Dual layer pixel optics for low light cameras

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Arecont Vision

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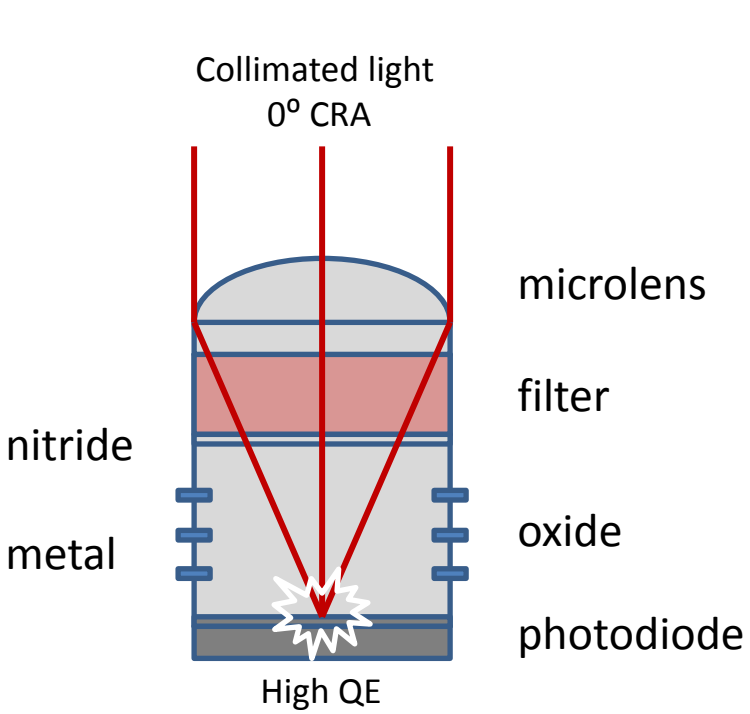
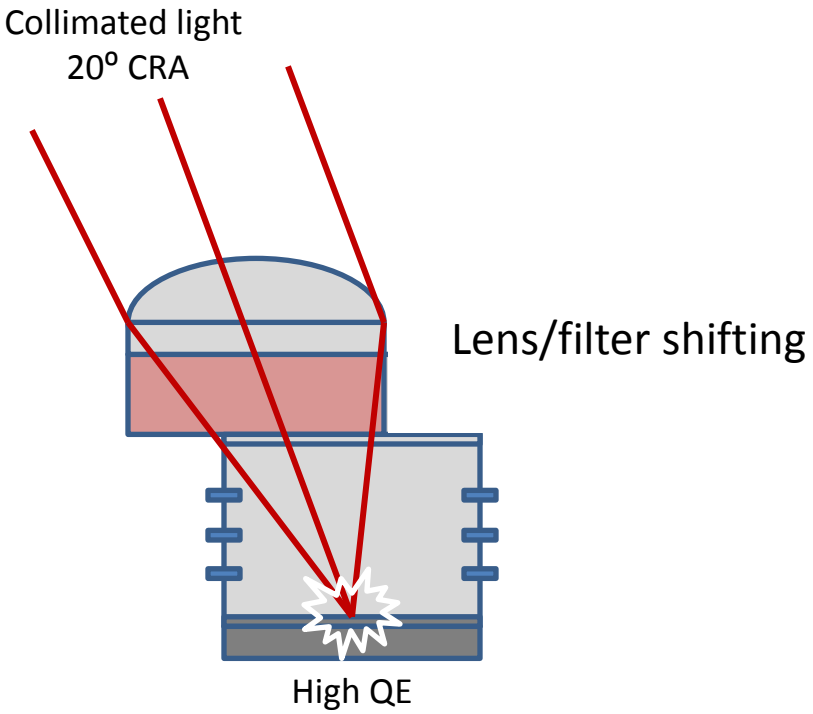
Traditional FSI Pixel Design

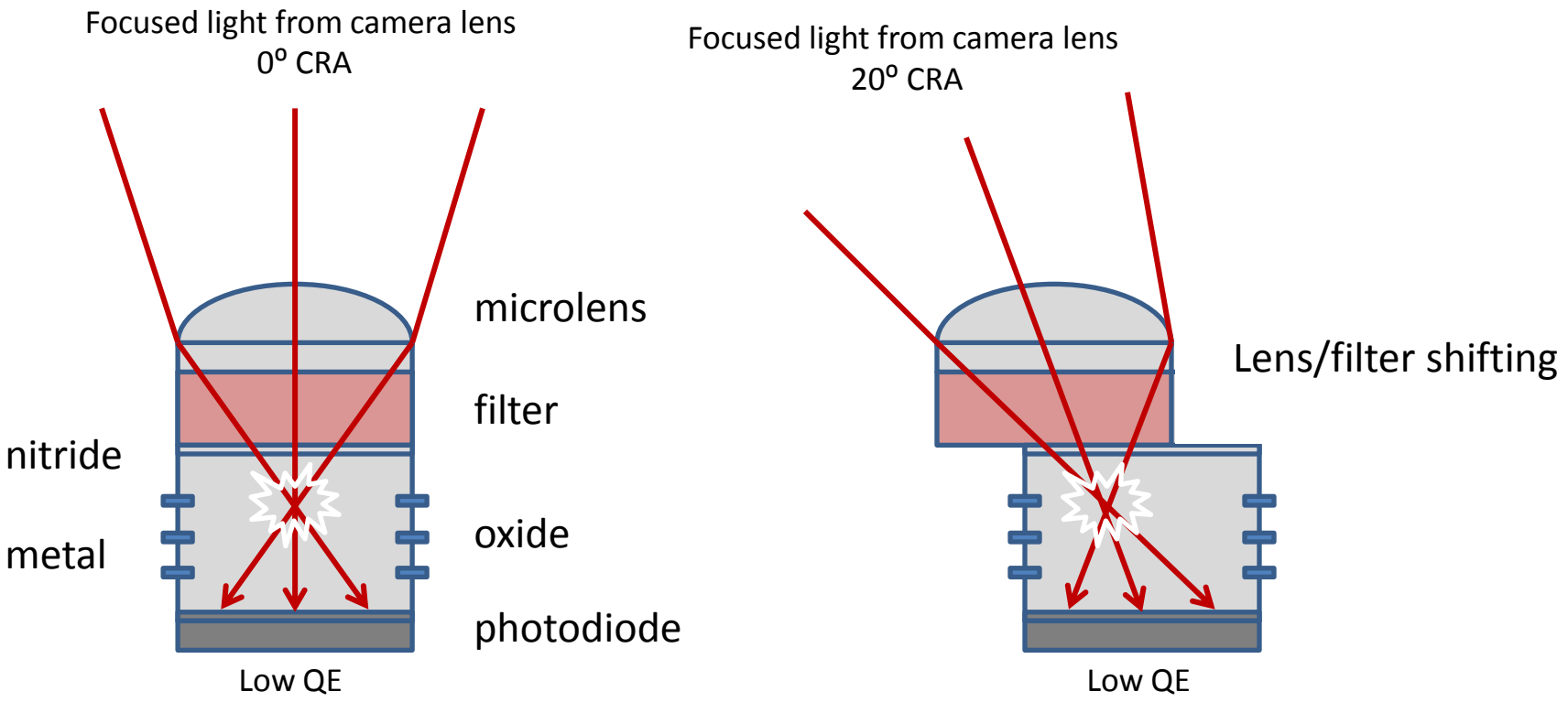
FSI: Front side illuminated





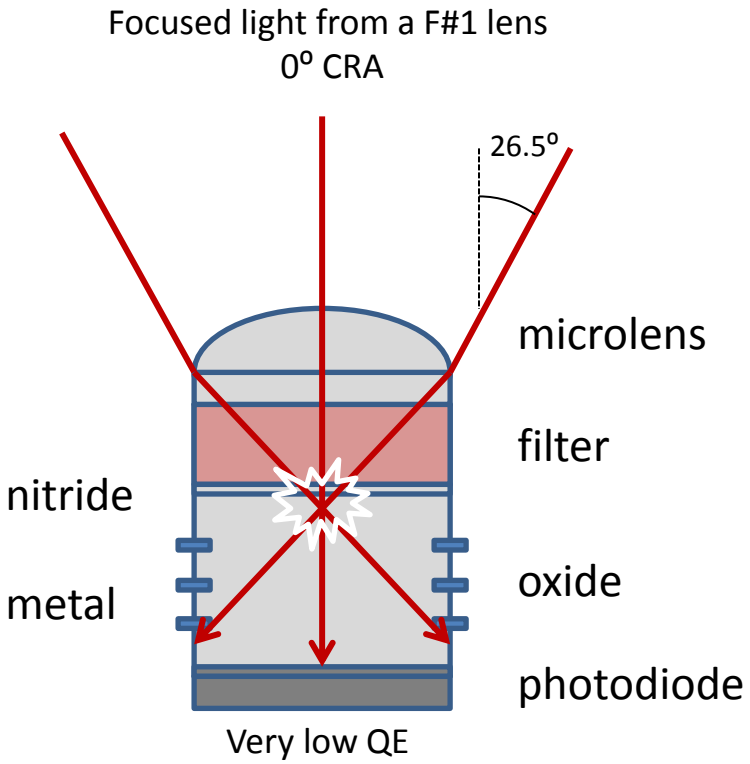
- Focal length of micro-lens designed to focus collimated light on photodiode
- High quantum efficiency (QE) requires focal point to be on photodiode
- High QE for on-axis collimated light
- Microlens shifting achieves high QE for off-axis collimated light with high chief ray angles (CRA)

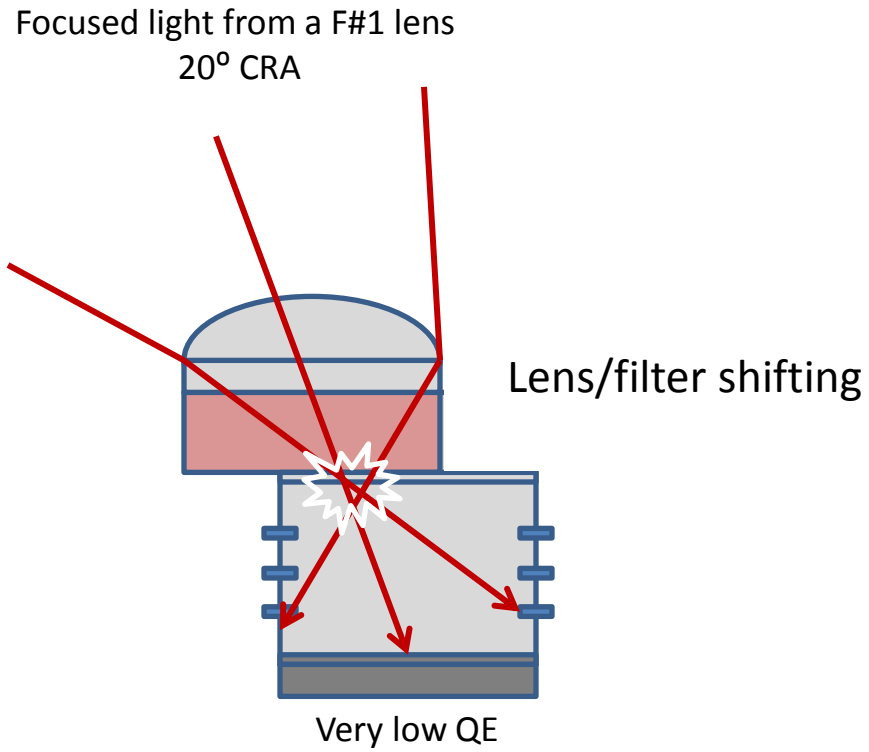
Problem: Pixels ignorant of camera lens



- Light rays falling on pixels of a camera are not collimated because of focusing from camera lens
- Since pixel microlenses are designed for collimated light, they do not focus non-collimated incoming rays at the photodiode
- This leads to light loss and QE degradation

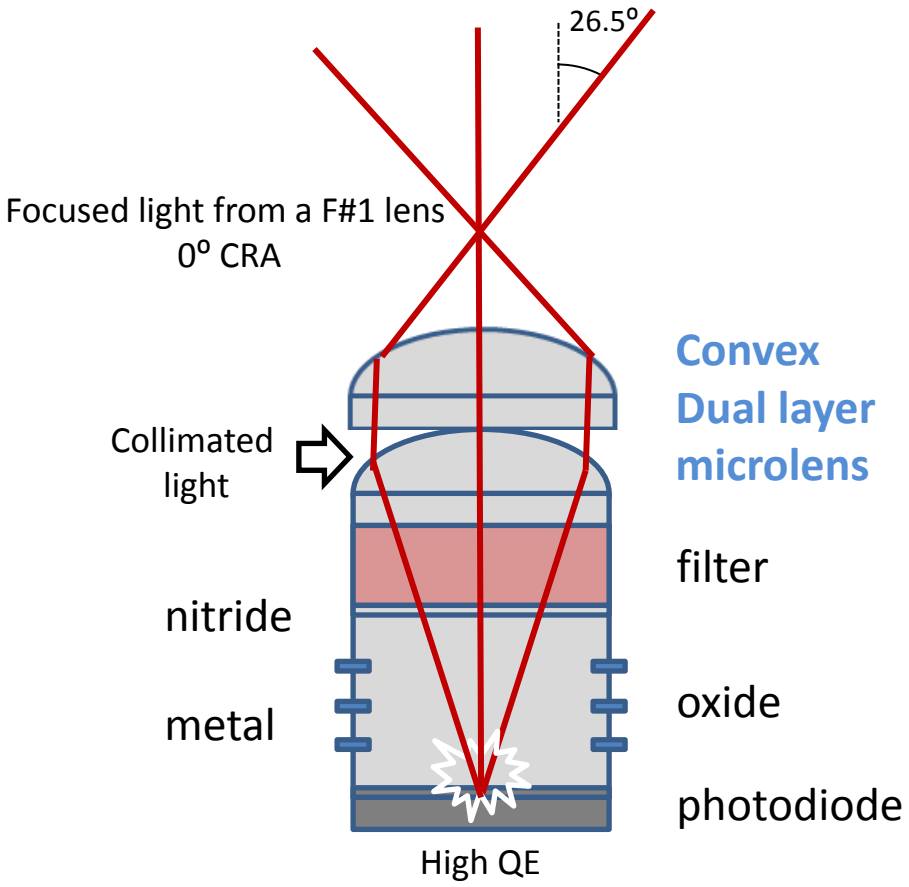
Problem: QE degrades for fast (low F#) camera lenses

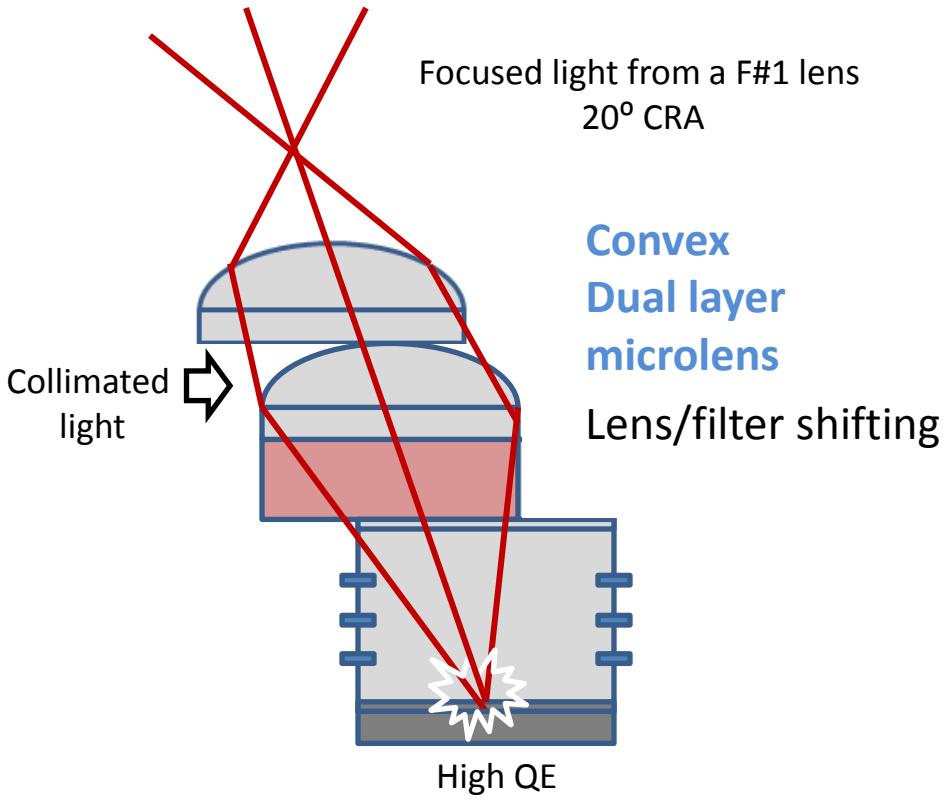




- Fast lenses (low F#) collect more light. They can be very useful in improving low-light sensitivity
- However, additional light collected by fast lenses have steep angles which are attenuated by pixels
- This leads to minimal low-light sensitivity improvement when fast lenses are used with FSI pixels
- Pixels with backside illumination (BSI) design perform better with low F# lenses, but BSI pixel technology is typically available only for small pixel sizes, which are unsuitable for advanced low-light sensitivity

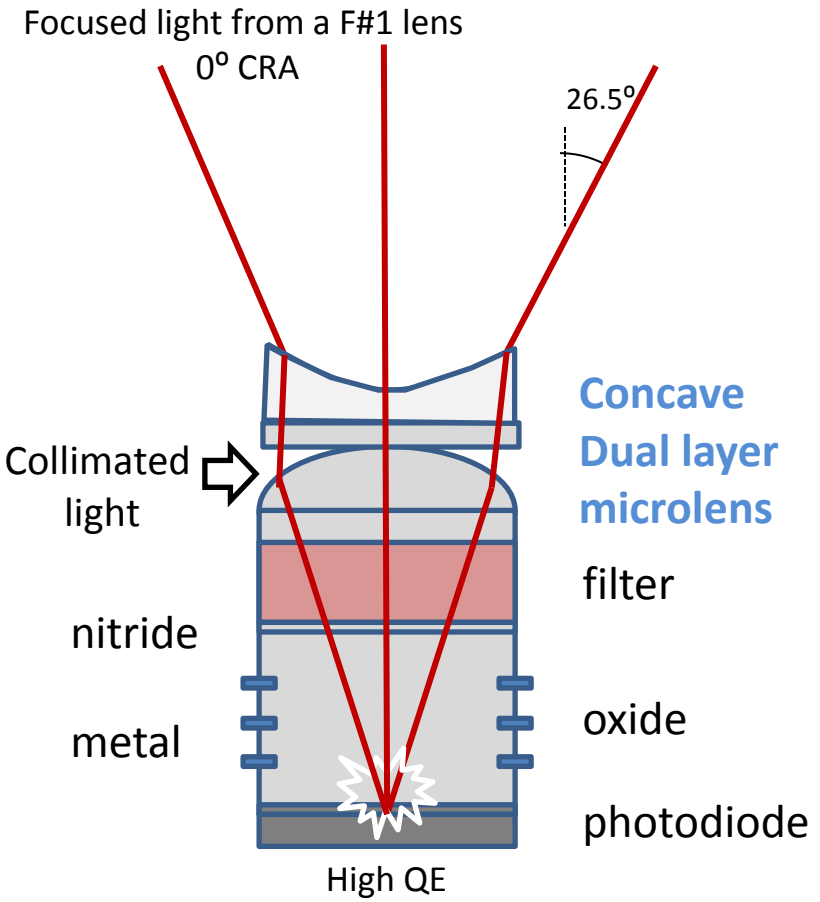
Invention: Dual layer pixel-optics for low-light cameras
Embodiment 1

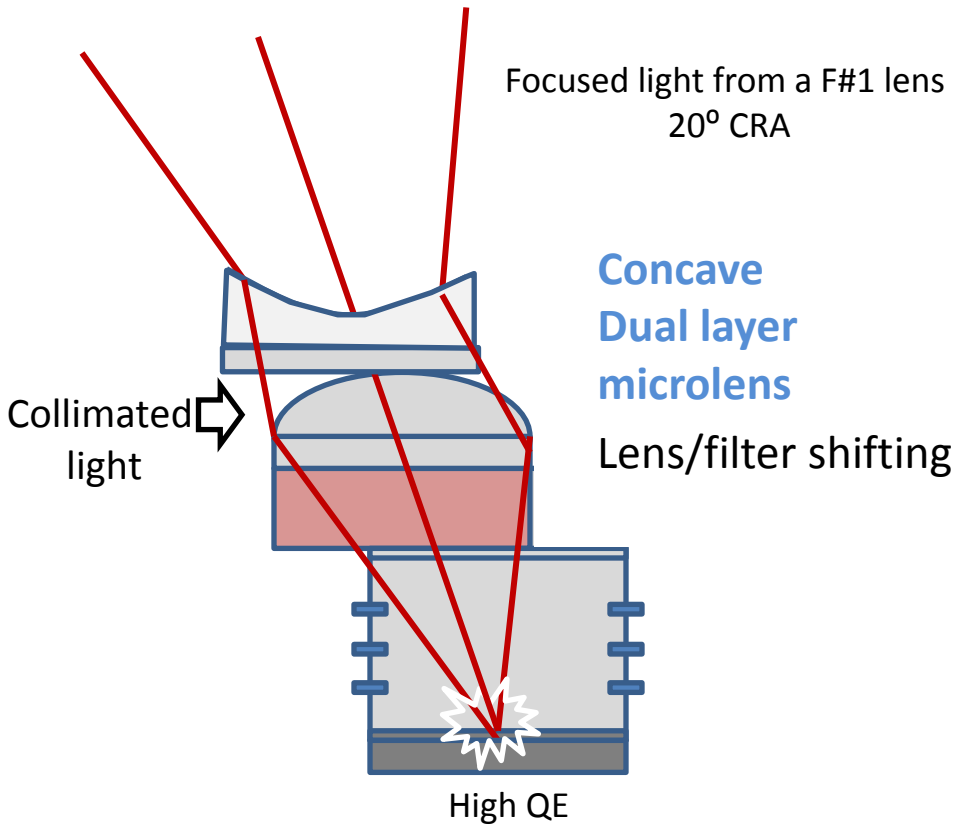




- Dual-layer microlenses have two microlenses for each pixel
- The first layer collimates all light so the second microlens layer can focus light on the photodiode
- High QE is achieved since focal point of light falls on the photodiode

Invention : Dual layer pixel-optics for low-light cameras
Embodiment 2





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Prior Art Literature

- US Patent US4694185: Light sensing devices with lenticular pixels, Kodak (1986)
- US Patent US5323052: Image pickup device with wide angular response, Sharp (1991)
- US Patent US5593913: Method of manufacturing solid state imaging device having high sensitivity and exhibiting high degree of light utilization, Sharp (1995)