CMOS Flatpanel Imager as an X-ray Detector for Synchrotron Radiation

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Flat-panel Imagers for X-rays

- aSe + TFT : medical, PX (Mar)
- Scintillator + TFT
- Scintillator + MOS photodiode matrix

  1～5 million pixels

Advantages over other Area Detectors

- Low-cost (10,000-30,000US$)
- Small and light (< 3cm thick, 1-3 kg)
- Fast readout (2-3 frames/sec)

Disadvantages

- High readout noise (multiplexor switching noise)
- Low gain (no amplification)

Shad-o-Box™

Rad-icon Imaging Corp.

Weight 1.26kg

Number of pixels	1024×1024
Size of pixels	48×48μm
Frame rate	2.7 /sec
Dynamic range	4000:1
AD converter	12 bits
Resolution	10 lp/mm
Scintillator	Kodak Min-R

C7942

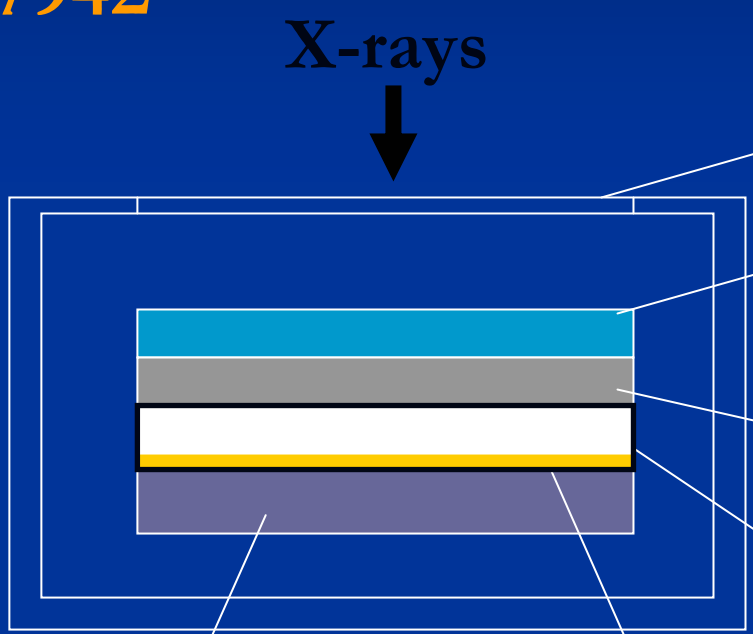
Hamamatsu Photonics K.K.

Weight 2.27kg

Number of pixels	2240×2368
Size of pixels	50×50μm
Frame rate	2.0 /sec
Dynamic range	2000:1
AD converter	12 bits
Resolution	8 lp/mm
Scintillator	Columnar CsI

Flipped scintillator plate for low energy x-rays

C7942



Window
0.5mm Al → plastic

plastic plate for pressing
↓
carbon plate

plastic sponge for cushion

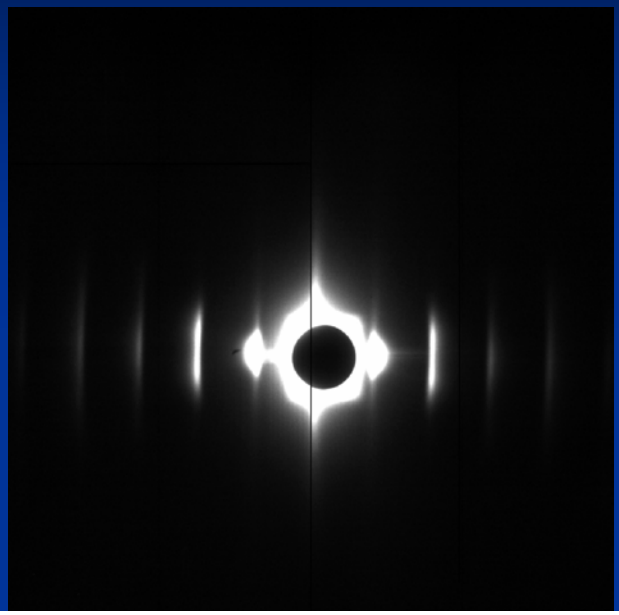
0.5mm glass plate (substrate of CsI)
↓
carbon plate

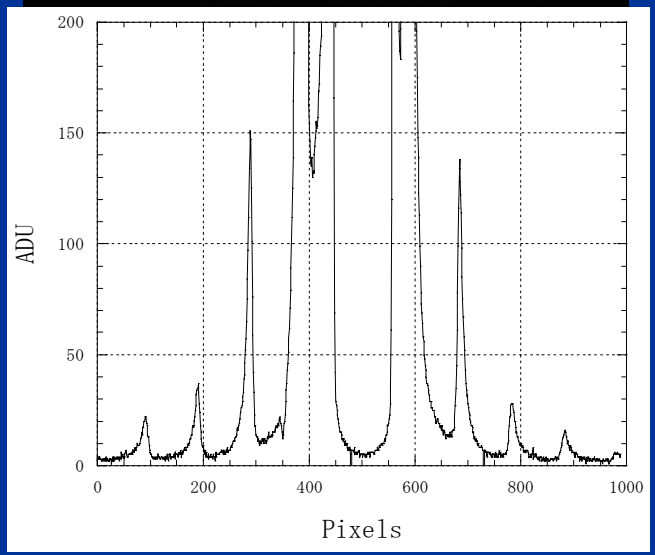
MOS image sensor

0.15mm columnar CsI:Tl crystal

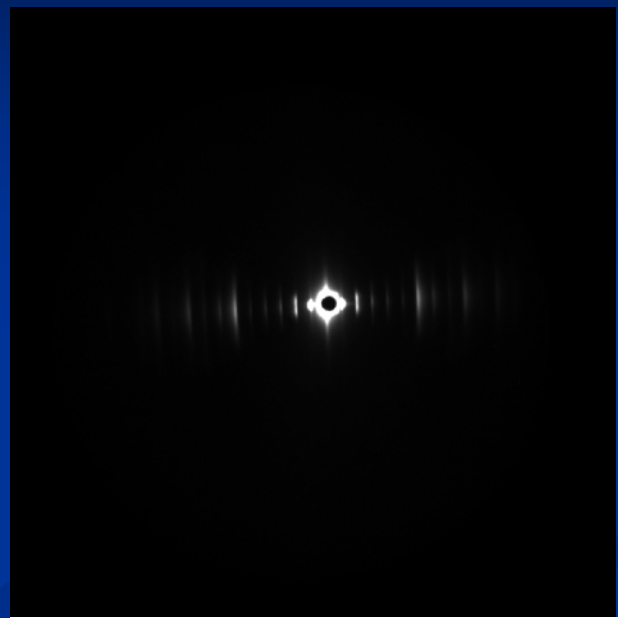
Collagen : diffraction patterns

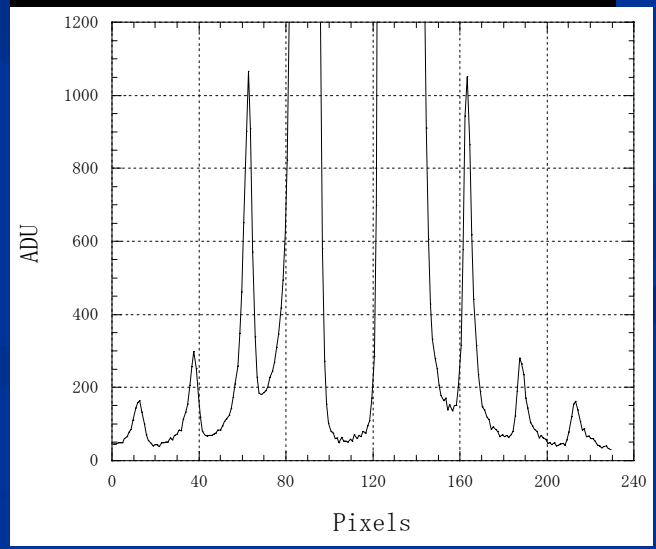
Shad-o-Box (2 sec)





X-ray image intensifer + CCD (0.5 sec)

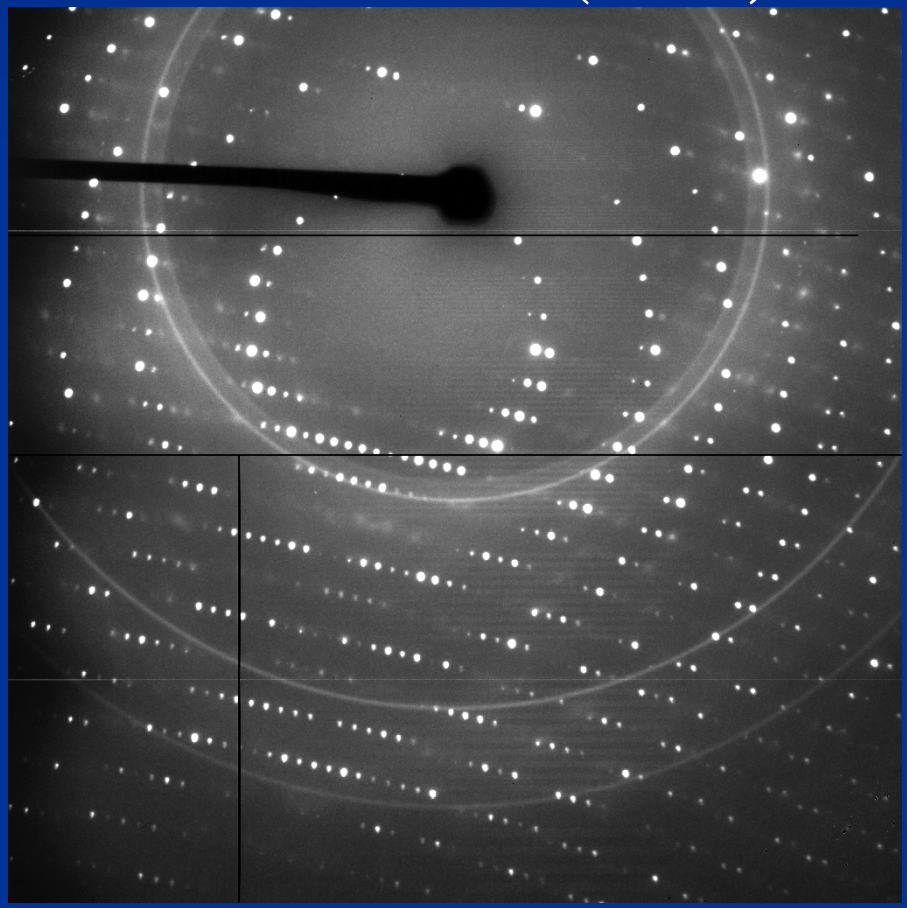




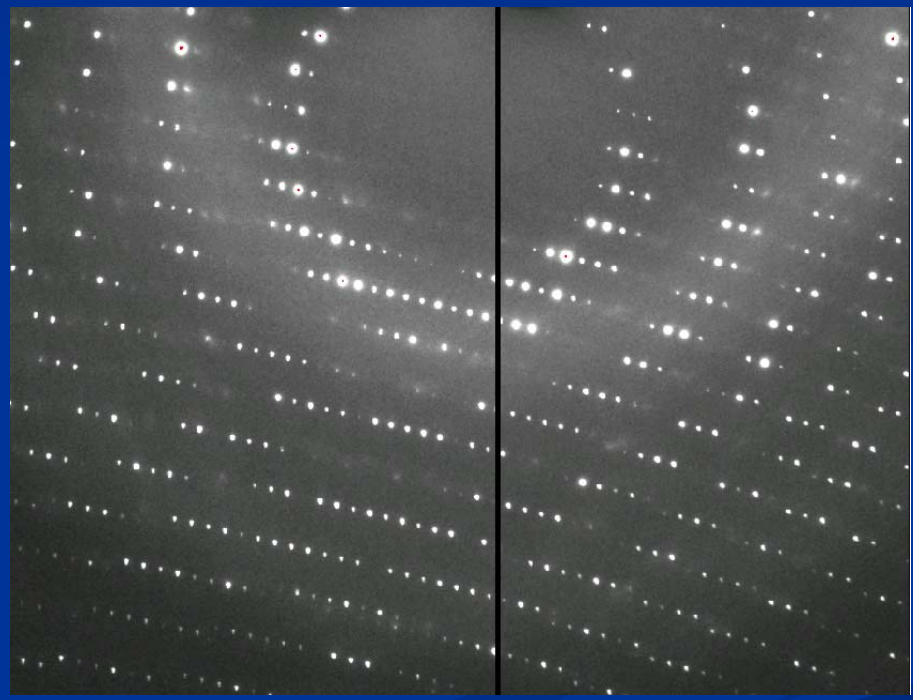
BL40XU
12.4 keV
l=2.8m

Quality of diffraction images

Shad-o-Box (5 sec)



Quantum 4R



BL38B1
E=18keV
Lysozyme

Medical imaging

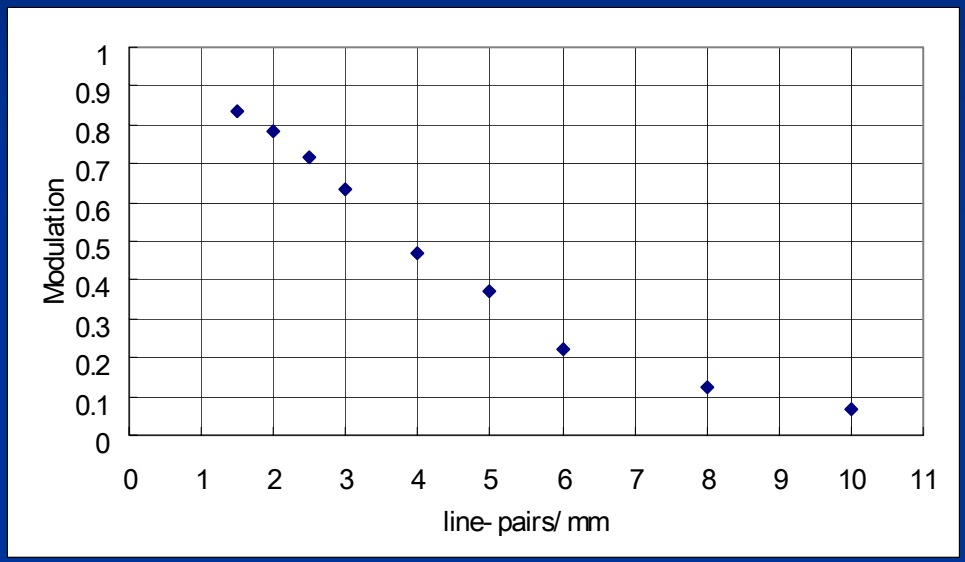
Mouse : Shado-o-Box

BL20B2 E=30keV

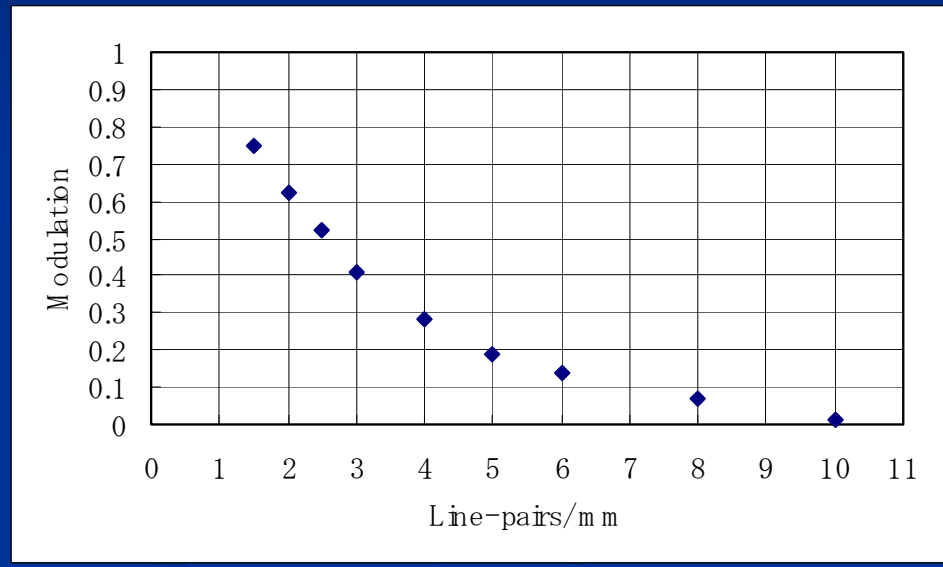
l=7m

Exposure=0.2sec

Resolution



Shad-o-Box

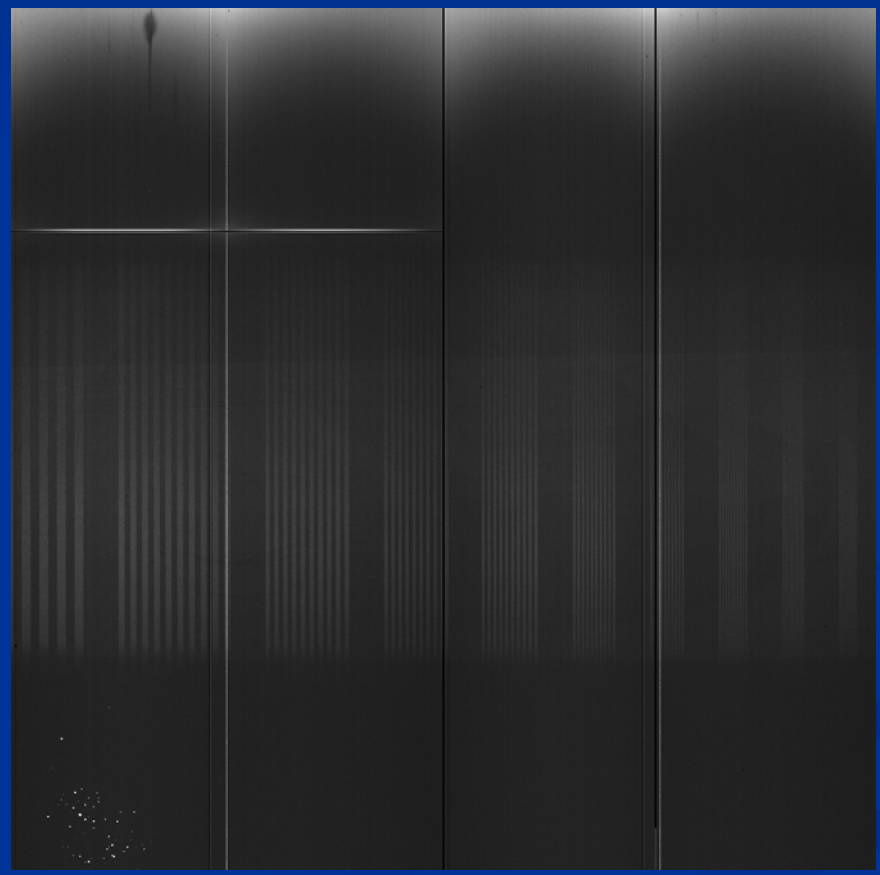


C7942

Image corrections

- Defects
  - Broken lines
  - Hot pixels
- Dark current subtraction
- Flatfield response
  - non-uniformity in sensitivity

Radiation damage



Shad-o-Box

Comparison

	Rad-icon Shad-o-Box 1024	Hamamatsu C7942	ADSC Quantum 210
Device	MOS (2)	MOS (8)	CCD (4, cooled)
Number of pixels	1024×1024	2240×2368	4096×4096
Area (mm)	49.3×49.2	120×120	210×210
Pixel size (μm)	48	50	51
Readout time (sec)	0.44	0.44	1
Dark curr. (e^-/sec)	4000	5900	0.015
Readout noise (e^-)	500	1100	7@1MHz
ADC (bits)	12	12	16
Well-depth (e^-)	2,000,000	2,200,000	270,000
Conversion gain (e^-/x-ray photon)	250@20keV	800@20keV	8 @12keV
Scintillator	Gd_2O_2S:Tb	CsI:Na (150 μm)	Gd_2O_2S:Tb
Price (US$)	ca. 10,000	ca. 25,000	ca. 610,000

Future

- Lower readout noise
  (now 150e^- : RadEye@0.5MHz)
- Larger area
  Tiling (RadEye8 : 98.4 square)
  Larger wafer (*ca.* 20 cm square)

There is a driving force from the medical field for improvement.