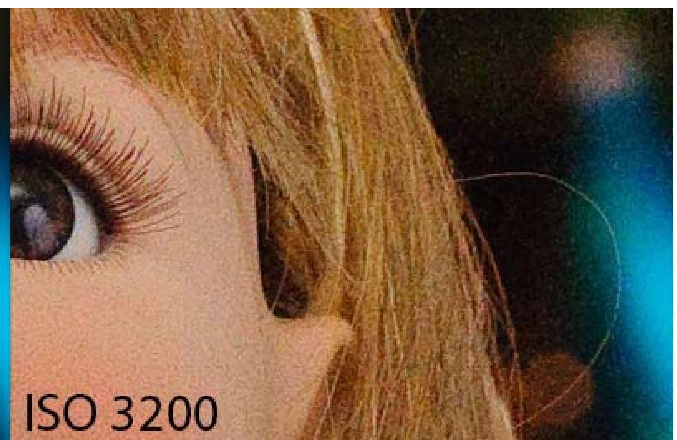
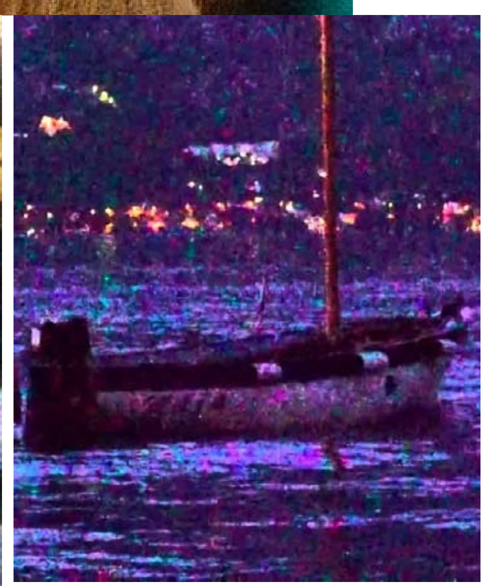
Film/Pixel Sensitivity

- Film or digital cameras measure sensitivity as ISO
- ISO=100 gives a picture in sunlight at ~F#16 and 1/60th sec
- Double ISO can cut exposure time in half or go up 1 F stop
- Film ranged from ISO 20 to ISO 1600: 100 was typical
- (1600 ISO is 4x more sensitive than 100 ISO)
- At high ISO films were very grainy
- Colour films much gainer than B&W
- DSLR’s get 50-409,600 ISO these days
- But at highest ISO get digital noise
- Makes the pictures look grainy
- Gets colour (Chromenance) and signal (intensity level) shifts



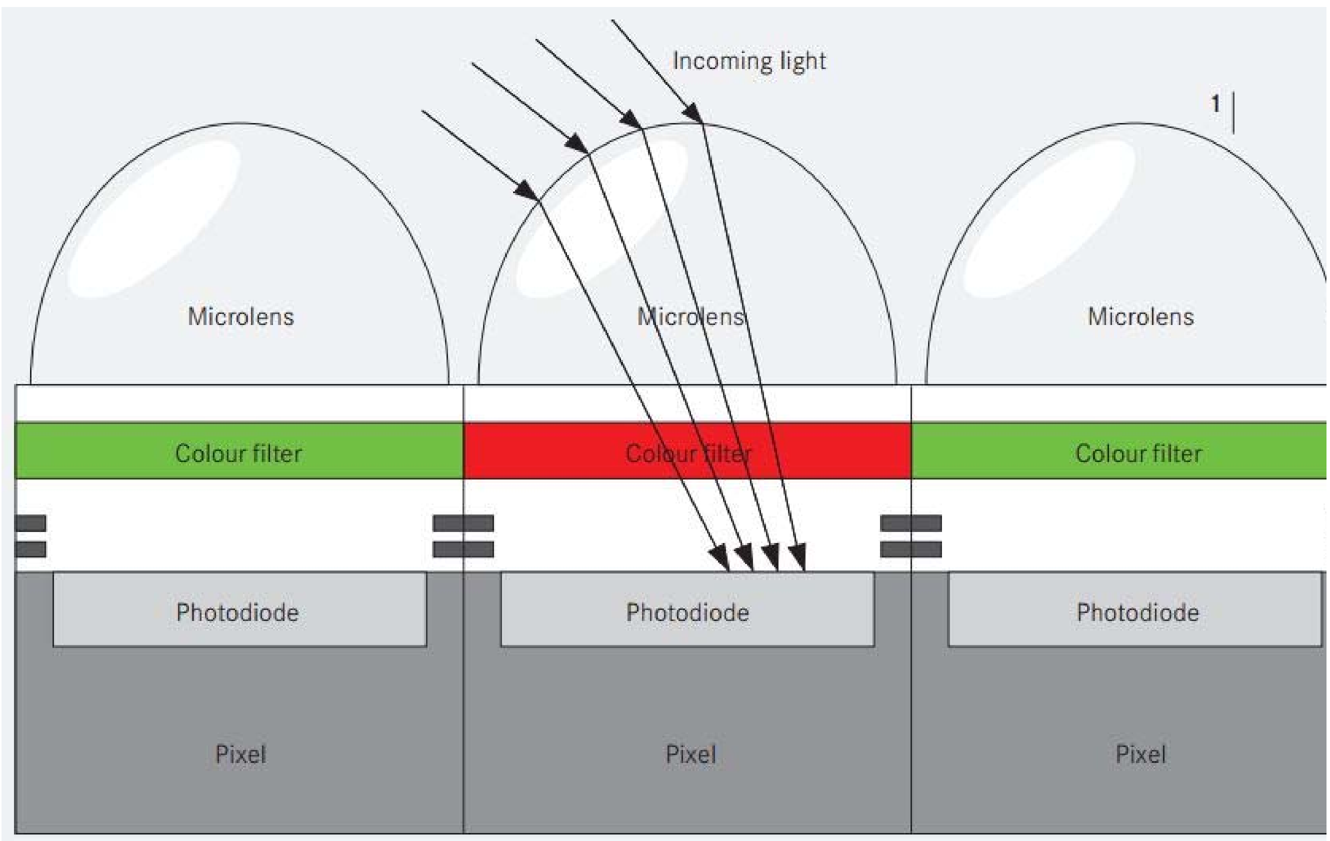

12,800 ISO

12,800 ISO


409,600 ISO

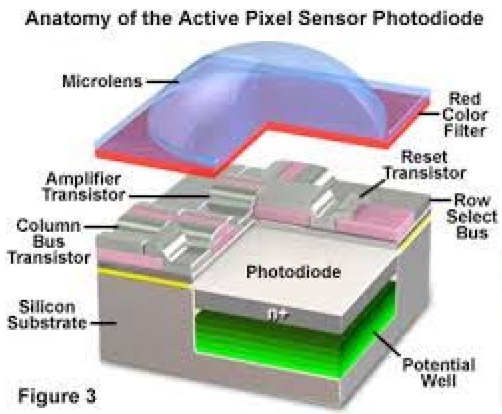
Microlens & APS pixel

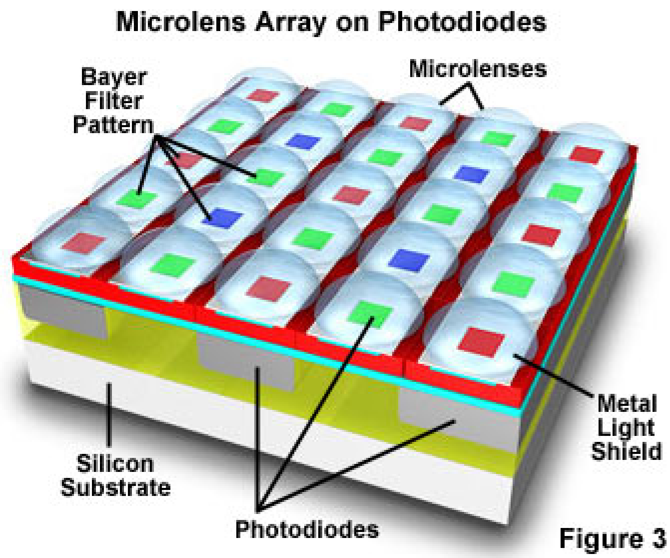
- APS typically has 25%-50% fill factor (fraction PD to pix area)
- Rest of light wasted – true of 1st generation APS (2004)
- Top ISO was 6400
- Noise very noticeable at ISO 1600
- About generation 3 began adding microlenses ~ 2008
- Nearly factor 4 in sensitivity
- Now top ISO goes to 3200 with nill noise (4 Fstops)
- Top end in most camera is IS0 25,600
- Microlens does not need to focus image
- Just get light to the photodiode

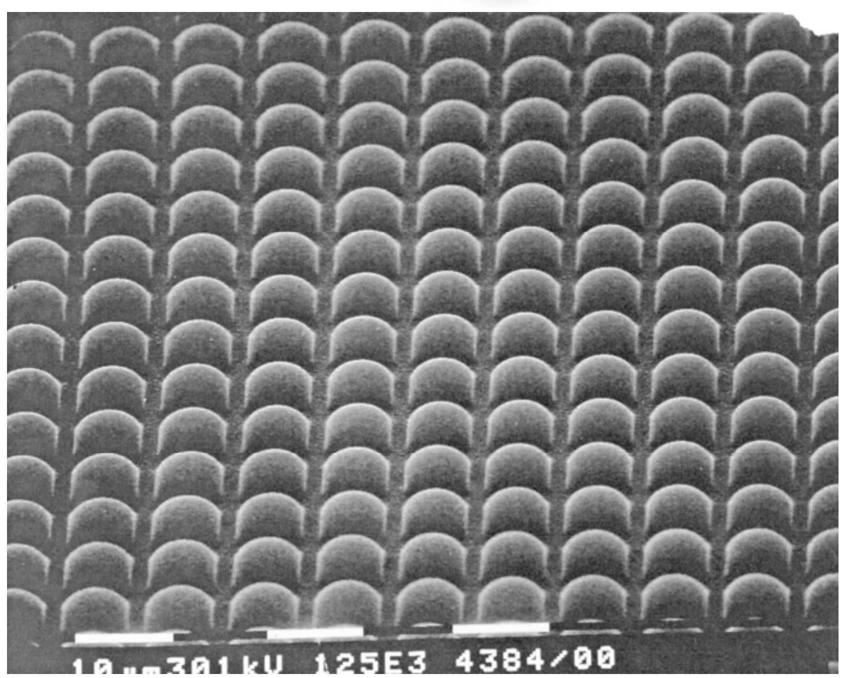


Fabrication of Microlenses

- Photodiode is off centre usually
- Microlens is added top layer
- Max curve about half size of pixel
- Typically of glass or plastic
- Significant added fabrication step

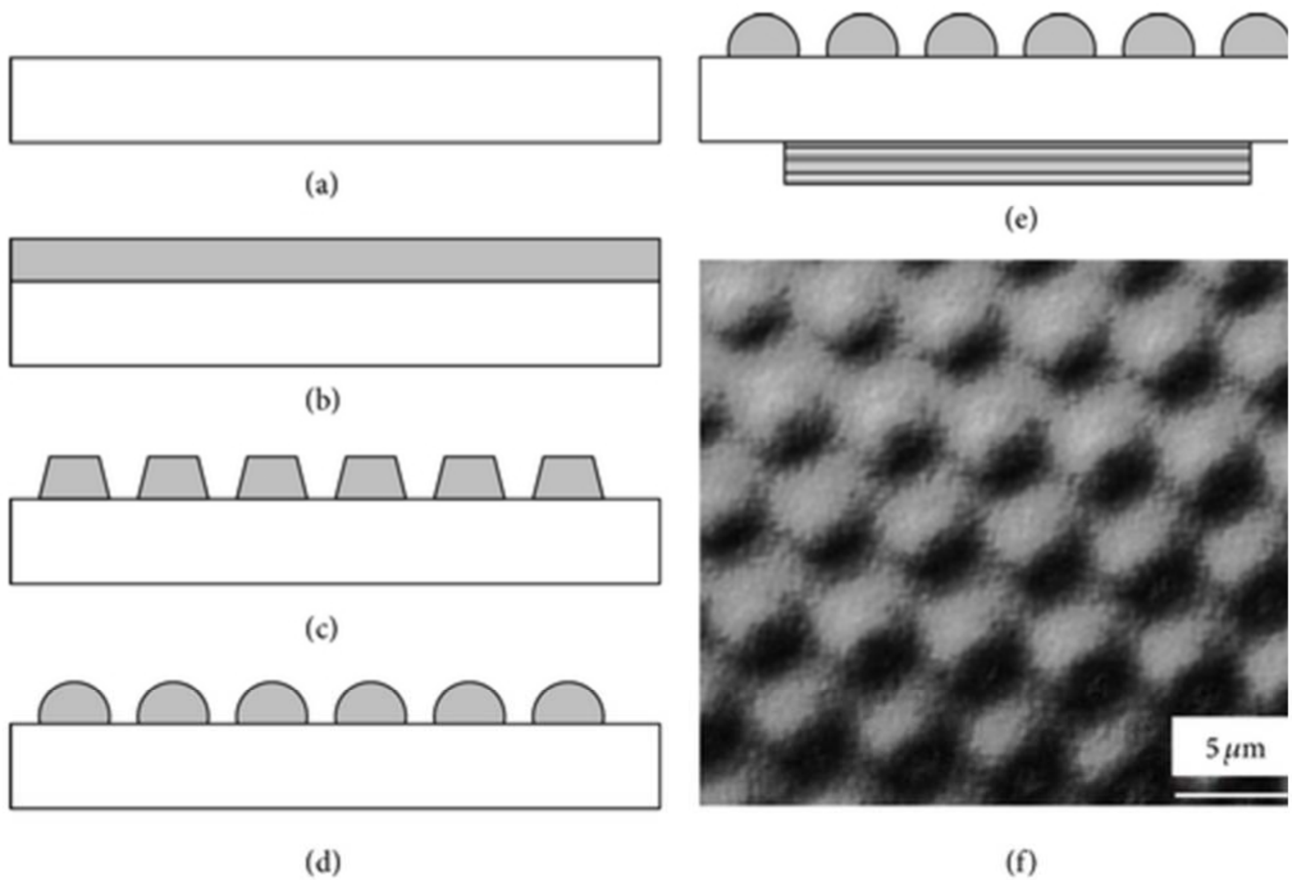






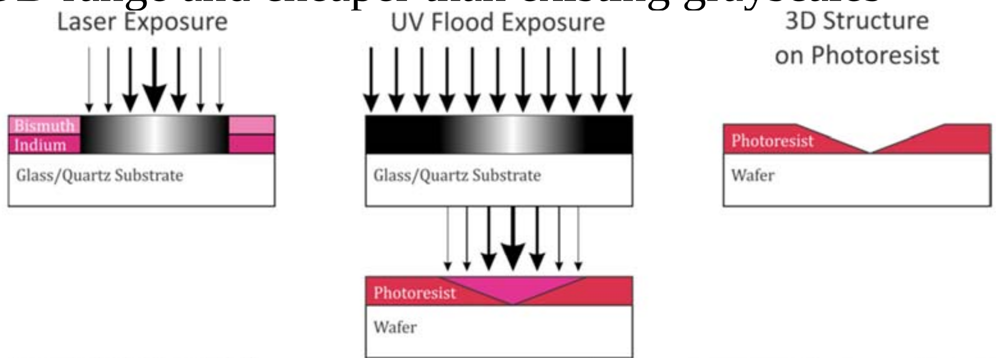
Microlens Methods

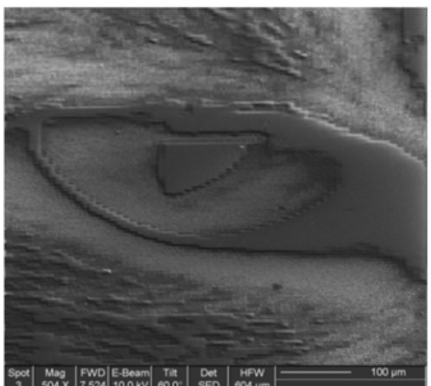
- 2 typical methods: reflow and microfabrication
- In reflow deposit a layer of plastic/photoresist
- Initially pattern layer into separate squares
- Then heat and reflow plastic
- Surface tension causes spherical lens
- Advantage straight forward
- Problems: lens is centered on pixel
- But photodiode array is often not in the centre of pix
- No control of shape

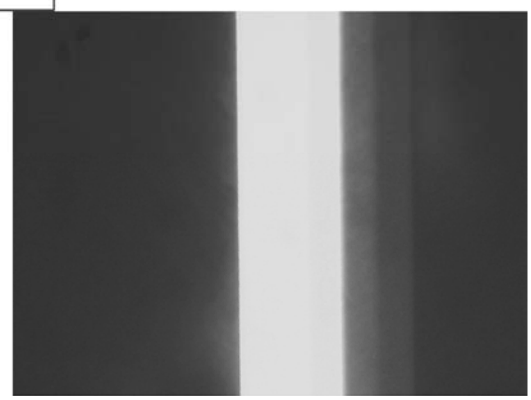


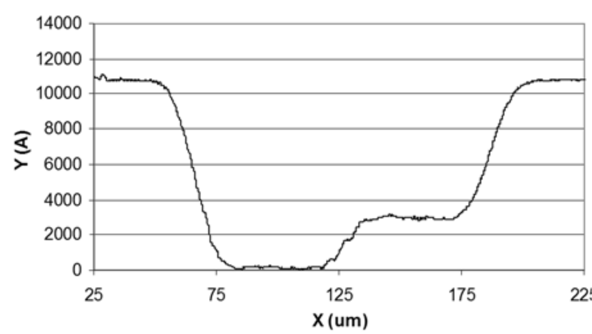
Grayscale Photomasks

- Grayscale masks contain many gray levels
- When hits photoresist developed thickness function of exposure
- Can create 3D microfabricated devices (eg. Microoptics, MEMS)
- Better OD range and cheaper than existing grayscales



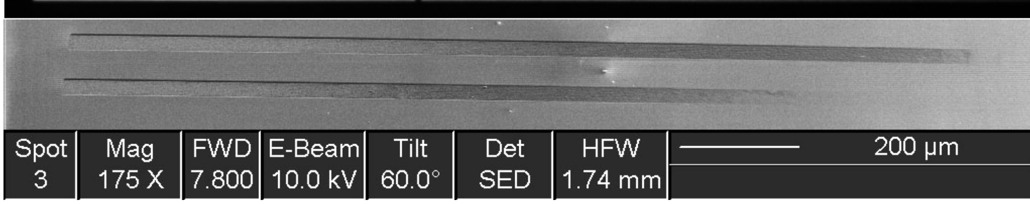






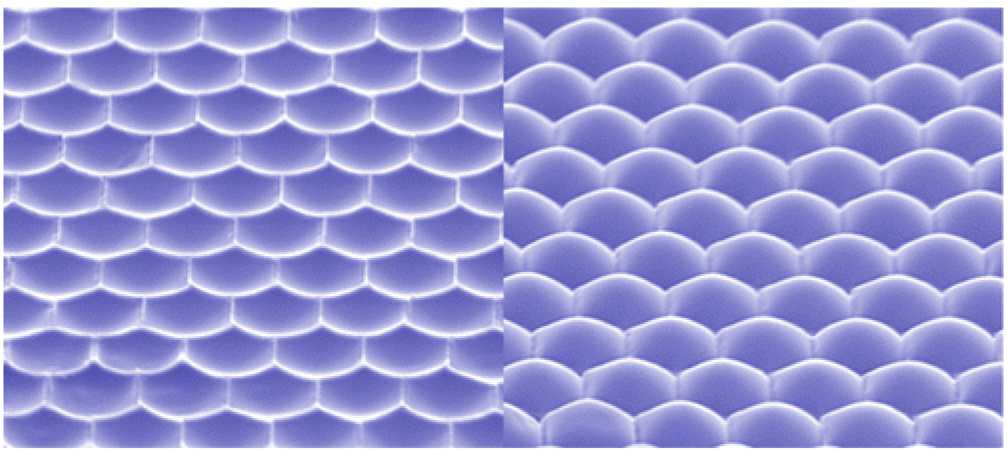
Original picture

Grayscale mask



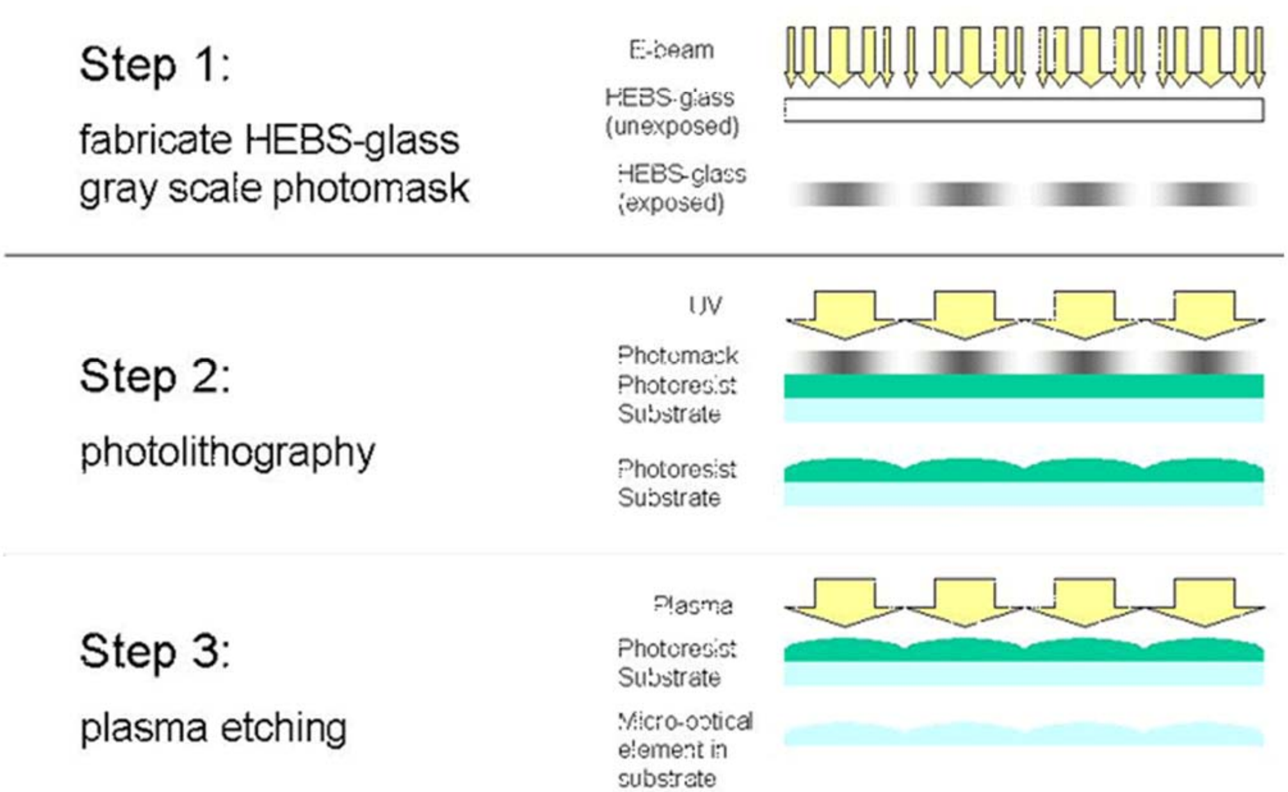
Lithography Gray Scale Mask Method

- Use 3D photolithography
- Some materials (SU-8) are like negative photoresist
- Expose to mask – where lots of UV thin
- Little UV get structure
- Develop afterword to get lens
- Advantage – now control shape of lens
- Disadvantage: grayscale masks expensive $500K



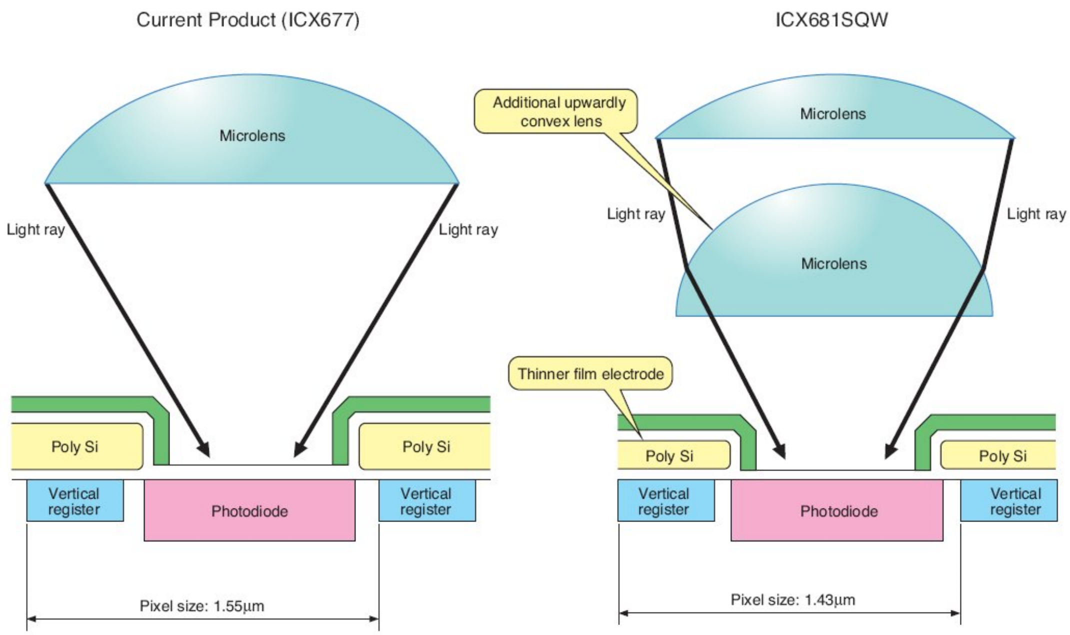
Etching Microlenses

- Again use Gray Scale mask
- Deposit glass layer
- Now flow on photoresist
- Pattern photoresist in 3D shape
- Use plasma etching transfer pattern from resist into glass
- Plasma for glass has Florine base
- For resist Oxygen base
- Must get mixtures so rate of photoresist etch = glass etch
- Advantage get lens in glass
- More complex process – especially controlling etching



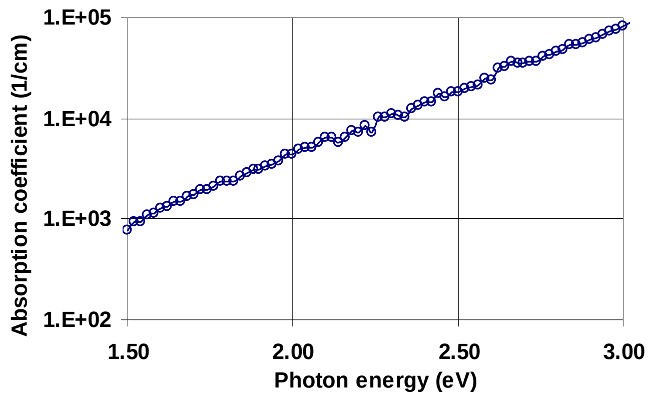
Smaller Pixels More Lenses

- As pixels shrink single lens is not enough
- Near 1 micron need double lens
- More than what a single lens
- Hence now add lens plus protection layer
- Must add leveling layer of low index mater
- Then second lens layer



Color and Sensitivity

- Different pixel colors have different sensivity
- Due to absorption depth in the silicon
- Blue close to surface
- Hence huge surface effect
- Red deep
- Also get 1 e-h pair per photon
- But energy of photon goes with the color
- Hence blue has lower sensitivity (almost half sensitivity)



. Absorption coefficient of silicon crystal at various wavelengths.