LSST Focal Plane and Detector Development

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Abstract

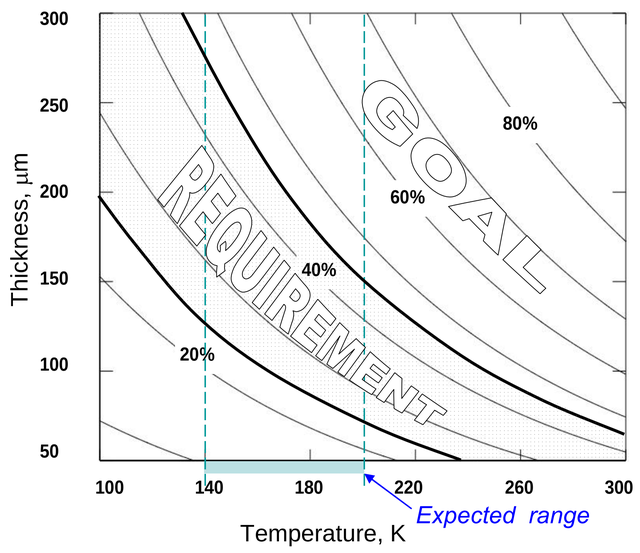
The LSST focal plane is the largest and most complex ever proposed for an astronomical instrument. The demands of the science to be done and the nature of the cadence and very wide field preclude the use of any existing imager, so a custom device must be developed. Both CCD and CMOS imagers are being considered. We present several background studies on the size, organization, imager characteristics, and packaging we intend to develop in order to populate and read out this giant imaging focal plane.

Key Requirements

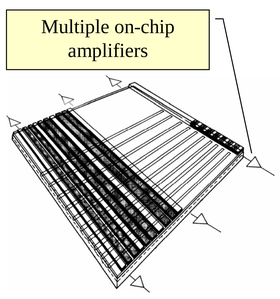
Extended red QE	⇨	*Thick sensitive material*
Image quality matched to telescope	⇨	*Low diffusion, high resistivity substrate, high applied voltage*
Fast, low noise readout	⇨	*Fine segmentation*
Operation in f/1.25 beam	⇨	*Mechanically flat imaging surface*
Large area focal plane	⇨	*Large format, high fill factor, high manufacturing yield*

Quantum Efficiency

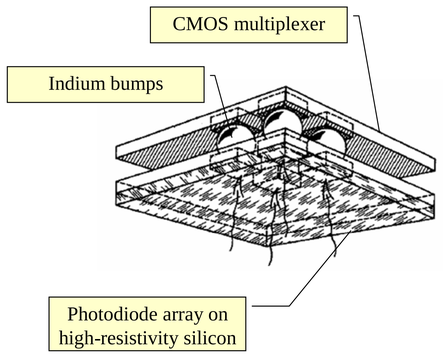
Internal QE at 1 μm is strongly temperature sensitive



Candidate Detectors



Multi-output, back-illuminated CCD



Hybrid PIN-CMOS

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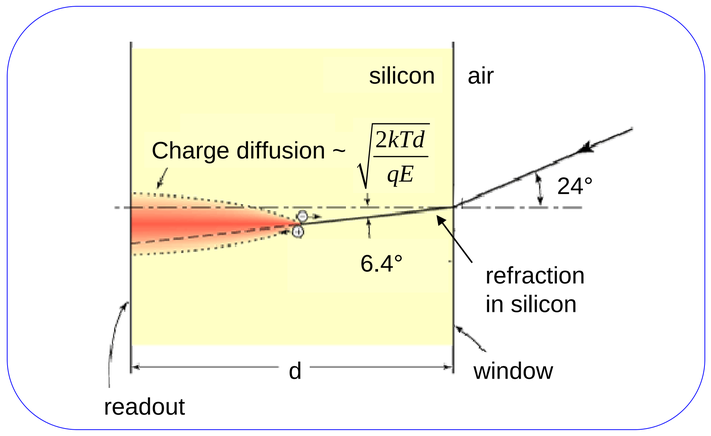
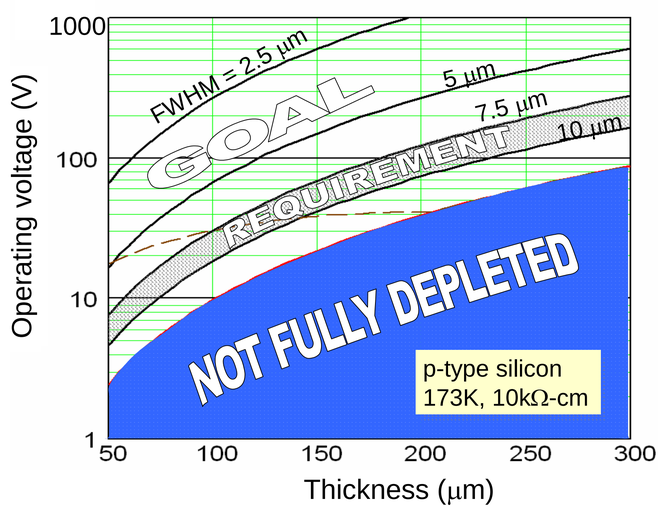
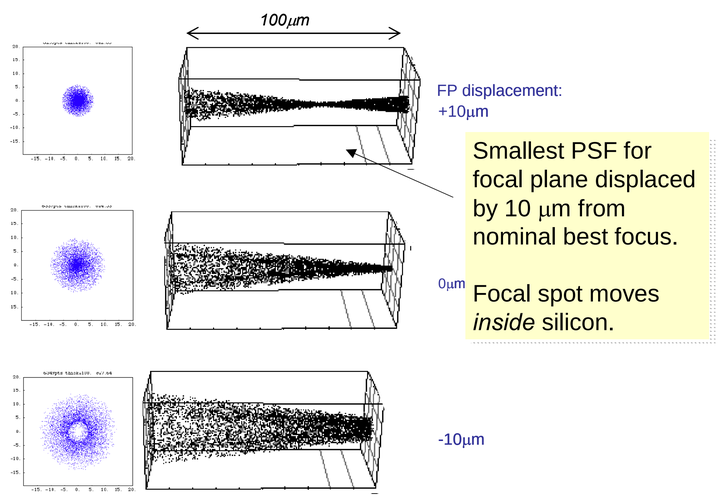
Point Spread Function



Diffusion vs. thickness and operating voltage

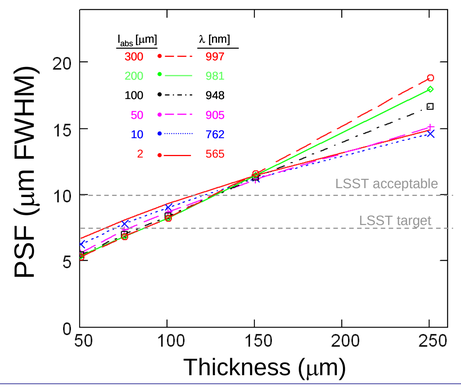


Absorption of 1 μm light in thick sensor



Smallest PSF for focal plane displaced by 10 μm from nominal best focus.

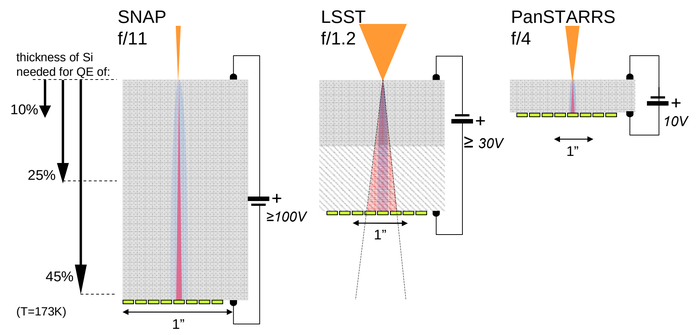
Focal spot moves *inside* silicon.



PSF vs. thickness: effects of diffusion and beam divergence.

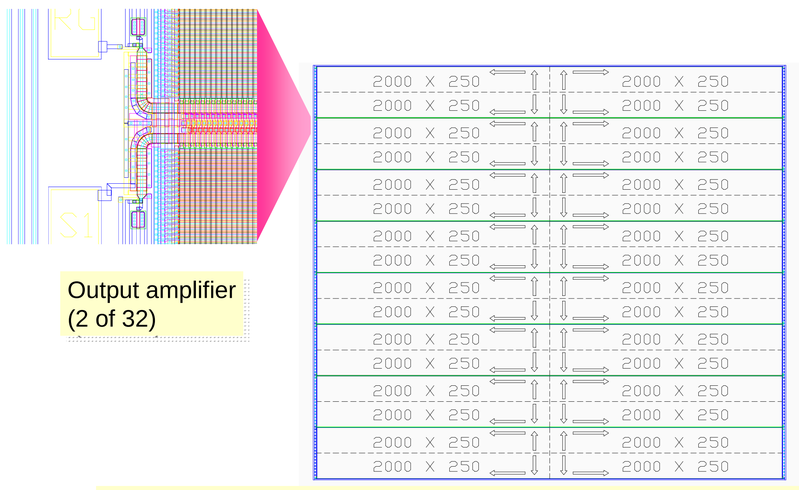
FP position optimized at each wavelength

Comparison with other sensors



	SNAP	LSST	Pan-STARRS	
Sensor thickness	200	60 - 120	30	μm
Camera focal ratio	10.8	1.2	4	-
Pixel size	10.5	10	12	μm
Pixel angular size	0.1	0.2	0.3	arcsec
Pixel full well	130,000	90,000	96,000	e^-
Sensor flatness	+/- 10	+/- 5	<+/- 20	μm
Camera active area	520	3200	1440	cm^2
Readout time	20	2	2	sec

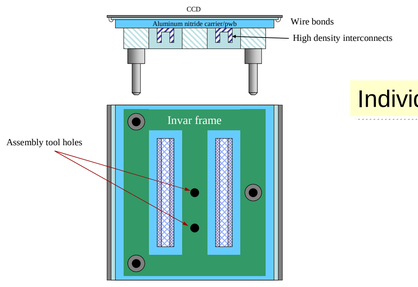
Strawman 4Kx4K CCD design



Output amplifier (2 of 32)

Format: 8 x (4 x 2000 x 250) = 16 Mpix
32 amplifiers to achieve 2 second readout at moderate clock rates.
10 μm pixels, fill factor 96.5%

Packaging concepts



Individual sensor

Sensor sub-array