gbit/s (820 Mpix/s)
Number of pins	273 (280PGA package)
Pixel pitch	7um
Shutter type	rolling
Conversion gain	>10 uV/e
Quantum Efficiency	30%
ADC , 2368 x1	10bit (9 bit accuracy)
Dark FPN, rms	2 mV
PRNU at 1/2 Sat	<2%
Temporal Noise	<100e
Power supply	3.3V
Power consumption	<800mW